WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Analysis of Mangrove Distribution and Density using Sentinel-2A Satellite Imagery in Litianak Mangrove Ecotourism, Rote Ndao Regency, East Nusa Tenggara Province

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DOI : https://doi.org/10.55248/gengpi.5.1224.3510

ABSTRACT

Mangrove ecosystems can minimise the impact of climate change by absorbing carbon dioxide (CO2). Mangrove ecosystems are one of the potential resources in Rote Ndao Regency found in coastal areas. The use of remote sensing techniques for mapping mangrove distribution and density is very effective. The purpose of this study is to determine the distribution and density of mangroves in 2017 and 2023 using Sentinel-2A satellite imagery. The method used is maximum likehood with supervised classification and NDVI. The results showed that the mangrove area has increased or increased the area where the mangrove area in 2017 and 2023 amounted to 250.92 ha; 266.74 ha. NDVI analysis shows that in 2017 the NDVI class rarely has an area of 39.93 ha. Moderate NDVI class has an area of 73.71 ha and dense NDVI class has an area of 137.27 ha. While in 2023 the sparse NDVI class has an area of 31.10 ha around. The moderate NDVI class has an area of 25.49 ha and the dense NDVI class has an area of 210.15 ha.

Keywords: Distribution, Density, Mangroves, Sentinel-2A.

Introduction

Mangrove forests are the only woody halophytic forests that live along tropical and subtropical coasts (Alongi, 2012). Mangroves have very important functions and benefits in supporting the life of coastal areas (Febryano et al. 2015). Mangroves play an important role in the process of carbon sequestration and storage related to climate change and global warming. Mangrove ecosystems have a much higher ability to bind carbon compared to terrestrial forests and tropical forests (Wandarni et al. 2018; Donato et al. 2011).

According to Wahyudi et al. (2018) the carbon stock of mangroves in Indonesia reached 891, 70 tonnesC/Ha. Mangrove forests can assimilate atmospheric CO2 into organic compounds to produce new leaves, roots branches and stem tissue, maintain existing tissue, create storage reserves and develop chemical defences (Alongi, 2018). Mangrove forests can store approximately 800 to 1200 C/ha of carbon or 4 to 5 times that of terrestrial forests and can reduce 10% to 31% of estimated annual emissions in Indonesia (Rahman et al. 2020). However, the area of mangrove forests has decreased by 30% to 50% in the last half century due to coastal development, pond expansion, and over exploitation (CIFOR, 2012).

East Nusa Tenggara (NTT) Province has a coastline length of approximately 5,700 km, most of which is covered by mangrove vegetation. The area of mangrove forests in NTT reaches 40,614.11 ha, which is spread across all districts and cities with varying extents (BPHM Region 1 Bali, 2011). Rote Ndao Regency is one of the regencies located in East Nusa Tenggara Province that has potential resources, namely mangrove ecosystems with an area of 1840.67 Ha. Where the largest mangrove area is in Northwest Rote District, which reaches 541.59 Ha (DKP, 2018). Mangrove area and density is one of the factors that affect the ability of mangrove forests to absorb and store carbon. According to Windarni et al. (2018) the ability of mangroves to absorb carbon is influenced by stem diameter, area, and density. Declining mangrove area has a major impact on carbon storage and nutrients for the ecosystem (Perez et al. 2018). Given the important role of mangrove ecosystems, research on the condition of mangroves in this location is important to do. The use of remote sensing methods is very effective and important in monitoring changes in mangrove cover and carbon storage so that changes in the extent of damaged or reduced mangrove forest areas can be identified and carbon storage can be identified based on the appearance of satellite imagery (Nissa, 2017). Through the use of remote sensing that records the earth's surface periodically, the growth and decline of mangrove areas can be monitored in a relatively short time (Winarso, 2019). The purpose of this study was to analyse the distribution of mangroves and their density in Litianak Mangrove Ecotourism, Northwest Rote District, Rote Ndao Regency, East Nusa Tenggara Province using Sentinel-2A satellite imagery.

Research Location

This research was conducted in Mangrove Ecotourism, Northwest Rote District, Rote Ndao Regency, East Nusa Tenggara Province. The research location can be seen in Figure 1.

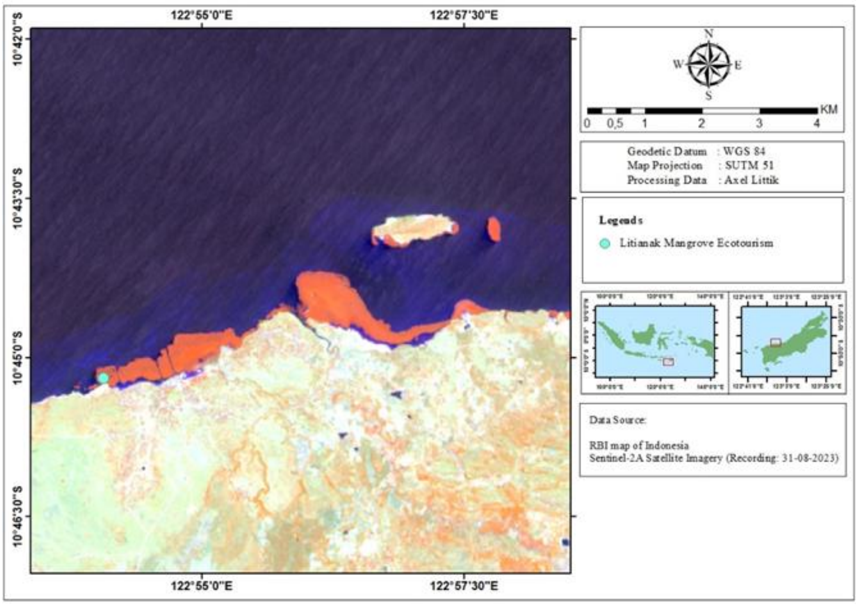

Figure 1. Research Location

Methodology

The method used in this research is descriptive with remote sensing techniques. The software used is ArcMap 10.8 and ENVI 5.3 and the material used is Sentinel-2A Satellite Imagery obtained from the Coppernicus Open Access Hub with recording years 2017 and 2023.

Data Analysis

There are several steps involved in processing image data, namely: band merging, geometric correction, image cropping, and image classification. Sentinel-2A satellite image is one of the high-resolution images and has 13 bands consisting of 4 10 m resolution bands, 6 20 m resolution bands, and 3 60 m resolution bands. The bands used in this study are 8 (NIR), 11 (SWIR) and 4 (Red). This composite produces a false colour display (Dharmawan et al. 2020).

Furthermore, the image obtained has a fairly large area coverage so it is necessary to do cropping, this aims to make image processing easier and more efficient because the coverage area can be controlled. Classification of images by distinguishing mangrove and non mangrove areas is done by the method of maximun likelihood in ENVI 5.3 software. ArcMap 10.8 software analyses the area and density of mangroves. Mangrove area is calculated automatically with geometry calculate.

The next stage is the analysis of mangrove density using the NDVI (Normalised Difference Vegetation Index) vegetation index which has high accuracy. According to Tran et al. (2020) NDVI has an accuracy test of more than 80% and has been used by 82% of researchers in the world to map mangrove density. NDVI values range from -1 to 1, and are used to indicate vegetation density (Hendrawan et al. 2018). Classification of mangrove density levels into 3 classes based on NDVI values consisting of sparse vegetation, moderate vegetation, and dense vegetation can be seen in Table 1. The formula of NDVI is:

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

Where:

NIR: Band Near Infrared (Band 8)

Red: Band red (Band 4)

Table 1. Classification of NDVI values (Forestry Department, 2006)

Vegetation Classification	**Value**
Sparse	-1,0 ≤ NDVI ≤ 0,32
Medium	0,33 ≤ NDVI ≤ 0,42
Dense	0,43 ≤ NDVI ≤ 1,00

Results and Discussion

Based on the results of the analysis of mangrove area on satellite imagery in 2017 and 2023 has changed with an additional area of about 15.82 Ha. Mangrove area in 2017 ranged from 250.92 Ha (Figure 2.) and in 2023 ranged from 266.74 Ha.

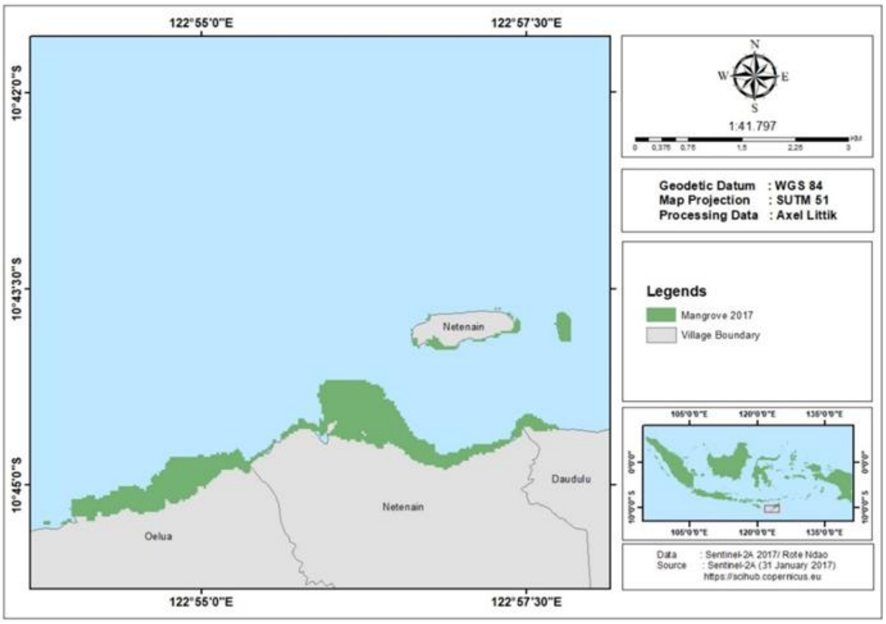

Figure 2. Map of mangrove area in 2017

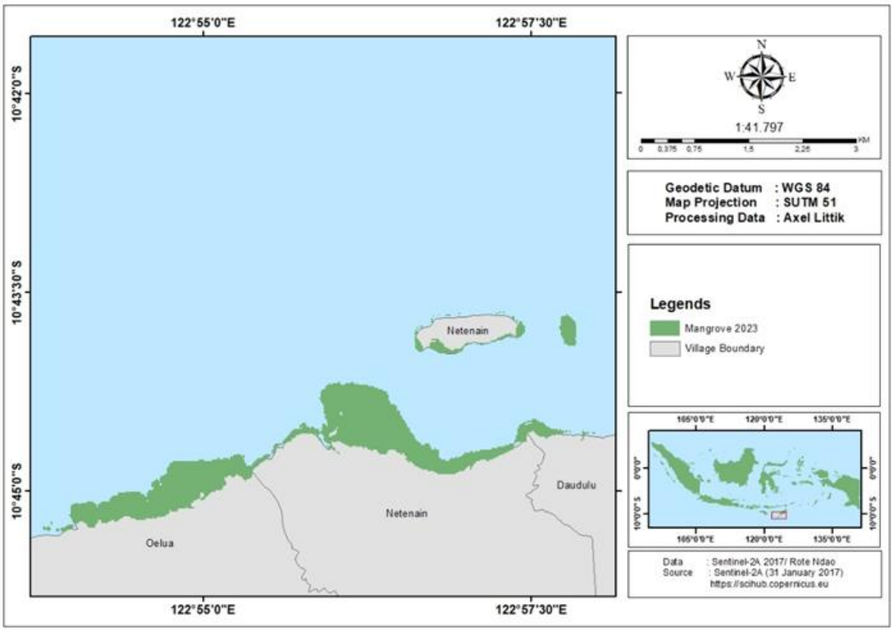

Figure 3. Map of mangrove area in 2023

Based on the results of mangrove density analysis using the NDVI index (Normalized Difference Vegetation Index) in 2017 and 2023 images can be seen in Figures 4 and 5. Mangrove density is divided into three classes: sparse (red), medium (yellow), and dense (green) with vulnerable values of -1 to 1. Pratama and Isdianto, (2017) state that the higher the mangrove density value, the higher the number of mangrove individuals in the pixel.

In 2017 (Figure 4) the mangrove area ranged from 250.92 ha with a sparse NDVI class having an area of 39.93 ha about 15.92%. Medium NDVI class has an area of 73.71 ha about 29.38% and dense NDVI class has an area of 137.27 ha about 54.71%. While the distribution of mangroves in 2023 (Figure 5) has an area of 266.74 ha with NDVI class rarely has an area of 31.10 ha about 12%. Moderate NDVI class has an area of 25.49 ha about 10% and dense NDVI class has an area of 210.15 ha about 79%.

The addition of area and density in this location occurs naturally and artificially. The addition of mangroves is naturally caused by accretion which causes an increase in land which is the habitat of mangrove plants (Eddy et al. 2016). According to Pimple et al. (2020) the addition of mangrove area occurs due to natural mangrove stands that have the potential and role as a source for propagules needed by mangroves. Propagules are mangrove fruits which can grow when they are released from mangrove parents that fall to the forest floor or mangrove substrate (Pribadi et al. 2014). This can cause mangrove area to increase naturally.

Artificially, mangrove areas receive attention from the government and NGOs (Non-Governmental Organisations) who carry out mangrove rehabilitation, planting is carried out every year and in 2019 the mangrove area was designated as ecotourism and in 2021 the Seroja tropical cyclone disaster occurred in the Sawu sea area of East Nusa Tenggara which caused strong winds accompanied by high tides which caused a lot of damage to the coastal area. After the disaster, the surrounding community felt the importance of the mangrove ecosystem and planted mangroves at several points which made the condition of mangroves improve every year.

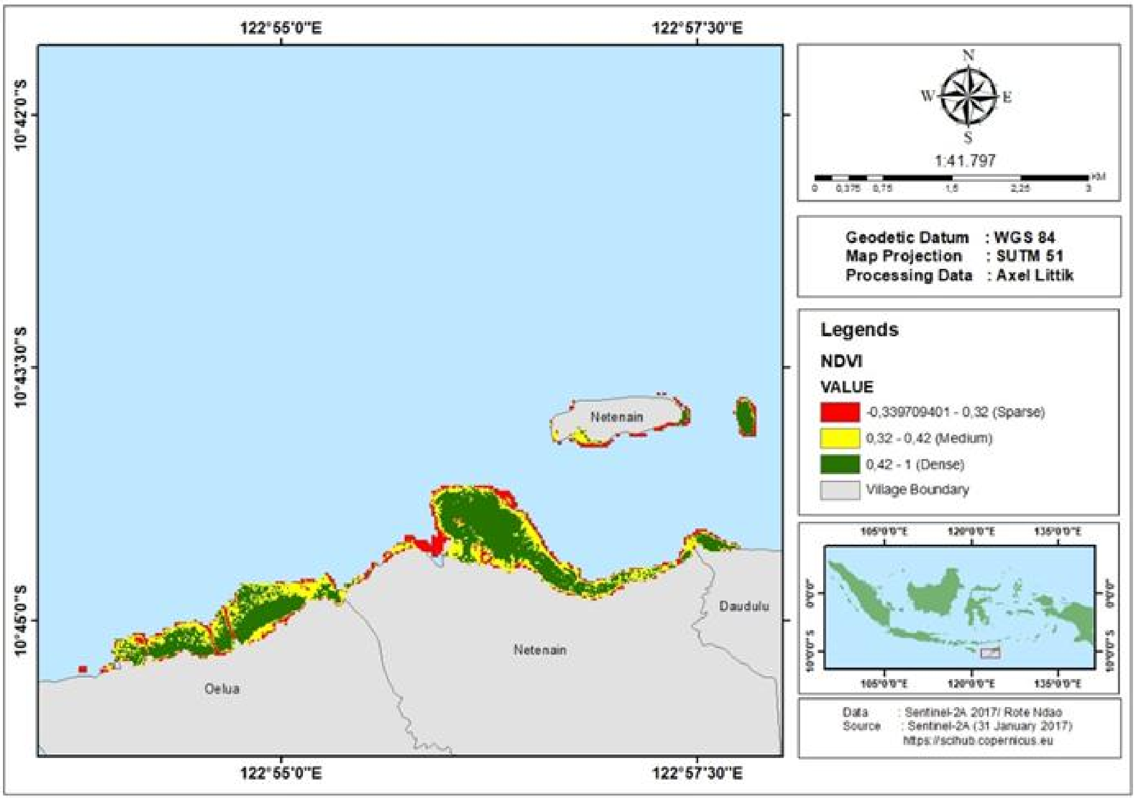

Figure 4. Mangrove density in 2017

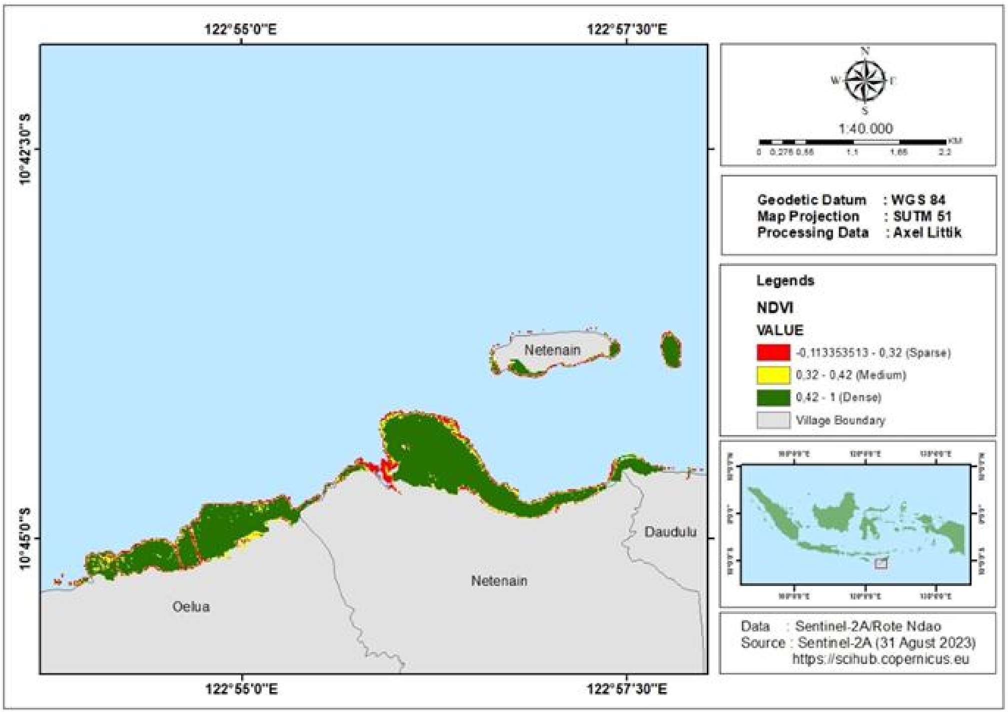

Figure 5. Mangrove density in 2023

Conclusion

Based on the results of research on the distribution of mangrove area and density conducted at Litianak Mangrove Ecotourism, Northwest Rote District, Rote Ndao Regency, East Nusa Tenggara Province, it can be concluded that mangrove area has increased every year by around 15.82 ha where the mangrove area in 2017 was 250.92 ha and in 2023 was 266.74 ha. The results of NDVI analysis, sparse and moderate categories decreased by about 8.84 ha (6.80%) and 48.23 ha (37.11%). While the dense category has increased by about 72.88 ha (56.09%).

Acknowledgements

The authors would like to express their sincere gratitude to the European Space Agency (ESA) for the use of Sentinel-2A satellite data, and to all those who have assisted in this research and the writing of the manuscript.

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