MANGROVE HEALTH ANALYSIS USING SENTINEL-2A IMAGE WITH NDVI CLASSIFICATION METHOD (Case Study: Sungai Batang - Kuala Secapah Mempawah Timur)

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ABSTRACT

This study aims to determine 1) the mangrove vegetation density index, 2) the health of mangrove plants in Sungai Batang Village to Kuala Secapah. The data used in this study is the image of Sentinel-2A, dated June 8, 2020. The data taken are vegetation density (NDVI) and mangrove health. The method in this study uses the vegetation index transformation (NDVI). Data analysis used the supervised classification method and the vegetation density index (NDVI). The results showed that the NDVI value of -1 – 0.32 indicates a sparse vegetation density, a value of 0.33 – 0.42 indicates a medium density and 0.43 – 1 indicates a dense density. From this NDVI index value, it can be used as a basis for classifying the health of mangrove vegetation. The health of mangrove vegetation based on the vegetation index value of 0.43 – 1 (meet) indicates that the health of the mangrove vegetation is very good. Vegetation value 0.33 – 0.42 (moderate) indicates good health of mangrove vegetation and vegetation index value -1 – 0.32 (rare) indicates poor vegetation health. Mangrove health level is very good with an area of 3.0314 km^2, healthy has an area of 0.204806 km^2 and poor health has an area of 0.625875 km^2.

***Keywords**: Health; Analysis; Mangrove; Sentinel-2A; NDVI.*

A. INTRODUCTION

As an archipelagic country, Indonesia is very famous for its diversity of natural resources, both on land and at sea. One of the marine resources owned is the Mangrove forest. Mangrove forests represent coastal ecosystems in Indonesia (Khakhima et al., 2018). Mangrove forest is a type of forest located at the mouth of a river or along the coast whose life is strongly influenced by the tides (tidal) of seawater. Mangrove forests are tropical trees and shrubs that also grow in protected intertidal zones (Jia et al., 2019). The ecological function of the Mangrove forest is to maintain the stability and balance of the ecosystem (Andriansah et al., 2020) because the Mangrove forest is a source of nutrients and a foraging area for other habitats.

Mangroves can be found in almost all of the Indonesian archipelago, the widest distribution of mangroves is in Irian Jaya with an area of 1,350,600 Ha (38%), Kalimantan with an area of 978,200 Ha (28%), and Sumatra with an area of 673,300 Ha (19%). In other areas, mangroves will grow and develop well on beaches that have large and protected river mouths (Andriansah et

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al., 2020; Noor et al., 2006), as well as small waves.

Another role of mangrove forests is to protect the coast from tidal waves, abrasion that comes from the sea, provide economic benefits from the biodiversity that lives in mangrove ecosystems (Ishtiaque et al., 2016), maintain soil fertility in coastal areas (Noor et al., 2006). Mangrove forests can also protect settlements, buildings, and agriculture in coastal areas from strong winds, seawater intrusion, support the livelihoods of coastal communities, and can store high carbon stocks (Duke et al., 2014; Nurhaliza et al., 2021). In other words, the mangrove forest is an ecosystem with high economic productivity, habitat for many types of flora and fauna. Mangroves make a significant contribution to the supply of organic matter, which is very important as a source of energy for biota that lives in the surrounding waters (Susiana, 2015).

The adaptability of mangrove forests is very high. Mangroves can live in diverse environments and can grow and thrive in coastal ecosystems that are highly saline, saturated with water, unstable soil conditions, and even in anaerobic conditions (Nurhaliza et al., 2021). Mangrove forests in general have very high ecological and economic functions. However, this function continues to decline and is degraded (Noor et al., 2006). The decline and degradation of mangrove forests can be caused by various factors. One of the contributing factors is humans, namely due to the construction of facilities and the increasing human population (Cissell et al., 2018). In addition, dredging for reclamation also has an impact on mangrove forest damage (Arshad et al., 2020).

Mangrove vegetation is also vulnerable to water quality. Despite having high adaptability to changes in salinity, mangroves are very vulnerable to changes in water quality (Nurhaliza et al., 2021; Schaduw, 2018). Mangrove forests will be stressed and even die if there is damage or disturbance to the water quality of coastal areas where mangrove forests live. Pressure on mangrove forests causes a decrease in the quantity and quality of mangrove health so that the functions and benefits of mangrove forests cannot continue optimally (Nurhaliza et al., 2021).

The activity of constructing an international standard container port not far from the research location clearly has a major impact on forest sustainability. The decline in water

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quality due to activities at the container port has caused the sensitive mangrove forest to begin to degrade. As an area rich in nutrients, the sustainability of this forest must be maintained. Because they are rich in nutrients, mangrove forests are highly productive ecosystems with significant ecological and socioeconomic importance in the world (Collins et al., 2017; Danoedoro, 2012; Jia et al., 2019; Richards & Friess, 2016). However, the situation is at an alarming rate when compared to inland forests over the last century (Friess & Webb, 2014). Therefore, conservation and restoration of Mangrove forests are currently very intensively carried out.

The study of mangrove forests using satellite-based remote sensing techniques (Kamal et al., 2016) currently the most frequently used tool today. Remote sensing is considered more effective in mapping mangrove conditions compared to conventional or terrestrial methods (Khakhima et al., 2018). Currently there are many options to choose from regarding the satellite sensor, which is used. Mangrove vegetation also has a unique spectral reflection, where the spectral represents a combination of soil, water and vegetation because mangrove vegetation grows in coastal areas (Khakhima et al., 2018; Lee & Yeh, 2009). In addition, the mangrove canopy also affects the spectral reflection of mangroves (Kuenzer et al., 2011). In principle, forest density can be estimated by remote sensing using a vegetation index transformation approach (Danoedoro, 2012).

B. MATERIALS AND METHODS

Study Area

The research location is between the Batang-Kuala Secapah River, East Mempawah sub-district, Mempawah district, West Kalimantan Province. The study area is located between 109^{o}0'0" - 109^{o}3'0" east longitude and 0^{o}17'0" - 0^{o}18'0" north longitude. The Batang River to Kuala Secapah is along the coast of the Natuna Sea. Sungai Batang Village to Kuala Secapah is traversed by small rivers that empty into the Natuna Sea with Mangrove trees growing on either side of the river and the beach and relatively small waves. The research location can be seen in **Figure 1**.

Data Collection

The data used in this study is Sentinel-2A, dated June 8, 2020. This satellite image belongs to the type of multispectral imagery with 13 spectral

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bands (4 bands at a spatial resolution of 10 m, 6 bands at a spatial resolution of 20 m, and 3 bands at a resolution of 20 m). The data used in determining the density of the mangrove canopy is a 10 meters spatial resolution band in the form of visible and near-infrared bands. The image is downloaded at *scihub.copernicus.eu* which is at the TOA Reflectance level.

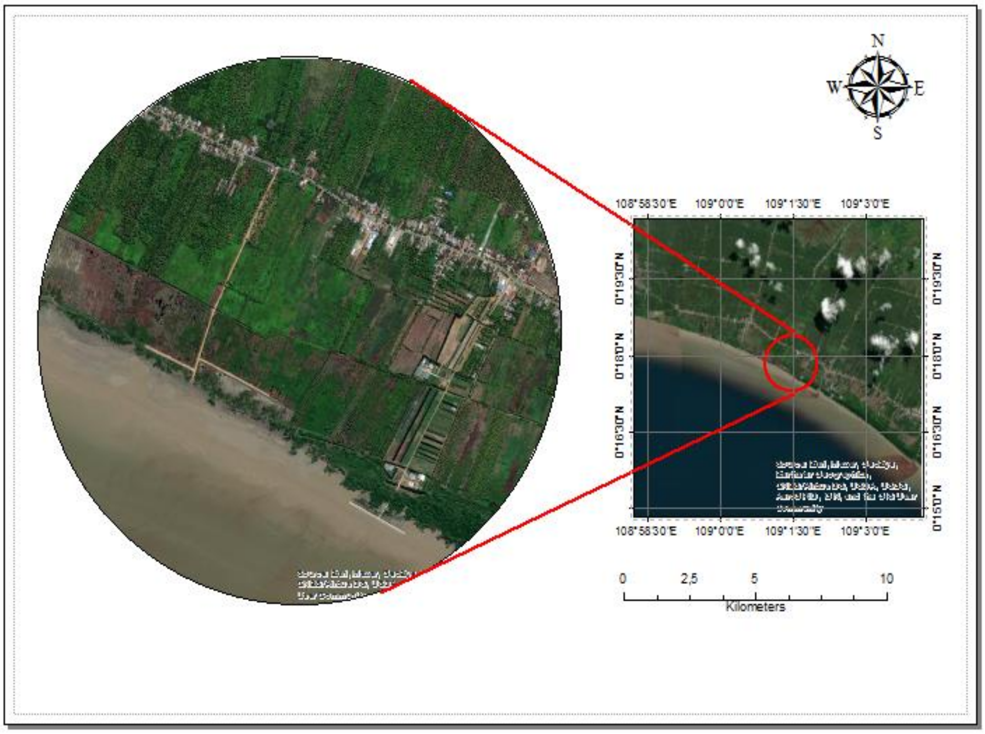

Figure 1. Study Area

Data Analysis

Data analysis in this study used the Supervised Classification and Vegetation Density Index (NDVI) method. The supervised classification includes a set of algorithms based on the inclusion of object samples (training area) based on spectral values. The classification system must be prepared in advance by the user, as is the case with manual classification. Two important things must be considered in the classification and criteria of the sample (Danoedoro, 2012).

The vegetation index transformation (NDVI) is based on the canopy density model (Umarhadi & Syarif, 2017). The greenness of the vegetation in the image is correlated with the density of the vegetation canopy. The principle of NDVI analysis is to measure the level of the greenness of vegetation. For the purpose of detecting the level of greenery in

Sentinel-2A images, it is correlated with leaf chlorophyll content. Based on this information, the best channels to use for NDVI analysis are infrared and red channels. Therefore, mathematically, NDVI uses the (NIR-RED) / (NIR + RED) Algorithm, or the channels used are:

$$NDVI = \frac{\text{Band 8} - \text{Band 4}}{\text{Band 8} + \text{Band 4}}$$

Where :
Band 8: Near- Infrared
Band 4: Reflectance of the Red
NDVI: Normalized Difference Vegetation Index

Mangrove canopy density is classified based on the calculated NDVI value range. The density classification refers to the Mangrove Inventory and Identification Guidelines by the Direktorat Jenderal Rehabilitasi Lahan dan Perhutanan Sosial Departemen Kehutanan (Ardiansyah & Buchori, 2014; Kehutanan, 2005). The classifications are as follows:

1. Thick canopy density (0.43-1.00)
2. Medium crown density (0.33-0.42)
3. Infrequent crown density (-1.00- 0.32)

From the algorithm results, the index value ranges from -1 to 1. The results obtained from the analysis are used as parameters to determine the health of mangroves in the Batang-Kuala Secapah River area. In general, a larger index value indicates better health than a smaller value (Nordhaus et al., 2019).

C. RESULTS AND DISCUSSION

Classification Process

Before processing the Sentinel-2A image, the processes include radiometric correction, atmospheric correction, and vegetation index transformation. The results of processing the Sentinel-2A image with a resolution of 10 meters taken in 2020 and the composite results of band 8 and band 4 on object classification in the vegetation area, can be seen in **Figure 2**. The composite image display is divided based on the color composite of the vegetation index with values ranging from -1 to 1 are represented, in red, yellow, and dark green, respectively.

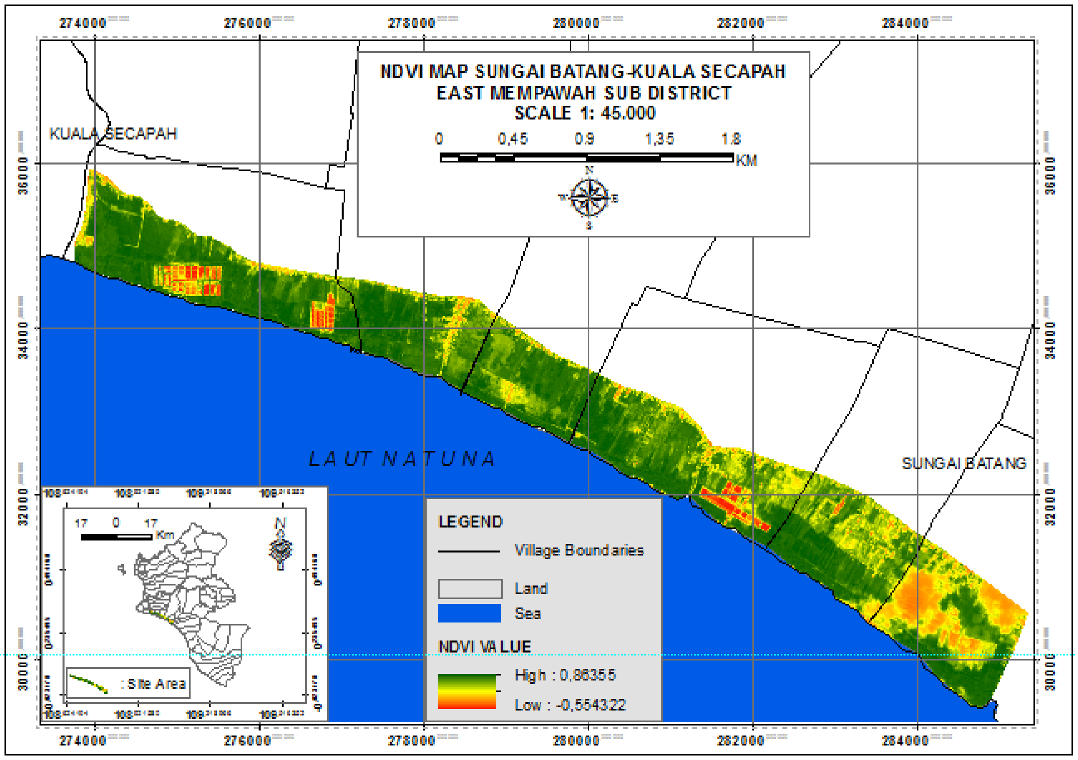

Figure 2. Mangrove NDVI Sungai Batang- Kuala Secapah East Mempawah

Based on the results of the analysis, it is known that the NDVI value of the research location is -0.55 to 0.88. The level of vegetation density in the classification process is based on the Ministry of Forestry (2005). The classification results obtained the level of rare vegetation density with NDVI values ranging from -1 – 0.32, medium vegetation density with NDVI values ranging from 0.33 – 0.42, and dense vegetation density values ranging from 0.43 – 1. Index values Negative vegetation density indicates an object other than vegetation, it can be a body of water or a building.

The health of mangrove vegetation along the Batang River to Kuala Secapah, Mempawah Timur sub-district, Mempawah Regency is, vegetation that has a large density index (NDVI) value indicates better vegetation health than a smaller vegetation density value. The relationship between the value of vegetation density (NDVI) with mangrove health is based on the intensity of the greenness of the vegetation. The greenery intensity of the mangrove vegetation in the image is correlated with the canopy or vegetation density. This is due to the high greenery intensity of the vegetation indicating that the chlorophyll content in the vegetation is good. Therefore, Mangrove vegetation density and NDVI index value can be used as the basis for classifying Mangrove vegetation health.

Based on this connection, the vegetation density index value of 0.43 – 1 (density) indicates that the health of the mangrove vegetation is very good. The value of the vegetation density index of 0.33 – 0.42 (moderate) indicates that the health of the mangrove vegetation is good and the value of the vegetation density index of -1 – 0.32 (rare) indicates that the health of the vegetation is poor. Based on these data, it can be concluded that the data generated from Sentinel 2A images can generally be used to monitor the health of vegetation or plants, especially in this case Mangrove plants. The results of the field survey can be seen in several Mangrove sites in the research location as can be seen in Figure 3.

Figure 3. Mangrove Forest used for Tourism

The results of the analysis of the Mangrove Health Index based on the percentage of pixel area based on the NDVI value can be seen in **Table 1**.

Table 1. Percentage of Health Quality Classification Based on NDVI Pixel Area

Health Quality	Pixel Area (Ha)	Pixel (%)
Very Good	303.1433966	78.49
Good	20.48059374	5.30
Bad	62.58746318	15.91
Total	386.2114535	100

Source: Calculation Results

Based on the table data above, it is known that the mangroves in the villages of Sungai Batang to Kuala Secapah have varying densities when viewed from the pixel frequency obtained. From this density, it can be classified the percentage of mangrove health areas through image data. Mangrove health is very good having a pixel area percentage of 78.49%, good health has a pixel area percentage of 5.30% and bad health has a pixel area percentage of 15.91%. When viewed from the percentage area, in general, the health of the Mangrove vegetation in Sungai Batang to Sungai Secapah villages is very good.

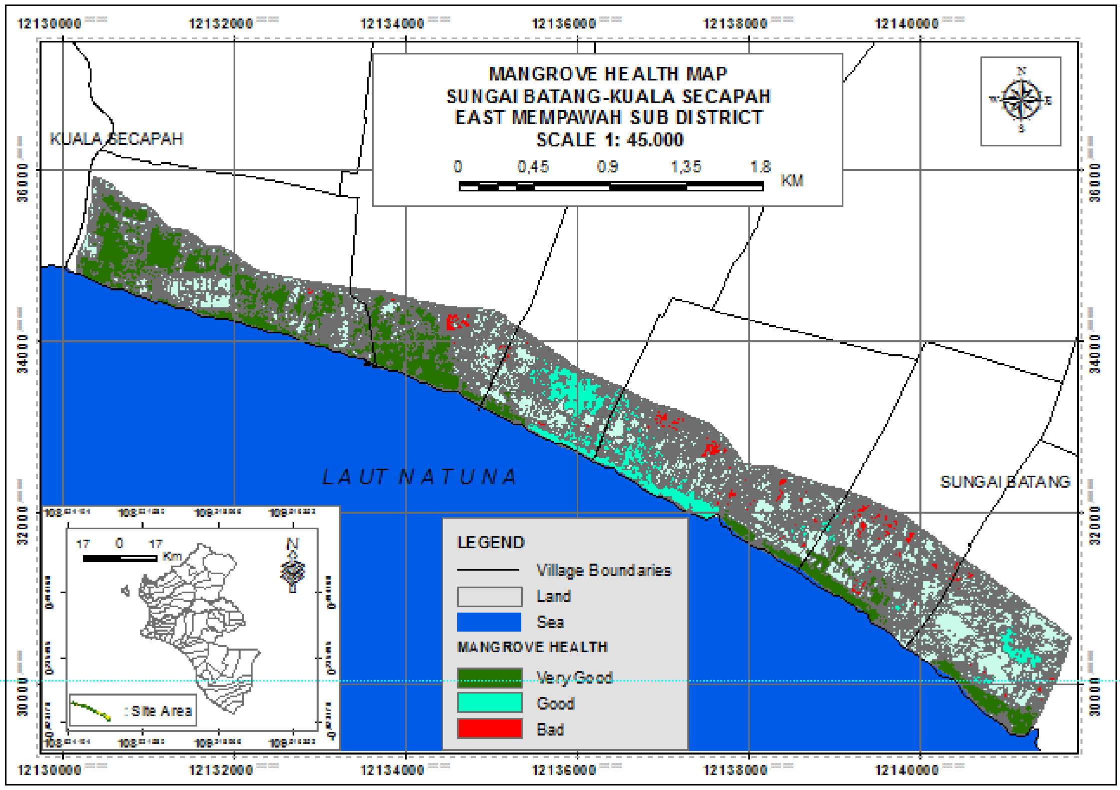

Figure 4. Mangrove Health Map Sungai Batang- Kuala Secapah East Mempawah

D. CONCLUSIONS

Sentinel-2A imagery can be applied for analysis of plant density index (NDVI) and plant health. With the help of the Geographic Information System and with a research approach that emphasizes the spectral approach, the estimation of plant density index (NDVI) and plant health can be classified more easily. Based on the results of the study, it can be seen that: 1) the composite results of band 8 and band 4 on the classification of objects in the vegetation area, the image display is divided based on the color composite of the vegetation index results with values ranging from -1 to 1 which are represented, respectively in red, yellow and dark green. The mangrove vegetation density level with rare classification has an NDVI value, ranging from -1 – 0.32, medium vegetation density with an NDVI value ranging from 0.33 – 0.42, and the vegetation density value with dense density classification has an NDVI value ranging from 0.43 – 1, 2) The level of health of mangrove vegetation is very good with an area of 3,0314 km^2, with a pixel area of 78.49%. The health level of mangrove vegetation with good classification has an area of 0.204806 km^2, with a pixel area percentage of 5.30% and a poor health level has an area of 0.625875 km^2, with a pixel area percentage of 15.91%. When viewed from the area and percentage, in general, the health of the mangrove vegetation in the villages of Sungai Batang to Sungai Secapah is very good.

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