Buletin Poltanesa Vol. 24 No. 2 (December 2023) 242-247 p-ISSN 2721-5350 e-ISSN 2721-5369
https://doi.org/10.51967/tanesa.v24i2.2942 © 2023 Politeknik Pertanian Negeri Samarinda

Trends in Margasari Mangrove Forest Health Indicators, East Lampung Regency

Mohamad Ilham Nurfaizi
Department of Forestry, University of Lampung, Bandar Lampung, 35145, Indonesia
Ilhamnn18@gmail.com

Rahmat Safe'i
Department of Forestry, University of Lampung, Bandar Lampung, 35145, Indonesia
rahmat.safei@fp.unila.ac.id
**Corresponding author*

Hari Kaskoyo
Department of Forestry, University of Lampung, Bandar Lampung, 35145, Indonesia
hari.kaskoyo@fp.unila.ac.id

Rudi Hilmanto
Department of Forestry, University of Lampung, Bandar Lampung, 35145, Indonesia
rudihilmanto@gmail.com

***Abstract*—**Mangrove forests are a life-support system and have ecological, socio-cultural, and economic benefits. Monitoring trends in forest health indicators is carried out to control forest damage so that it remains below the loss threshold, thereby ensuring the sustainability of mangrove forests. The margasari mangrove forest is one of the ecosystems in lampung province that acts as a buffer and protector for coastal areas. A healthy forest is one that can carry out its functions in a real way, be they conservation functions, protection functions, or production functions. The margasari mangrove forest is categorized as a protected forest, so it needs to be monitored intensively so that its sustainability is maintained. The aim of the research is to determine trends in health indicators for the margasari mangrove forest in east lampung regency. The research was carried out using the forest health monitoring method, observing each tree in the plot clusters and analyzing ecological indicators including productivity, vitality, and site quality. The research results show that productivity indicators have increased by 1.716 m3/ha S-C and 10.31 m3/ha P-T, CLI has increased by 3.22 S-C and 4.86 C-T, VCR has decreased by 2.05 S-C and 0.01 C-T, and indicators of soil pH experienced a decrease in S-C of 0.002 and an increase in C-T of 0.085. The fluctuations and condition of each indicator are influenced by changes in the condition of the ecological indicators of the mangrove forest and by human activities and natural conditions that threaten the sustainability of the mangrove forest.

***Keywords*—**Mangrove forests, Margasari, Trend, Indicators, FHM

I. INTRODUCTION

Monitoring trends in forest health indicators is carried out to determine the level of trend in forest health indicator conditions that occur in a forest area (Nabila et al., 2022). Health indicator trend monitoring data is used as a reference in management units for sustainable forest management, so that decisions can be made quickly and accurately (Alnursa, 2022). Mangrove forests are a life support system and have ecological, socio-cultural and economic benefits (Nurfaizi and Safe'i, 2023). Monitoring forest health indicators is an activity carried out to control forest damage, so that it remains below the loss threshold, thereby ensuring the sustainability of mangrove forests (Safe'i, Kaskoyo, et al., 2022). The margasari mangrove forest, which functions as a coastal protector, is a strategic location for fishing for fishermen and has the potential to store carbon absorption. Currently monitoring trends in forest health indicators is still rarely carried out, even though monitoring forest health is important. By knowing the trend of forest health indicators, we can find out what the trend condition of each forest health indicator is forest health indicators include productivity, vitality, biodiversity and site quality. Productivity measurement is a measurement carried out to determine the condition of tree growth within a certain period; vitality is a measurement carried out to determine the condition of tree damage that has occurred, including the type of damage, location of damage, and level of severity (Safe'i et al., 2019).

A measurement of biodiversity indicators is a measurement carried out to determine the condition of biodiversity in a forest area. Site quality measurements are carried out to determine the condition of soil fertility. This is done to find out whether the condition of the soil supports the growth of trees in an area. This is related to the condition of nutrient storage or nutrients stored in the soil. The margasari mangrove forest has an area of 817.59 ha and is in the green zone of the gunung balak KPH. The dominant vegetation is api-api *Avicennia sp*. and mangroves *Rhizophora sp*. (Abda, 2019). The margasari mangrove forest is a habitat for marine biota, preventing marine intrusion, preventing abrasion, and protecting coastal areas (Safe'i *et al*., 2022). Therefore, it is necessary to monitor trends in margasari mangrove forest health indicators as a form of sustainable forest management (Ecke et al., 2022). The natural resources contained in mangrove forests have several relationships that fulfill the needs of living creatures, such as food and the environment. Mangrove forests have great tourism potential for community welfare, but the use of mangrove forests is not yet optimal due to inadequate human resources. Ecologically, mangrove forests have a very important role for the environment, such as blocking waves, blocking winds from the sea, and providing a place for wild animals to live (Alnursa, 2022).

Forest health monitoring is a method used to determine the condition of forest health indicators. This method was developed in the united states as a method used by management units in forest management. This assessment of forest health conditions or forest health indicators has been implemented for

a long time, since 1997. Good planning can produce good forest conditions according to their function. In making policies and decisions, an accurate and real basis is needed as a reference in determining long- and medium-term management. However, if decision-making is not based on ecological parameters, the goals to be achieved for sustainable forest management in a prosperous community will not be met. Monitoring forest health trends is carried out based on follow-up research that has been carried out previously, namely research carried out in 2020 and 2021. The first research was carried out to determine the status, and the second related to changes that occurred. This forest health indicator assessment aims to determine the current condition and whether the forest is said to be healthy or not. The second assessment was carried out to determine changes that occurred after measuring the status, and the third assessment was carried out to determine trends that occurred in a mangrove forest area (Rizky Pratama et al., 2022). The method refers to ecological indicators including productivity, vitality, and site quality (Ardiansyah & Safe'i, 2021). Forests are said to be healthy if they can carry out their main functions, including protection, conservation, and production (Safe'i et al., 2018). The functioning of forests has a comprehensive impact on the sustainability of forest ecosystems. The aim of the research is to determine trends in health indicators for the margasari regency mangrove forests.

II. LITERATURE REVIEW

Mangroves are a type of tree that can live between fresh water and sea water. Mangrove forests are characterized by being influenced by tides; fresh water flows from land to sea. So the surrounding mangrove forest will become brackish water (Nurcahyani et al., 2022). The margasari mangrove forest has an area of 817.59 ha (Nurfaizi and Safe'i, 2023). The margasari mangrove forest is an ecosystem that holds physical, ecological, and economic potential (Siddiq, 2023). The existence of mangrove forests has a role as a barrier to abrasion, resists seawater intrusion, and provides real benefits to the surrounding community for the livelihood of fishermen looking for fish. Forest health, according to (Pangestu et al., 2022), ecosystem health or forest health is related to biological interactions.

Forest health assessment is intended to identify current forest conditions, changes, and trends that are occurring (Safe'i et al., 2021). Assessment of trends in forest health indicators is an activity carried out to determine trends in forest health indicators in a forest area, which include productivity, vitality, and site quality. Information regarding forest health becomes a reference in decision-making in the sustainable management of mangrove forests. The success of a forest health indicator is influenced by the environmental conditions of the mangrove ecosystem and the silvicultural system implemented (Indriani et al., 2020). A healthy forest is a forest that can carry out its functions, such as protection, conservation, and production (Safe'i & Upe, 2022).

III. RESEARCH METHODS

The research was conducted in the mangrove forest of margasari village, labuhan maringgai district, east lampung regency, in 2022. The tools used in the research included tally sheets, plastic labels, permanent markers, magic cards, compasses, pine nails, 20-cm paralon, roll meters, price meters, tape meters, digital cameras, and GPS. The object of this research is to measure all tree stands in measuring plots that follow the standard forest health monitoring references in mangrove forests. The forest health monitoring standard is a standard for measuring forest health using ecological indicators of mangrove forests, covering productivity, vitality, and site quality. An overview of the research location can be seen in figure 1.

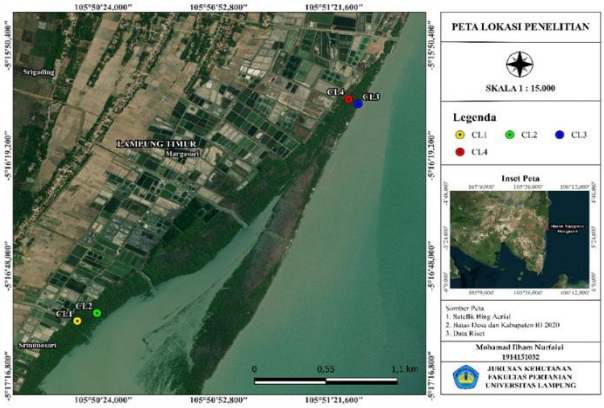


Figure 1. Research location

A. *Research stages*

Assessment of trends in forest health indicators is carried out by observing ecological indicators, which include productivity, vitality, and site quality of all vegetation in poll clusters. The determination of plot clusters in mangrove forests is based on strata C/Avicennia sp. and D/Rhizophora sp. Therefore, the number of cluster plots created was four clusters distributed in each stratum. The research stages include determining the location of plot clusters in a forest area using previous research locations that were carried out in 2020 and 2021, making plots for each cluster in the form of a circle, collecting data including productivity values and tree growth rates over a period of time, measuring the vitality and condition of tree damage and tree canopy conditions, assessing site quality and soil fertility in forest areas, which aims to determine how the condition of the area supports tree growth, and analyzing research data using the forest health monitoring method. The form of the cluster design can be seen in figure 2.

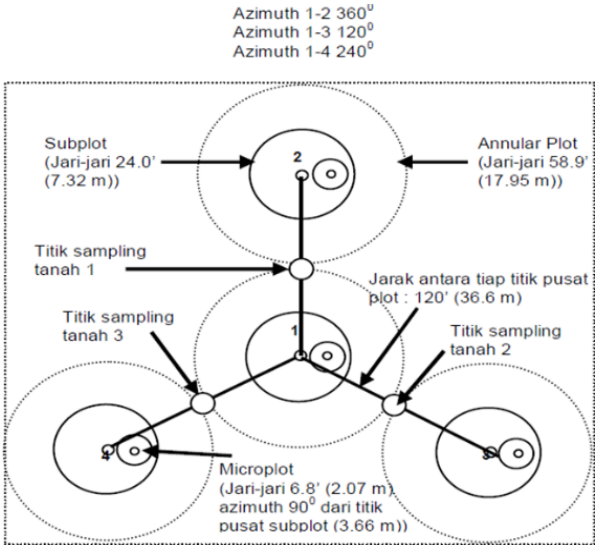


Figure 2. Form of FHM cluster plot

This method is designed to determine the condition of forest health by calculating the weighted value and the extract score value for each forest health indicator parameter. After obtaining the status values, changes, and trends in forest health indicators, a comparison of indicator measurements is carried out based on measurements that have been carried out for 3 years (Safe'i, Rezinda, et al., 2022).

B. Measuring mangrove forest health indicators

Measuring trends in mangrove forest health indicators is carried out using the forest health monitoring method. Observation of each tree in the plot cluster, with analysis of ecological indicators including productivity, vitality, and site quality. The explanation of each ecological indicator is as follows.

1. Productivity

Measurement of tree growth in an annular plot. Productivity measurements were carried out at the tree stage that had a diameter of ≥20 cm. The productivity formula can be seen based on equation 1 (Safe'i & Upe, 2022).

$$LBDS = 1/4\ \pi(dbh)^2 \quad (1)$$

Information. LBDS: basal area, π: 3.14, dbh^2: tree height at breast height.

2. Vitality

Vitality measurements for each tree are carried out visually, including damage to and condition of the tree canopy. Observation of damage covers the tree roots to the crown. Measurement of tree damage to the annular plot. The crown condition observation section includes crown density, crown diameter, width and crown diameter, live crown ratio, dieback/CDB, and foliage transparency. The condition of tree damage was analyzed based on the damage index value at the plot cluster level. The vitality formula can be seen based on equation 2 (Safe'i et al., 2021).

$$IK = X\ x\ Yx\ Z \quad (2)$$

Description. X: location of damage, Y: type of damage, Z: severity of damage

3. Tread quality

The site quality data used is soil pH conditions. Soil samples were taken at three points between annular plots. Each sample was taken using a pipe with a diameter of 15 cm and a depth of 10 cm. Soil pH analysis is carried out using a pH meter.

C. Assessment of trends in mangrove forest health

Indicators the final assessment of mangrove forest health indicators is obtained from the final value of the condition of the forest health indicators, which is the result of calculations between each indicator. The final formulation of forest health indicator assessment can be seen in equation 3 (Safe'i et al., 2021).

$$NKH = \sum NT\ x\ NS \quad (3)$$

NKH: final value of forest health indicators; NT: weighted value of each indicator; NS: score value of each indicator.

IV. Results and Discussion

Assessment of trends in margasari mangrove forest health indicators using the Forest Health Monitoring/FHM method. By observing ecological indicators including tree productivity, tree vitality, canopy condition, and site quality, which were developed by Mangold in 1997, this method was designed because of concerns about global climate change caused by forest destruction (Indriani et al., 2020).

1. Trend tree productivity indicator

The productivity indicator assessment aims to obtain the standby potential value of the margasari Mangrove Forest (Safe'i, 2020). In this way, decision-making in sustainable management can be considered from the silvicultural aspect. The influence of high- or low-potential stands will influence how forests are managed sustainably. The trend value of productivity indicators in the margasari mangrove forest has increased in several plot clusters. This shows that there is an increase in tree growth performance. The data on trend values of tree productivity indicators is presented in table 1.

Table 1. Trend values of tree productivity indicators

Cluster-plot	Productivity		
	Status (m^3/ha)	Change (m^3/ha)	Trends (m^3/ha)
1	0,031	0,05	1,48
2	0,028	1,5	1,769
3	0,045	0,32	5,145
4	1,51	1,46	5,248

The trend value of tree productivity indicators experienced an increase in tree growth performance, starting from cluster 1 at 0.73 m3/ha, cluster 2 at 1.6 m3/ha, cluster 3 at 2.68 m3/ha, and cluster 4 at 1.84 m3/ha. The trend value of tree productivity indicators in the margasari mangrove forest continues to increase, with an average increase of 6.87 m3/ha. The increase in productivity indicator values is influenced by optimal climatic conditions and low levels of pest attacks and damage to trees. Meanwhile, the decline in productivity values is influenced by pests and diseases, unsupportive environmental conditions, and coastal roughness, which affect the existence of mangroves (Yulianda, 2023).

2. Trend tree vitality indicator

Tree damage affects the psychological and physiological effects of trees; the value of the level of tree damage is determined by the severity, amount of damage, and type of tree damage. Assessment of trends in tree health indicators uses the damage index value for each individual tree (level index—CLI). The value of tree damage has increased continuously in several clusters, with a significant increase in the trend assessment. The CLI values for each FHM cluster plot are explained in table 2.

Table 2. Trend values of tree vitality indicators

Cluster-plot	CLI		
	Status	Change	Trends
1	0,58	1,8	2,80
2	0,59	1,96	1,53
3	2,07	2,7	4,50
4	1,58	1,58	4,07

The value of the tree vitality indicator shows how much damage the tree has experienced, but in Table 2, the accumulation of tree damage per cluster is explained. Clusters 1 and 2 continue to experience an increase in tree vitality values from assessing status, changes, and trends. Meanwhile, in clusters 3 and 4, the status assessment of changes did not experience an increase or decrease (the value remained constant), whereas in the trend assessment there was a significant increase. Cluster 1 experienced an increase with an average value of 1.72; cluster 2 was 1.15; cluster 3 was 1.53; and cluster 4 was 1.24. Based on the accumulated results, it shows that the trend of increasing tree vitality indicator values in the margasari mangrove forest is 5.66. A damage type is a variant or form of damage that occurs to individual trees. There are several dominant damages that occur in the margasari mangrove forest, such as open wounds on tree trunks, broken roots, and the loss of dominant shoots. This type of damage is identified based on the characteristics or symptoms that occur in terms of size, shape, color, and texture (Rohman et al., 2023). This damage can occur due to biotic and abiotic factors, such as human activities and natural conditions.

3. Trend indicator for tree crown condition

The crown of a tree is the part of the tree trunk from the diameter of the tip to the top of the tree. Visual crow ration/VCR calculation. The VCR trend value for each measurement is presented in table 3.

Table 3. VCR indicator trend values

Cluster-plot	VCR		
	Status	Change	Trends
1	3,75	2,52	2,99
2	3,04	2,99	2,51
3	3,33	2,7	2,69
4	3,72	3,58	3,58

The trend value of the mangrove forest VCR indicator decreased in each cluster; in cluster 1, there was an average decrease of 0.75, while in cluster 2, there was a decrease with an average of 0.52, cluster 3 experienced an average decrease of 0.63, and cluster 4 experienced an average decrease of 0.13. The decrease in the value of the VCR indicator is caused by strong winds (Farhaby et al., 2020). The density factor also limits the growing space so that the growth of branches and leaves is hampered, which is caused by slow tree metabolism and photosynthesis processes (Nurfaizi and Safe'i, 2023).

4. Trend indicator of tread quality conditions

Soil pH conditions affect tree growth. Tree vegetation in mangrove forests will grow optimally if the pH is in a neutral range of 6.6 to 7.7. With neutral soil pH conditions, mangrove vegetation finds it easier to absorb nutrients (Setiawan, 2013). The details of the soil pH for each measurement are presented in table 4.

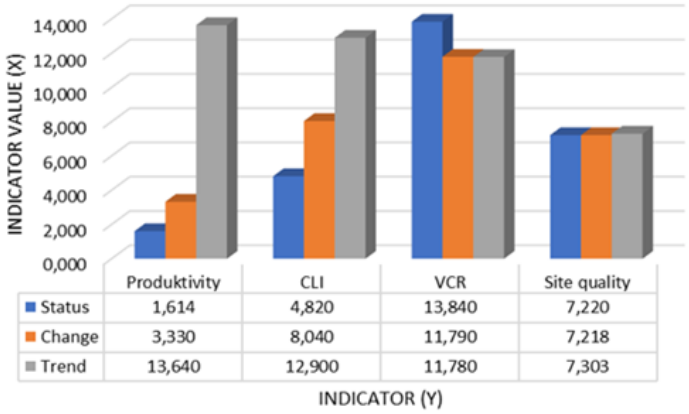
Table 4. Trend of soil pH condition indicators

Cluster-Plot	*Tread quality*		
	Status	Change	Trends
1	7,1	7,1	7,26
2	7,2	7,24	7,36
3	7,32	7,27	7,33
4	7,26	7,26	7,26

In Table 4, it is explained that the soil pH trend condition is at number 7 with alkaline conditions. Clusters 1 and 2 showed an average increase in pH of 0.16; for cluster 3, there was an average increase of 0.01, while cluster 1 did not experience an increase or decrease in value. Soil pH conditions in the range of 6-7 are a suitable pH for mangrove growth. High pH is influenced by low soil sulfur content, which is caused by the weathering of organic material in mangrove vegetation. Meanwhile, the low soil pH in mangrove areas is caused by the breakdown of vegetation litter by microorganisms, resulting in increased organic acids and decreased soil pH (Farhaby, 2019).

5. Trend values of margasari mangrove forest health indicators

The final value of forest health indicators is obtained based on data analysis for each indicator. Next, data analysis was carried out regarding the comparison of measurement values for status indicators, changes, and trends. The measurement results and data are presented in figure 3.



	Produktivity	CLI	VCR	Site quality
Status	1,614	4,820	13,840	7,220
Change	3,330	8,040	11,790	7,218
Trend	13,640	12,900	11,780	7,303

Figure 3. Trend values of forest health indicators

In figure 3, the health indicator values of the margasari mangrove forest are shown. In the assessment, productivity indicators experienced a continuous increase of 1,716 m3/ha S-C and 10.31 m3/ha C-T. This shows that mangrove forests are experiencing an indicator trend that continues to increase (improving) as time goes by. The CLI trend in the margasari mangrove forest experienced an increase of 3.22 S-C and 4.86 C-T. The higher the CLI value, the greater the value of tree damage, which continues to decrease. The VCR indicator continues to decline from year to year: 2.05 S-C and 0.01 C-T. Measurements of soil pH indicators showed a decrease in S-C measurements of 0.002 and an increase in C-T measurements of 0.085. The high and low values of forest health indicators are influenced by the values of ecological indicators in the mangrove forest location. A comparison of measurements is carried out to determine the health condition of the forest from year to year in order to make the right decisions so that the mangrove forest is sustainable. The condition of the margasari mangrove forest health indicators is caused by the interaction of the surrounding community and natural conditions that are naturally threatening. Community interactions with forests can have a significant impact on forest sustainability. Both in the form of management, protection, and sustainable use (Gumilar, 2018). Thus, it is necessary to preserve and protect mangrove forests from various disturbances that threaten the existence of healthy forests so that the forests are sustainable for a prosperous community.

V. CONCLUSION

The health indicators of the margasari mangrove forest in east lampung regency experience fluctuations in quality from year to year. The productivity/tree growth and tree vitality/damage indicators have increased with each measurement from status condition to trend, so it can be said that productivity conditions continue to rise, while the VCR indicator has decreased in value with each measurement, so the trend is down and soil pH has decreased in measuring changes and experiencing increases in trend measurements. The fluctuations and condition of each indicator are influenced by changes in the condition of ecological indicators that affect the silvicultural system of mangrove forests, human activities, and natural conditions that significantly threaten the sustainability of mangrove forests.

REFERENCES

Abda, M. K. (2019). Mitigasi bencana terhadap abrasi pantai di kuala leuge kecamatan aceh timur. *Jurnal Samudra Geografi*, *02*(01), 1–4.

Alnursa, D. S. (2022). Manfaat hutan mangrove dalam kehidupan masyarakat di kelurahan guraping kecamatan oba kabupaten tidore kepulauan. *Jurnal Ilmiah Wahana Pendidikan*, *8*(21), 698–706.

Ardiansyah, F., & Safe'i, R. (2021). Analysis of changes in health of coastal mangrove forest on the East Coast of lampung. *IOP Conference Series: Earth and Environmental Science*, *755*(1). https://doi.org/10.1088/1755-1315/755/1/012028.

Ecke, S., Dempewolf, J., Frey, J., Schwaller, A., Endres, E., Klemmt, H. J., Tiede, D., & Seifert, T. (2022). UAV-based forest health monitoring: a systematic review. *Remote Sensing*, *14*(13), 1–45. https://doi.org/10.3390/rs14133205.

Farhaby, A. M. (2019). Kajian awal kondisi hutan mangrove di desa kurau timur kabupaten bangka tengah propinsi kepulauan bangka belitung. *Jurnal Biosains*, *5*(3), 99. https://doi.org/10.24114/jbio.v5i3.14074.

Farhaby, M, A., Safitri, Y., & Wilanda, M. (2020). Kajian awal kondisi kesehatan hutan mangrove di desa mapur kabupaten bangka. *Samakia : Jurnal Ilmu Perikanan*, *11*(2), 108–117.

https://doi.org/10.35316/jsapi.v11i2.789.

Gumilar, I. (2018). Participation of coastal peoples in the preservation of mangrove forest ecosystems (Case Study in Indramayu Regency of West Java). *Jurnal Ilmu-Ilmu Sosial Dan Humaniora*, *20*(2), 145–153.

Indriani, Y., Safe'i, R., Kaskoyo, H., & Darmawan, A. (2020). Vitalitas sebagai salah satu indikator kesehatan hutan konservasi. *Jurnal Perennial*, *16*(02), 40–46.

Nabila, A. P., Febryano, I. G., Safe'i, R., & Hilmanto, R. (2022). Komposisi vegetasi mangrove di pulau pahawang, provinsi lampung. *Journal of Tropical Marine Science*, *5*(2), 104–110. https://doi.org/10.33019/jour.trop.mar.sci.v5i2.3272.

Nurcahyani, A., Safe'i, R., Bintoro, A., & Kaskoyo, H. (2022). Study of vitality change in teak community forest management (case study on teak community forest in natar sub-district, south lampung regency, lampung province). *IOP Conference Series: Earth and Environmental Science*, *1115*(1). https://doi.org/10.1088/1755-1315/1115/1/012054

Nurfaizi, M, R. S. (2023). The influence of community participation on health trends in the mangrove forest of labuhan maringgai district , east lampung. *IOP Conference Series: Earth and Environmental Science*, *10* (1755–1315). https://doi.org/10.1088/1755-1315/1277/1/012022.

Pangestu, A. Y., Safe'i, R., Darmawan, A., Kaskoyo, H., & Andrian, R. (2022). Black-box testing on web-gis of forest health monitoring using equivalence partitioning techniques. *AIP Conference Proceedings*, *2563*(October). https://doi.org/10.1063/5.0104748.

Pratama, M., Safe'i, R., Kaskoyo, H., & Febryano, I. G. (2022). Forestry value for health status: an ecological review. *IOP Conference Series: Earth and Environmental Science*, *995*(1). https://doi.org/10.1088/1755-1315/995/1/012002.

Rohman, N., Safe'i, R., Yuwono, S. B., Winanrno, G. D., Harianto, S. P., & Setiawan, A. (2023). Penilaian kesehatan tahura banten pada blok koleksi tumbuhan dan atau satwa. *Jurnal Belantara*, *6*(1), 31–40. https://doi.org/10.29303/jbl.v6i1.890.

Safe'i R, Maulana I, Ardiansyah F, Banuwa I,S., Harianto, S, P., Yuwono, Y. A. (2022). Analysis of damage to trees in the coastal mangrove forest of east lampung regency. *International Journal of Sustainable Development and Planning*, *17*(1743-761X), 308–312.

Safe'i, R. (2020). Nilai status dan perubahan kesehatan hutan mangrove (Studi kasus hutan mangrove di desa margasari, kecamatan labuhan maringgai, kabupaten lampung timur). *Perennial*, *16*(2), 73–79.

Safe'i, R., Febryano, I. G., & Aminah, L. N. (2018). Effect of the existence gapoktan to farmer income and land cover change in community forest. *Sosiohumaniora - Jurnal Ilmu-Ilmu Sosial Dan Humaniora*, *20*(2), 109–114.

Safe'i, R., Indriani, Y., Darmawan, A., & Kaskoyo, H. (2019). Status pemantauan kesehatan hutan yang dikelola oleh kelompok tani hutan SHK Lestari : studi kasus Kelompok Tani Hutan Karya Makmur I Desa Cilimus , Kecamatan Teluk Pandan , Kabupaten Pesawaran , Provinsi Lampung. *Jurnal Silva Tropika*, *3*(2), 185–198.

Safe'i, R., Kaskoyo, H., & Ardiansyah, F. (2022). The trend in types of tree damage in mangrove forest management areas, east lampung regency. *Indonesian Journal of Social and Environmental Issues (IJSEI)*, *3*(3), 223–232. https://doi.org/10.47540/ijsei.v3i3.672.

Safe'I, R., Latumahina, F. S., Dewi, B. S., & Ardiansyah, F. (2021). Short communication: assessing the state and change of forest health of the proposed arboretum in wan abdul rachman grand forest park, Lampung, Indonesia. *Biodiversitas*, *22*(4), 2072–2077. https://doi.org/10.13057/biodiv/d220456.

Safe'i, R., Rezinda, C. F. G., Banuwa, I. S., Harianto, S. P., Yuwono, S. B., Rohman, N. A., & Indriani, Y. (2022). Factors affecting community-managed forest health. *Environment and Ecology Research*, *10*(4), 467–474. https://doi.org/10.13189/eer.2022.100405.

Safe'i, R., & Upe, A. (2022). Mapping of tree health categories in community forests in lampung province. *IOP Conference Series: Earth and Environmental Science*, *995*(1). https://doi.org/10.1088/1755-1315/995/1/012004.

Siddiq, S, A. (2023). Peran pemerintah dan perilaku masyarakat dalam menjaga ekosistem hutan mangrove di Kabupaten Langkat. *SUPLEMEN*, *15*. https://bnr.bg/post/101787017/bsp-za-balgaria-e-pod-nomer-1-v-buletinata-za-vota-gerb-s-nomer-2-pp-db-s-nomer-12.

Tanjung, C, Yulianda, F, K. (2023). Penilaian kesehatan mangrove di desa jago jago, kabupaten tapanuli tengah, sumatera utara mangrovet. *Jurnal Teknologi Perikanan Dan Kelautan*, *14*(2), 157–167.