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ANALYSIS OF MANGROVE COVER AND DENSITY CHANGES BASED ON NDVI IN THE COASTAL AREA OF SOUTH LAMPUNG REGENCY, 2020–2023

Analisis Perubahan Tutupan Dan Kerapatan Mangrove Berbasis NDVI di Pesisir Kabupaten Lampung Selatan Tahun 2020–2023

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ABSTRACT

Mangrove ecosystems are an essential component of coastal areas, providing ecological, physical, and socio-economic functions. Mangroves play a crucial role in protecting coastlines from abrasion, reducing wave energy, and providing habitats for various aquatic organisms. Changes in mangrove cover over time reflect environmental pressures as well as the effectiveness of management and rehabilitation efforts in a particular region. This study aims to analyze changes in mangrove cover in the coastal area of South Lampung Regency during the period 2020–2023 using a spatial and multitemporal approach based on satellite imagery. The data used consist of Landsat 8 OLI/TIRS imagery from 2020 to 2023, which were analyzed using the Normalized Difference Vegetation Index (NDVI). The analysis was conducted to identify the distribution, extent, and dynamics of changes in mangrove cover and density spatially and temporally. The results indicate that mangrove cover in the coastal area of South Lampung Regency showed an increasing trend during the observation period, although pressures from coastal activities were still identified in several locations. Variations in NDVI values reflect differences in mangrove density ranging from low to high, indicating diverse mangrove vegetation conditions. The information generated from this study is expected to support sustainable mangrove management and conservation planning in the coastal area of South Lampung Regency.

Keywords: mangrove, land cover change, NDVI, remote sensing, South Lampung

ABSTRAK

Ekosistem mangrove merupakan salah satu komponen penting dalam wilayah pesisir yang memiliki fungsi ekologis, fisik, dan sosial ekonomi. Keberadaan mangrove berperan dalam melindungi garis pantai dari abrasi, meredam energi gelombang, menahan sedimen, serta menyediakan habitat bagi berbagai biota perairan. Perubahan tutupan mangrove yang terjadi

dari waktu ke waktu dapat mencerminkan adanya tekanan lingkungan maupun keberhasilan upaya pengelolaan dan rehabilitasi yang dilakukan di suatu wilayah. Penelitian ini bertujuan untuk menganalisis perubahan tutupan mangrove di wilayah pesisir Kabupaten Lampung Selatan pada periode 2020–2023 menggunakan pendekatan spasial dan multitemporal berbasis citra satelit. Data yang digunakan berupa citra Landsat 8 OLI/TIRS tahun 2020–2023 yang dianalisis menggunakan indeks vegetasi Normalized Difference Vegetation Index (NDVI). Analisis dilakukan untuk mengetahui sebaran, luas, serta dinamika perubahan tutupan dan kerapatan mangrove secara spasial dan temporal. Hasil penelitian menunjukkan bahwa tutupan mangrove di pesisir Kabupaten Lampung Selatan mengalami kecenderungan peningkatan selama periode pengamatan, meskipun pada beberapa lokasi masih ditemukan tekanan akibat aktivitas pesisir. Variasi nilai NDVI menunjukkan perbedaan tingkat kerapatan mangrove dari rendah hingga tinggi yang menggambarkan kondisi vegetasi mangrove yang beragam. Informasi yang dihasilkan dari penelitian ini diharapkan dapat menjadi dasar dalam mendukung perencanaan pengelolaan dan konservasi mangrove secara berkelanjutan di wilayah pesisir Kabupaten Lampung Selatan.
Kata Kunci : mangrove, perubahan tutupan, NDVI, penginderaan jauh, Lampung Selatan

INTRODUCTION

The mangrove ecosystem is a coastal ecosystem that plays a strategic role in maintaining the balance of the coastal environment. Mangroves serve as natural coastal protection from abrasion and ocean waves, retain sediment, and maintain coastal water quality. Furthermore, mangroves provide habitat, spawning grounds, and nursery areas for various aquatic organisms, making their presence crucial for maintaining coastal ecosystem productivity (Rahardian *et al*., 2019).

In recent decades, Indonesia's mangrove ecosystems have been under significant pressure due to human activity. The conversion of coastal land into residential areas, fish ponds, and coastal infrastructure development has led to a decline in the area and quality of mangroves in various regions. This pressure has triggered changes in mangrove cover, both in the form of area reduction due to degradation and area increase as a result of gradual rehabilitation and conservation activities. Mangrove rehabilitation and conservation efforts are crucial to ensure the sustainability of mangrove ecosystems and their continued benefit to coastal communities (Handriani *et al*., 2025).

Changes in mangrove cover are an important indicator for assessing the condition and sustainability of coastal ecosystems (Rahadian et al., 2019). Information on changes in mangrove cover is essential for coastal area management planning, evaluating the effectiveness of rehabilitation programs, and determining spatially data-based conservation policies. Monitoring mangrove changes is essential to assess growth and identify areas requiring improvement (Abd-El Monsef & Smith, 2017).

South Lampung Regency is one of the coastal areas in Lampung Province with a diverse distribution of mangrove ecosystems. This region has a fairly long coastline and encompasses several coastal districts with relatively extensive mangrove potential. In recent years, various mangrove rehabilitation activities have been carried out by the local government and community, potentially influencing the spatial and temporal dynamics of mangrove cover change (Damsir *et al*., 2023; Herison *et al*., 2018).

Monitoring changes in mangrove cover can be effectively conducted by utilizing remote sensing technology and geographic information systems. This approach allows for the analysis of large areas with greater time and cost efficiency than conventional field surveys. Land-use changes can be implemented both spatially and temporally. The use of remote sensing has proven to be an effective method for collecting accurate data on land-use change through

rapid and inexpensive modeling (Rasyidah *et al*., 2025). One vegetation index widely used in mangrove studies is the Normalized Difference Vegetation Index (NDVI), which describes the condition and density of vegetation based on spectral reflectance characteristics (Jumsar *et al.*, 2023; Setiawan *et al*., 2018).

Based on this background, this study aims to analyze changes in mangrove cover in the coastal area of South Lampung Regency during the 2020–2023 period using a multitemporal spatial approach based on satellite imagery. The results are expected to provide scientific contributions in providing spatial information on mangroves and serve as a basis for consideration in planning sustainable mangrove management and conservation.

RESEARCH METHODS

Time and Place of Research

This research was conducted in 2025, with the study location in the coastal area of South Lampung Regency, Lampung Province. The research area encompasses several coastal sub-districts with mangrove ecosystems with varying environmental conditions and levels of utilization. The selection of the research location was based on the relatively extensive presence of mangroves and the presence of coastal activities that have the potential to influence changes in mangrove cover. Changes in mangrove cover are dominated by anthropogenic pressures, not solely natural processes. These pressures arise through the interaction of mutually reinforcing physical, economic, social, cultural, and institutional factors (Tuturop *et al*., 2025).

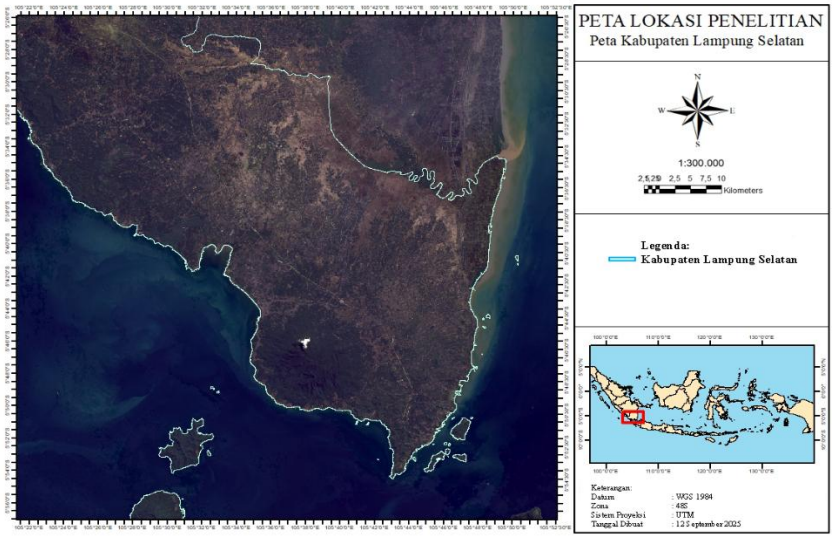

Figure 1. Map of research locations on the coast of South Lampung Regency.

Data and Data Sources

Data The data used in this study is secondary data in the form of Landsat 8 OLI/TIRS satellite imagery from 2020, 2021, 2022, and 2023, obtained from the official USGS Earth Explorer source. Other supporting data includes administrative base maps obtained from Ina-Geoportal as georeferencing and regional classification, as well as other supporting data relevant to the analysis of mangrove cover change. Landsat is one of the satellites used to detect changes in land cover area, including mangroves, and shoreline changes. Although Landsat imagery is categorized as medium-resolution remote sensing data (Hendrawan *et al*., 2018), Landsat imagery was used because it offers a relatively comprehensive time series spanning 10 years. Furthermore, Landsat imagery has a higher sensitivity to the correlation between NDVI values and vegetation density in the field compared to Sentinel imagery (Rafsenja *et al*., 2020).

Remote sensing can provide information on the characteristics of objects in an area due to its ability to detect objects both spatially and temporally. Remote sensing techniques are used to map mangrove areas, species distribution and mangrove density (Parera *et al*., 2024).

Mangrove Cover Change Analysis

Analysis of changes in mangrove cover was carried out using a remote sensing approach and geographic information systems through the calculation of the Normalized Difference Vegetation Index (NDVI). According to (Rasyidah *et al*., 2025), the vegetation index is a spectral transformation of two or more bands designed to increase the contribution of vegetation resulting from photosynthetic activity and variations in canopy structure. The Normalized Difference Vegetation Index (NDVI) vegetation index is widely used to calculate forest health by combining two bands, namely Red and Near Infrared (NIR). Healthy vegetation is characterized by a high NDVI value and vice versa. The results of the NDVI will produce a value ranging from -1 to +1. If the value obtained is negative, the object obtained by the sensor is most likely water, if it is close to +1, it is the reflectance value of the vegetation. NDVI is calculated based on the difference in reflectance of the red (Red) and near infrared (Near Infrared/NIR) spectrum which represents the level of greenness and density of vegetation. In this study, NDVI calculations used Landsat 8 imagery with band 5 as the NIR channel and band 4 as the Red channel. The resulting NDVI values were then classified into low, medium, and high mangrove density classes to describe the condition and changes in mangrove cover spatially and temporally (Marlina, 2022; Setiawan *et al*., 2018). The NDVI calculation formula is presented in Table 1.

Table 1. Algorithms used

Algorithm	Equation	Index Value Range
NDVI (Normalized Difference Vegetation Index)	$NDVI = \frac{NIR + RED}{NIR - RED}$	0.00 – 1.00

Data Analysis

Data analysis was conducted quantitatively and descriptively by comparing the results of mangrove cover classifications for each observation year. Changes in mangrove area and density were analyzed temporally to identify trends occurring during the study period. The results are presented in tables and thematic maps to facilitate interpretation and discussion.

RESULTS

Changes in Mangrove Coverage

The results of the spatial analysis indicate changes in mangrove cover in the coastal areas of South Lampung Regency during the 2020–2023 observation period. In general, mangrove cover has tended to increase year after year. The largest increase occurred in Ketapang District, increasing from 322.7 ha in 2020 to 387.6 ha in 2023. This change in cover occurred in almost all coastal districts included in the study, although the magnitude of the increase varied between regions.

Changes in mangrove cover during the observation period are presented in detail in Table 2, which shows the mangrove cover per year.

Table 2. Mangrove Area in South Lampung Regency 2020-2023

No	Kecamatan	Area (Ha/Year)			
		2020	2021	2022	2023
1	Katibung	3,5	3,5	3,7	3,2
2	Kalianda	37,8	35,1	43	41,4

3	Rajabasa	1,5	1,4	1,5	1,3
4	Bakauheni	83,9	87,8	93	95,8
5	Sragi	26	21,8	26,6	22,2
6	Ketapang	322,7	348,2	361,1	387,6
	Total Area	475,5	497,8	529,1	551,9

Source: Landsat 8 Satellite Image Processing

Spatial Distribution of Mangrove Cover

The spatial distribution of mangrove cover in the coastal areas of South Lampung Regency shows a distribution pattern that follows the coastline and river estuaries. Mangroves are distributed across several coastal segments with varying concentrations. A map of mangrove distribution for each observation year is shown in Figure 2, which shows changes in mangrove distribution spatially from year to year.

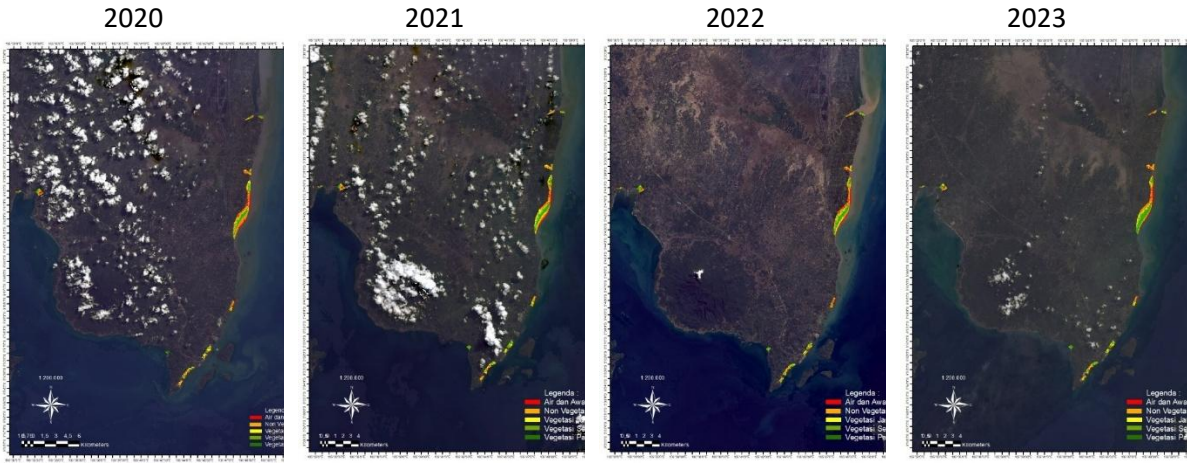

Figure 2. South Lampung Mangroves 2020-2023

Mangrove Density Classification Based on NDVI

The NDVI calculation results indicate that the mangrove vegetation index value in the study area ranges from -1 to +1. These NDVI values were then classified into three mangrove density classes: low, medium, and high. The classification results indicate that the majority of the mangrove area falls within the medium to high density class, while the low density class is found in certain areas with relatively smaller areas.

The distribution of mangrove density classes based on NDVI values for each observation year is shown in Table 3.

Table 3. Mangrove Density Classification

Mangrove Area Classification	Area (Ha/Year)			
	2020	2021	2022	2023
High	176,55	190,07	208,97	220,99
Medium	163,13	167,72	175,12	180,58
Low	135,87	140,11	145,78	150,35
Total	475,6	497,9	529,9	551,9

Temporal Changes in Mangrove Density

Temporal analysis showed changes in the area of each mangrove density class during the 2020–2023 period. The area of mangroves with medium and high densities tended to

increase, while low densities showed relatively small fluctuations. Changes in the area of each mangrove density class from year to year are presented in Figure 3.

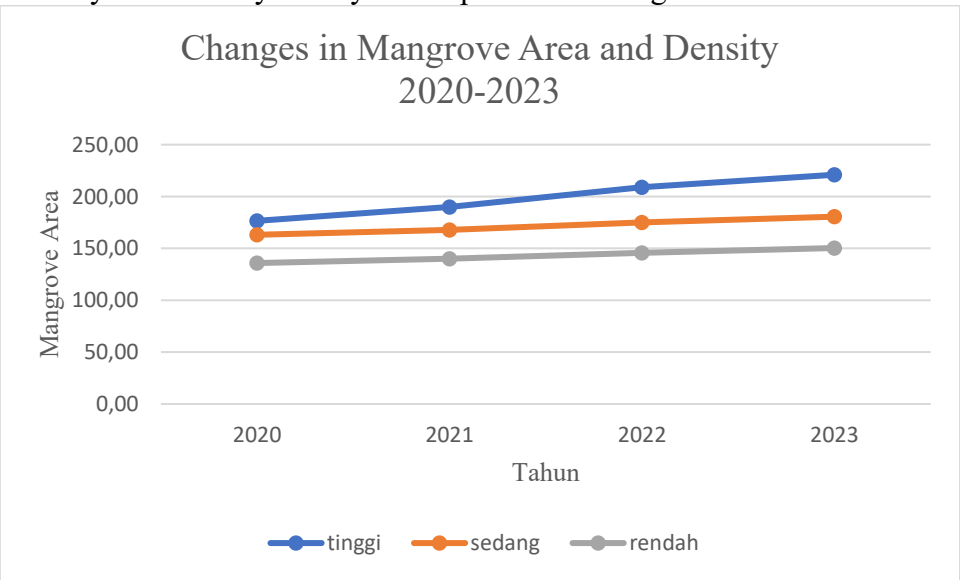

Figure 3. Changes in Mangrove Area and Density in 2020-2023

DISCUSSION

Dynamics of Changes in Mangrove Coverage Area

Perubahan Changes in mangrove cover in the coastal areas of South Lampung Regency during the 2020–2023 period indicate the dynamics of coastal ecosystems influenced by various factors. The increasing trend in mangrove area identified in this study indicates an ecosystem recovery process, both through natural regeneration and through mangrove rehabilitation activities that have been carried out in several coastal areas. Mangroves provide ecosystem services for commercial and subsistence fisheries. Despite their numerous functions and benefits, mangrove ecosystems are highly vulnerable to disturbances, both natural and due to human activities, which can lead to declines in their development (Parera *et al*., 2024). These results align with previous research that suggests that sustainable mangrove rehabilitation programs can have a positive impact on increasing mangrove area in the medium to long term (Herison *et al*., 2018). Furthermore, increasing awareness among coastal communities about the importance of mangrove functions also plays a role in reducing the rate of mangrove degradation due to land conversion. Mangrove ecosystem damage is caused by the clearing of areas for shrimp ponds, with this damage reaching 48%. Mangrove ecosystems on small islands often face various challenges. One of the consequences is human activities that damage mangrove ecosystems, as well as natural factors such as global warming and natural disasters. The reduction in area and the decline in water quality within mangrove ecosystems pose a serious threat to areas whose populations are highly dependent on their resources (Sulastri *et al*., 2023).

However, the differences in the magnitude of changes in mangrove area between regions indicate that mangrove dynamics are not occurring uniformly. The physical condition of the area, the pressure of human activity, and the intensity of coastal area management and monitoring are important factors influencing the success of mangrove restoration. The existence of mangrove forests must be continuously maintained through well-conceived planning and the implementation of sustainable management so that they can provide benefits

to the community for future generations. Rehabilitation of mangrove areas with relevant parties is crucial, given the multi-functional functions of mangrove forest ecosystems, and the current threats they face, making rehabilitation imperative (Fatimah *et al*., 2022).

Spatial Distribution Patterns of Mangroves in Coastal Areas

Distribusi The spatial distribution of mangroves, which tends to follow coastlines and river estuaries, reflects their ecological characteristics as vegetation that thrives optimally in tidal areas with an adequate supply of sediment and nutrients. This distribution pattern aligns with the findings of several studies that indicate that river estuaries are strategic locations for mangrove growth due to their relatively stable environmental conditions (Rahardian *et al*., 2019).

The expansion of mangrove areas in several coastal segments indicates improvements in coastal environmental conditions, particularly in locations previously experiencing degradation pressure. However, in several other locations, mangrove distribution remains limited, indicating ecological and anthropogenic barriers to mangrove regeneration. Human (anthropogenic) activities contribute significantly to the destruction of mangrove forests in Indonesia. Conversion of mangrove forests for fisheries, plantations, agriculture, salt ponds, settlements, industry, agriculture, logging (legal logging and illegal logging) and mining are the main anthropogenic activities causing degradation and loss of mangrove forests in Indonesia. More than 50% of mangrove forests are degraded or lost due to several factors, such as conversion of mangrove forests for fisheries, urbanization, pollution by oil and industrial waste and lack of public awareness (Eddy *et al*., 2017).

Mangrove Density Based on NDVI Analysis

The results of the mangrove density classification based on NDVI values indicate that most mangrove areas are in the medium to high density class. This condition indicates that the mangroves in the study area generally still have a fairly good level of vegetation health. NDVI, as a vegetation index, can describe the greenness and density of mangrove canopies through the vegetation's spectral response to red and near-infrared light (Marlina, 2022; Setiawan *et al*., 2018).

The presence of low density classes in a given area can reflect the condition of young mangroves, rehabilitation areas, or areas experiencing environmental stress such as abrasion and human disturbance. Therefore, low density classes do not necessarily indicate degradation but can also represent the early phase of mangrove growth. In the first year, mangrove seedlings typically focus more on establishing a root system for stability than producing significant leaves. Mangrove leaves play a crucial role in photosynthesis, which supports stem and root growth. Although the number of leaves is not yet significant, this can increase as ecosystem conditions improve (Irwanto *et al*., 2024).

Temporal Changes in Mangrove Density

Temporal changes in mangrove density indicate an increasing trend in the area of medium- and high-density mangroves during the study period. This condition indicates an improvement in the quality of mangrove cover, reflected not only in area but also in vegetation structure and density. Factors influencing the cover value are the distribution of mangrove species and the total number of mangrove tree trunk circumferences. The higher the number of mangrove tree trunk circumferences, the higher the cover value (Parmadi *et al*., 2016).

Increased mangrove density can be linked to the success of the rehabilitation and natural recovery process of the mangrove ecosystem, as well as reduced pressure from human activities in several coastal areas. This finding aligns with other studies that suggest that sustainably managed mangroves tend to show increased density and ecosystem stability. Sustainable mangrove ecosystem management is a highly complex endeavor because it requires an

accommodating nature and a synergistic collaborative mechanism between various stakeholders, representing their respective institutions, to ensure the successful implementation of each sustainable mangrove management plan (Muhsimin *et al.*, 2018).

Selain In addition to rehabilitation factors, changes in mangrove density are also influenced by coastal environmental conditions and coastal area use patterns that occurred during the observation period. Anthropogenic activities such as land conversion, coastal development, and pressure from fishing and settlement activities can influence the dynamics of mangrove density spatially and temporally. Therefore, the increase in mangrove density identified in several locations may reflect more controlled coastal management and reduced pressure on the mangrove ecosystem. One effort that can be taken to address mangrove land conversion is rehabilitation. Mangrove rehabilitation is an effort to restore damaged mangrove ecosystems and maintain ecosystem balance. Rehabilitation activities include attention to sediment stability, conservation, production management, and coastal protection. Steps that can be taken to manage mangrove vegetation include attention to mangrove growth, sediment characteristics, and water quality parameters (Solihat *et al*., 2022).

From a management perspective, information on changes in mangrove density based on NDVI plays a crucial role as a basis for evaluating mangrove ecosystem conditions and planning sustainable coastal management. A multitemporal spatial approach allows for periodic monitoring of changes in the mangrove ecosystem, thus allowing it to be used to assess the effectiveness of rehabilitation programs and as a consideration in determining mangrove conservation policies in the coastal areas of South Lampung Regency. The use of remote sensing provides an alternative and makes it easier for humans to determine the condition of mangroves in a time series manner (Febrianto *et al*., 2022). Information on the density of the mangrove ecosystem is very important to know as one of the considerations in managing coastal areas to comply with their designation as stated in the Regional Spatial Plan (RTRW) (Safitri *et al*., 2023).

CONCLUSION

This study shows that mangrove cover along the coast of South Lampung Regency experienced dynamics during the 2020–2023 period, with a tendency to increase in area. Mangrove distribution follows the coastline and river estuaries, with variations in density influenced by environmental conditions and human activities. NDVI-based analysis indicates a dominance of medium to high density classes, although areas with low density remain. Remote sensing and geographic information system approaches have proven effective in monitoring changes in mangrove cover spatially and temporally, and can serve as a basis for supporting sustainable mangrove management and conservation planning in coastal areas.

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