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# Apar Mangrove Density Analysis, Pariaman City, West Sumatra

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**ABSTRACT:** Coastal areas are highly vulnerable to climate change, particularly due to rising sea levels that significantly impact coastal ecosystems, including mangrove forests. Mangroves play a crucial ecological and economic role, yet they are deteriorated by various factors. Indonesia, which boasts the largest mangrove forest in the world, faces a substantial annual decline in mangrove forest areas, including in West Sumatra with a damage rate of 22.67%. In the city of Pariaman, located directly opposite the Indian Ocean, there is a Mangrove Forest Park in Desa Apar that is vital for the local ecosystem. This study aims to measure the density of mangroves in Apar Village using Landsat 8 satellite images and the NDVI (Normalized Difference Vegetation Index) method. The analysis results indicate that out of a total of 10 hectares of mangrove area, 8.88 hectares have a very high density, 0.55 hectares have a high density, and 0.11 hectares have a medium density. This data is crucial for planning mangrove protection policies and rehabilitation strategies and for supporting the development of sustainable ecotourism in the region. The use of technologies such as ArcGIS in NDVI analysis allows for accurate vegetation monitoring, providing a solid foundation for effective mangrove management and conservation.

**KEYWORDS:** Conservation, Density, Mangrove, NDVI, Pariaman

## I. INTRODUCTION

Coastal areas are the most vulnerable in the face of the phenomenon of climate change (Climate Change), which results in rising sea levels (Susanto et al., 2013). Coastal areas have a high level of complexity with various impacts caused by the current climate change phenomenon. The phenomenon of rising sea levels is one of the impacts of climate change that can be felt slowly, increasing the pressure on coastal areas (Rositasari et al., 2011).

Mangrove ecosystems are important for life in coastal areas. The structure of mangroves, with distinctive rooting and physiological properties, allows them to grow along coasts or river estuaries affected by sea tides. As one of the coastal ecosystems, mangrove forests are unique and vulnerable. This ecosystem has ecological and economic functions. Mangrove forests are located between sea and land waters where the ecosystem is influenced by waves, topography, and tides (Annisa Amin Yunita Nur et al., 2019).

Indonesia has the largest mangrove forest in the world, with an area of 4.125 million hectares. In general, mangrove forests are located in Sumatra, Kalimantan, and Papua. However, with the development of time, the area of forests in Indonesia has decreased. The problem of forest destruction, resulting in a decrease in forest area, leads to critical land (Ramayanti et al., 2015). According to records from the Ministry of Forestry, Indonesia has lost at least about 1.08 million hectares per year until 2009 (Setiawan et al., 2013).

This means that Indonesia is currently experiencing a decline in forest area which, if not addressed seriously, will pose a danger not only to Indonesia but to the world. Coastal and Marine Resources Management (BPSPL) of West Sumatra (2017) estimates the area of mangrove forests to be approximately 477,471.49 hectares, spread over seven provinces in Sumatra: Aceh, North Sumatra, West Sumatra, Riau, Jambi, South Sumatra, and the Riau Islands. West Sumatra is one of the seven provinces that still has mangrove forests, covering an area of 3,002.689 hectares. Currently, the area of mangrove forests in West Sumatra has a damage rate of 22.67%, or an area of 680.70 hectares with a percentage of damage that spreads (PSSDAL BAKOSURTANAL).

One of the mangrove ecosystems in West Sumatra is in the city of Pariaman. Pariaman city is mostly located on the coastal area with a coastline length of 12 km and an altitude of 2 to 35 meters above sea level, with a small hilly area. Pariaman city has a land area of 73.36 km² and a sea area of 282.56 km². This area is directly opposite the Indian Ocean (Pariaman City Government, 2014). Pariaman city is a division of Padang Pariaman Regency, formed with the enactment of Law No. 12 of 2002. Astronomically, the city of Pariaman is located between 00° 33‘ 00 “ – 00° 40‘ 43“ LS and 100° 04‘ 46“ – 100° 10‘ 55“ BT.

The Apar Village mangrove forest is one of the mangrove areas in Pariaman City. Pariaman city became the first city in West Sumatra to have a mangrove forest tourism park. This tourist park was opened in December 2017, located on Apar Pariaman Beach, north of Pariaman City, 100 meters from the sea and adjacent to the turtle conservation that has existed since 2009. At Apar Beach, mangroves grow on the banks of rivers and swamps, protecting from the waves. Formerly, the swamps around Apar Beach were only overgrown with nipah and almost became deforested swamps.

This study aims to assess the density of mangrove forests in Apar Village, Pariaman city. Knowing the level of mangrove density in this area can be an appropriate step to assess the potential of mangrove forests and prevent continuous deforestation, which could cause the earth to lose 80% of its forests by 2030 (Prasetio & Ripandi, 2019). The benefits of this study are that it can serve as a benchmark to determine the level of mangrove forest density in the mangrove ecotourism area of Apar, Pariaman city.

## II. RESEARCH METHODOLOGY

### *A.* Research Time and Location

This research was conducted in Apar Mangrove Park located in Apar Village, North Pariaman District, Pariaman City. Determination of location as the object of research is done intentionally (purposive). This research was conducted from October to December 2023.

### *B.* The Stage of Data Collection and Analysis

This study aims to measure the density of mangroves using the Normal differentiated vegetation index (NDVI) method. The first stage is preparation and planning, starting with setting specific research objectives, namely looking at the level of mangrove density in the Apar Mangrove Park area, Pariaman City.

This research was conducted in Apar Mangrove Park located in Apar Village, North Pariaman District, Pariaman City. Determination of location as the object of research is done intentionally (purposive). This is because Apar Mangrove Park is one of the mangrove forest areas in Pariaman city that is prone to degradation.

The next stage is the collection of satellite image data. The satellite images used, Landsat 8, were selected based on the spatial and temporal resolution required. Satellite images are downloaded from reliable sources such as the USGS Earth Explorer or the Copernicus Open Access Hub, with the selection of images free of clouds and according to the research period.

NDVI analysis and classification is done by classifying the value of NDVI to determine the density of mangrove, with categories such as: low NDVI (0.2 - 0.5), medium NDVI (0.5 - 0.7), and high NDVI (0.7 - 1.0). Mangrove density map was created based on NDVI value classification using ArcGIS software to visualize mangrove density distribution.

Field surveys were conducted to collect mangrove density data directly. Sampling Plot is used to measure the density and type of mangrove at some random point. The field Data is compared with the results of the NDVI analysis to validate the accuracy of the NDVI measurements, and calibration is performed if necessary to improve the accuracy of the data.

Remote sensing has been widely used to map resources. In this case, monitoring the value of the vegetation index using high spatial resolution images with the required bands is essential for determining the vegetation index calculation algorithm (Philiani et al., 2016). The Vegetation Index is the amount of greenery value of vegetation obtained from processing digital signal value data on the brightness of some satellite sensor bands. Vegetation index information is very necessary for recognizing the level of vegetation density and forest destruction in areas with extensive forests. Information on changes in vegetation density can be obtained from the data displayed by two or more satellite images taken in different years, such as 1999, 2005, and 2010 (Pangrango, 2012). In monitoring vegetation density, the Red band and NIR band are used (Que et al., 2019). To determine the vegetation index accurately, the Normalized Difference Vegetation Index (NDVI) method can be used to distinguish between forest vegetation and non-forest vegetation. This method allows us to determine the density of vegetation, such as forests, accurately (Aftriana, Parman, & Sanjoto, 2013). The NDVI has index values ranging from -1, indicating non-vegetation, to 1, indicating vegetation objects. The vegetation index can be calculated using the following equation:

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

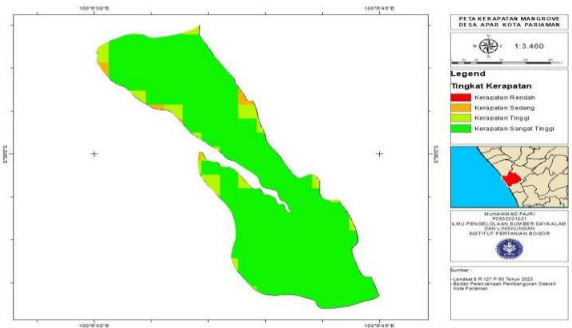
Description:

NDVI = Normalized Difference Vegetation Index
NIR = near infrared spectral Channel value
RED = spectral Channel value red

In this study,the image used in analyzing the density of vegetation is the image of landsat 8. The image Data used in this study is 2023 image data. In this study, the First Data Processing is atmospheric correction. Atmospheric correction is done in order to eliminate errors recorded by the sensor in the image due to the influence of the atmosphere as an intermediate field at the time of image data acquisition.

## III. RESULT AND INTERPRETATION

The classification of density distribution is done by NDVI (Normalized Difference Vegetation Index) on Landsat 8 satellite image in 2023. The results of data processing can be seen from the map image below:



Each type of mangrove has a different canopy cover area, which affects the reflectance value of the canopy detected by satellite images. In the image data processing results obtained, the larger the tree covers the area in the research area, the greater the percentage, and vice versa. If the tree covers a smaller area in the research area, the percentage is smaller.

The vegetation index was developed using a combination of near-infrared (NIR), visible red, and visible green bands. The NIR band is related to vegetation, the visible red band is useful for distinguishing soil and vegetation objects, and the visible green band is useful for assessing vegetation in the sea, land, and sediment. It has a smaller electromagnetic wavelength, making it more sensitive to the presence of recorded objects (ESA, 2015).

The NDVI vegetation index is widely used by researchers in assessing forest density (Zaitunah et al., 2017). The density level of vegetation can be represented by the NDVI value. Based on the results of data processing, the range of values obtained at the study site in 2023 ranged from low to very high. Mangrove density in this study was determined by overlaying the classification of land cover with the NDVI classification image.

The overlay results are then masked until only mangroves in the Apar mangrove park area remain. This process produced a total area of mangrove vegetation distribution of 10 hectares, with the most dominant density category being very high density, as shown in the following table:

**Table 1.Classification of mangrove density in Apar village**

| No | Density Classification | Area |
|---|---|---|
| 1 | Medium Density Mangrove | 0,11 ha |
| 2 | High Density Mangrove | 0,55 ha |
| 3 | Very High Density Mangrove | 8,88 ha |

**Source:** Primary data 2023

Table 1 shows the results of the NDVI analysis conducted using ArcGIS software to map and classify mangrove density in Apar Village. This analysis uses primary data from 2023 that describes the condition of mangrove vegetation in three density categories: medium, high, and very high. From the table, it can be seen that medium-density mangroves cover an area of 0.11 hectares, high-density mangroves cover 0.55 hectares, and the majority of the area is dominated by very high-density mangroves, covering 8.88 hectares.

The NDVI (Normalized Difference Vegetation Index) is a standard method for monitoring vegetation and measuring photosynthetic activity from satellite images. NDVI utilizes spectral information from the reflectance of near-infrared (NIR) light and red (Red) light absorbed by plants to evaluate the presence and condition of vegetation. In the context of mangroves, NDVI is an effective tool for identifying areas with denser vegetation or higher densities, reflecting the health of the mangrove ecosystem and the biodiversity of the area.

The spatial distribution of mangrove density classes depicted in this table provides important information for environmental management and conservation in Apar Village. Mangroves have a crucial ecological role in maintaining coastal ecosystems, protecting beaches from abrasion, providing habitat for various marine and terrestrial species, and playing a role in nutrient cycling and water filtration. An in-depth understanding of the structure and distribution of mangroves forms a strong basis for designing effective protection policies, rehabilitation strategies, and sustainable management.

Additionally, this data provides a foundation for decision-making related to land use and sustainable ecotourism development. By utilizing technologies such as ArcGIS to analyze and visualize NDVI data, local governments, conservation agencies, and local communities can work together to maintain the sustainability of mangrove ecosystems. This collaboration not only strengthens the monitoring and evaluation of mangrove conditions on a regular basis but also makes it possible to design appropriate interventions to support the restoration and preservation of mangrove ecosystems in Apar Village.

**Table 2. Mangrove types and density**

| Station | Mangrove Type | n | Di | RDi (%) |
|---|---|---|---|---|
| 1 | Rhizopora mucronata | 29 | 290 | 24,37 |
| | Oncoscperma tigillarium | 28 | 280 | 23,53 |
| | Soneratia caseolaris | 27 | 270 | 22,69 |
| | Nypa fructicans | 21 | 210 | 17,65 |
| | Calophyllum inophyllum | 5 | 50 | 4,20 |
| | Shorea | 4 | 40 | 3,36 |
| | Gnetum gnemon | 2 | 20 | 1,68 |
| | Rhizopora apiculata | 1 | 10 | 0,84 |
| | Hibiscus tiliaceus | 1 | 10 | 0,84 |
| | Terminalia catapa | 1 | 10 | 0,84 |
| 2 | Nypa fructicans | 63 | 630 | 46,32 |
| | Soneratia caseolaris | 38 | 380 | 27,94 |
| | Rhizopora apiculata | 22 | 220 | 16,18 |
| | Oncoscperma tigillarium | 4 | 40 | 2,94 |
| | Rhizopora mucronata | 4 | 40 | 2,94 |
| | Hibiscus tiliaceus | 3 | 30 | 2,21 |
| | Calophyllum inophyllum | 1 | 10 | 0,74 |
| | Baringtonia racemosa | 1 | 10 | 0,74 |
| 3 | Nypa fructicans | 35 | 350 | 47,95 |
| | Soneratia caseolaris | 34 | 340 | 46,58 |
| | Hibiscus tiliaceus | 3 | 30 | 4,11 |
| | Rhizopora apiculata | 1 | 10 | 1,37 |

Based on the data presented in the table, it can be concluded that there are variations in the composition of vegetation at three different stations. Station 1 showed a relatively high diversity of vegetation types with dominance by Rhizopora mucronata (24.37%), followed by Oncoscperma tigillarium (23.53%) and Soneratia caseolaris (22.69%). These three species have high density (Di) values of 290, 280, and 270 individuals per hectare, respectively. Nypa fructicans are also present in significant quantities (17.65%), with 210 individuals per hectare. Other species such as Calophyllum inophyllum, Shorea, and Gnetum gnemon show lower RDi values, below 5% each.

At Station 2, Nypa fructicans became the most dominant species with a percentage of RDi of 46.32%, followed by Soneratia caseolaris (27.94%) and Rhizopora apiculata (16.18%). Other species such as Oncoscperma tigillarium, Rhizopora mucronata, and Hibiscus tiliaceus showed lower presence with RDi values below 3%. This shows that Station 2 has a more centralized vegetation dominance in certain species compared to Station 1.

From the analysis of these data, it can be concluded that Nypa fructicans and Soneratia caseolaris are very dominant species at all stations, especially at stations 2 and 3. Differences in the value of RDi at each station indicate variations in the composition and structure of vegetation communities that may be caused by environmental factors such as salinity, soil quality, and water availability. The predominance of a particular species at different stations indicates the adaptation of the species to specific microhabitat conditions. This knowledge is very important in the management and conservation of mangrove forest ecosystems, given the important ecological role played by such vegetation in maintaining the balance of coastal ecosystems.

## CONCLUSIONS

Based on the results of the NDVI analysis using ArcGIS software, mangrove cover in Apar Village showed significant density variations, with a predominance of very high density covering 8.88 hectares, followed by high density covering 0.55 hectares, and medium density covering 0.11 hectares. The NDVI vegetation index, which utilizes a combination of the NIR, visible red, and visible green bands, is effective in monitoring and measuring the photosynthetic activity of vegetation, including mangroves. This analysis emphasizes the importance of different canopy covers on the reflectance values detected by satellite images, where the larger the area covered by trees, the higher the percentage.

Mangrove density data generated from the land cover classification overlay with NDVI images provides critical information for environmental management and conservation in Apar Village. Mangroves, which play an important ecological role in protecting beaches from abrasion, providing habitat for various species, and contributing to nutrient cycling and water filtration, require effective protection policies and sustainable rehabilitation strategies. The use of technologies such as ArcGIS allows for more accurate data visualization, supporting better decision-making regarding land use and ecotourism development. Collaboration between governments, conservation agencies, and local communities is essential to ensure the sustainability of mangrove ecosystems through regular monitoring and appropriate interventions.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