p-ISSN 2460-0768 e-ISSN 2597-6044
https://doi.org/10.20961/ge.v10i2.72707

GeoEco, Vol. 10, No 02. July 2024 Page. 140-151
https://jurnal.uns.ac.id/GeoEco/article/view/72707

USING SENTINEL-2 IMAGE FOR MANGROVE HEALTH ANALYSIS IN BAKAU KECIL VILLAGE, MEMPAWAH DISTRICT, WEST KALIMANTAN

Ajun Purwanto[1]*, Paiman[1]
[1]Geography of Education, Faculty of Education and Social Sciences, IKIP PGRI Pontianak, Indonesia

*E-mail: ajunpurwanto@ikippgriptk.ac.id

ARTICLE INFO

Article History
Received : 31/03/23
Revised : 29/04/24
Accepted : 17/05/24

Citation:
Purwanto, A., And Paiman, P., (2024) Using Sentinel-2 Image For Mangrove Health Analysis In Bakau Kecil Village, Mempawah District, West Kalimantan. Geoeco. Vol. 10, No. 2.

ABSTRACT

This study aims to determine 1) The index of mangrove plant vegetation density, and 2) the state of the mangrove plants in the village of Bakau Kecil. Transforming the NDVI was the method employed in this study. The canopy density model can be applied using NDVI. The degree of vegetation canopy density was correlated with the intensity of greenness. The outcomes demonstrated that NDVI values ranged from -1 to 0.32, indicating sparse vegetation density, 0.33 to 0.42, indicating medium density values, and 0.43 to 1, indicating dense density values. One can categorize the condition of the mangrove vegetation based on the NDVI index value, which is shown above. Based on a vegetation index value of 0.43 - 1, which indicates very good health, mangrove vegetation can be considered to be in excellent condition. The mangrove vegetation is in good health (vegetation value 0.33-0.42, Moderate), and the vegetation is in poor health (vegetation value -1-0.32, Rare), according to the vegetation index. Mangrove health is very good, with a pixel area percentage of 68.88 percent; good health has a pixel area percentage of 23.98 percent; and poor health has a pixel area percentage of 7.14 percent.

Keywords: *Analysis; Health; Sentinel-2; Mangrove*

INTRODUCTION

Indonesia is a country with a lot of natural resources. One of these resources is the Mangrove forest. Mangroves are a type of wetland that is found near the sea. They are very important because they help protect coastlines from erosion. Mangrove forests represent coastal ecosystems in Indonesia (Khakhima et al., 2018). A type of forest found close to a river or the coast is known as a mangrove forest. A type of forest found close to a river or the coast is known as a mangrove forest. These forests are very affected by the tides, which makes their life very interesting. Mangrove forests are tropical trees and shrubs that 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 Mangrove forests are a source of nutrients and foraging areas for other habitats.

The forest needs to be able to sustain itself with the right amount of nutrients, so it's important to keep the area healthy. Because it is rich in nutrients, mangrove forests are very productive ecosystems with significant ecological and socio-economic importance worldwide (Collins et al., 2017; Jia et al., 2019; Richards & Friess, 2016). The role of mangrove forests is to protect the coast from tidal waves and abrasion from the sea, providing economic benefits from the biodiversity that lives in the mangrove ecosystem (Ishtiaque et al., 2016), maintain soil fertility in coastal areas (Noor et al., 2006). However, the situation has been alarming compared to the inland forests for the past century (Friess & Webb, 2014). Researchers are very busy trying to protect Mangroves from being damaged, so they can continue to help the environment in the future.

In the Indonesian archipelago, mangroves are practically ubiquitous, but they are most widely distributed in Irian Jaya, where they cover 1,350,600 ha (38 percent of the island), Kalimantan, where they cover 978,200 ha (28 percent), and Sumatra, where they cover 673,300 ha (19 percent). Mangroves will grow and develop well in other areas on beaches with large and protected river mouths (Andriansah et al., 2020; Noor et al., 2006) and small waves.

Various methods are used to identify the distribution and condition of mangrove forests. One of the methods used to identify the distribution and condition of mangrove forests is to utilize the normalized difference vegetation index (NDVI) and green normalized difference vegetation index (GNDVI) (Masitha, 2017), canopy density or plant canopy (Andriansah et al., 2020; Umarhadi & Syarif, 2017; Wachid et al., 2017).

The Normalized Vegetation Index (NDVI) has good accuracy in studying mangroves in coastal areas. The concept of NDVI is relatively simple: utilizing the best Near Infra Red (NIR) light reflected by chlorophyll and red light radiation absorbed by green plants. (Akbar et al., 2020). The method of measuring canopy density is using the canopy cover. Canopy cover is the land area covered by the vertical projection of the vegetation canopy or tree canopy (Jennings et al., 1999; Wachid et al., 2017).

Accurate information about the area and condition of the Mangrove forest is crucial. This information can be used for efficient ecosystem management and policy and decision-making processes (Hamilton & Casey, 2016; Kuenzer et al., 2011). Its presence in tidal or intertidal zones often makes mangrove forests challenging to access through field surveys (terrestrial). For these purposes, for decades, Remote Sensing. For decades, efforts to monitor the distribution of mangrove forests and their condition have been carried out using Remote Sensing (Cárdenas et al., 2017)

Remote Sensing has enormous benefits for terrestrial survey activities, and this is because Remote Sensing can determine the characteristics of an area without going directly into the field. Remote Sensing can describe objects on the earth's surface by the shape and location of objects similar to the original (Nurmalasari & Santosa, 2018). Moreover, in areas that are difficult to reach, Remote Sensing is very effective to use. Various sectors are used, such as meteorology and climatology, forestry, population, and marine (oceanography). The study of mangrove forests using satellite-based remote sensing techniques (Kamal et al., 2016) is the method most often used today due to the difficulty of access and logistics in the field in this wet forest. Remote Sensing is considered more effective in mapping the condition of mangroves compared to conventional or terrestrial methods (Khakhima et al., 2018). Regarding the satellite sensor that will be used, there are many options. 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). Remote Sensing can estimate forest density using a vegetation index transformation approach (Danoedoro, 2012).

This study aims to analyze the density and health of mangrove forests using sentinel-2 by utilizing the Normalized Vegetation Index (NDVI) and the canopy or plant canopy.

MATERIALS AND METHODS

Study Area

Bakau Kecil village, Sungai Kunyit sub-district, East Mempawah sub-district, Mempawah district, and West Kalimantan province are the areas where the research is being conducted. The research location is between 109°0'0" - 109°3'0" E and 0°17'0" - 0°18'0" N. The research area has an area of 451.41 ha, with a flat topography. Sungai Bakau Kecil Village is directly adjacent to the north by Antibar Village, the Natuna Sea to the south, to the west by Pasir Wan Salim Village and the east by Pasir Panjang Village and Parit Banjar Village. Historically and sociologically, Sungai Bakau Kecil Village has also given colour to the community. A small river flows through the community of Sungai Bakau Kecil and empties into the Natuna Sea. Mangrove trees line the river's banks and the beach, and the area's waves are generally calm. **Figure 1** depicts the site of the study.

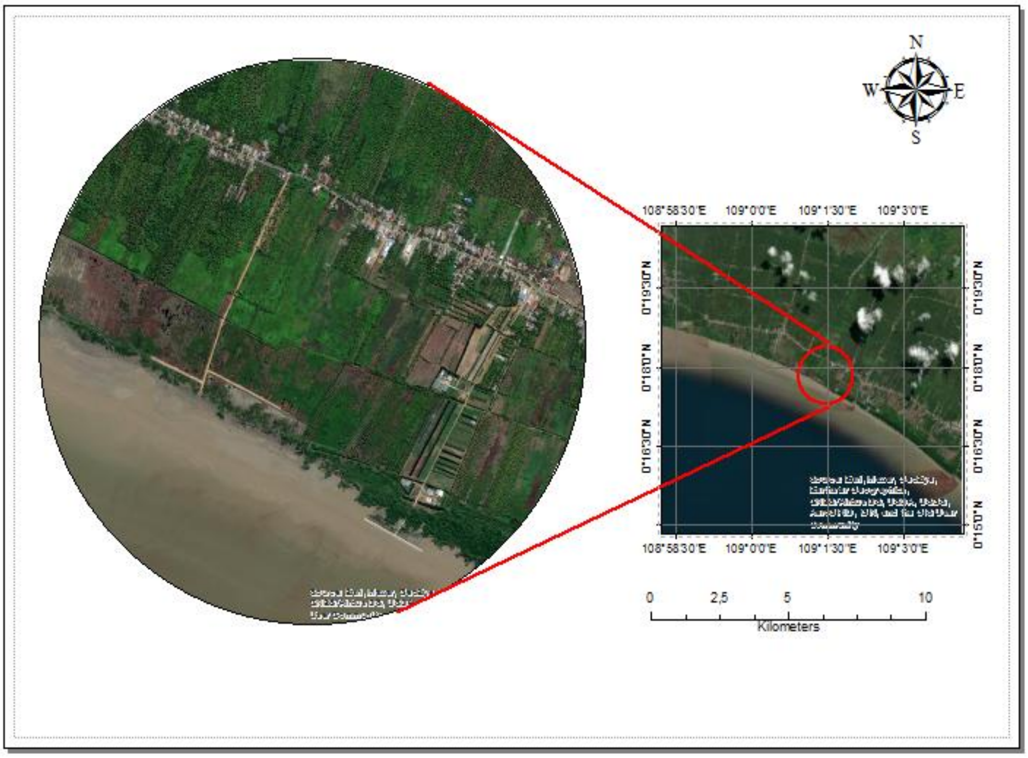

Figure 1. Study Area

Research Data

This study used Sentinel-2A data collected on June 8, 2020. This satellite image falls under the category of multispectral imagery and has 13 spectral bands, 4 of which have a spatial resolution of 10 meters, 6 of which have a spatial resolution of 20 meters, and 3 of which have a spatial resolution of 60

p-ISSN 2460-0768 e-ISSN 2597-6044
https://doi.org/10.20961/ge.v10i2.72707
GeoEco, Vol. 10, No 02. July 2024 Page. 140-151
https://jurnal.uns.ac.id/GeoEco/article/view/72707

meters. A 10 m spatial resolution band with visible and near-infrared bands was used to calculate the density of the mangrove canopy. Calculating mangrove canopy density requires preliminary data processing, such as radiometric correction, atmospheric correction, and vegetation index transformation. The image is available for download at the TOA Reflectance level at sci-hub. copernicus. eu. In order to match the image's pixel value to the object's reflection value, radiometric correction is used. To reduce the atmospheric effect of energy reflected from objects on the surface to the sensor, atmospheric correction is carried out.

Method

The method used in this study is to correct the Sentinel-2A image and then transform the vegetation index (NDVI). The corrections made include radiometric correction and atmospheric correction. Vegetation index transformation (NDVI) is an approach to apply the canopy density model (Umarhadi & Syarif, 2017). The goal of NDVI analysis is to quantify how green the vegetation is. The greenness of the vegetation in the image correlates with the vegetation canopy's density. Therefore, it is correlated with leaf chlorophyll content to detect the greenness level in Sentinel-2 imagery. The infrared and red channels are the most effective ones for NDVI analysis, according to this information. As a result, the channels used or the (NIR-RED) / (NIR RED) Algorithm are used in NDVI mathematics:

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

Where:

Band 8	=	Near Infrared (Near Infrared)
Band 4	=	Reflectance of the Red (Red)
NDVI	=	Normalized Difference Vegetation Index

The classification of mangrove canopy density is based on the calculated NDVI value range. The density classification refers to the Mangrove Inventory and Identification Guidelines by the Directorate General of Land Rehabilitation and Social Forestry of the Ministry of Forestry (Ardiansyah & Buchori, 2014; Kehutanan, 2005). The categories are as follows:

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

The index value, as determined by the algorithm's outcomes, lies between -1 and 1. In order to assess the condition of the mangroves near Bakau Kecil Village, the analysis's findings are used as parameters. Generally, a more significant index value indicates better health than a smaller value (Nordhaus et al., 2019).

RESULTS AND DISCUSSION

Classification Processes

The following operations are completed prior to processing the Sentinel-2A image: radiometric correction, atmospheric correction, and vegetation index transformation. **Figure 2** illustrates the outcomes of processing the Sentinel-2A image with a resolution of 10 meters acquired in 2020 and the conflicting results of bands 8 and 4 on object classification in the vegetation area. Red, yellow, and dark green are used to represent the vegetation index values from -1 to 1, respectively, in the composite image display.

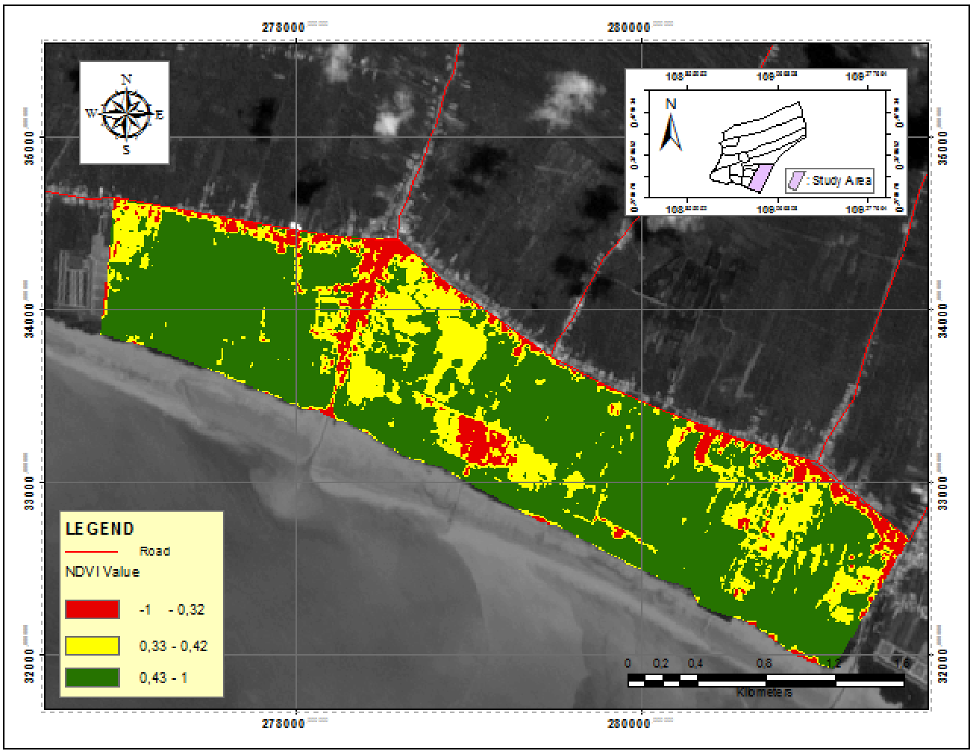

Figure 2. NDVI Value of The Study Area

According to the Ministry of Forestry's classification process from 2005, rare vegetation density was defined as having an NDVI value between -1 and 0.32, medium vegetation density as having an NDVI value between 0.33 and 0.42, and dense vegetation density as having an NDVI value between 0.43 and 1. As was previously mentioned, there is a correlation between the canopy or density of vegetation and the amount of greenery in the image. Based on the density of mangrove vegetation and the NDVI index value above, the obtained NDVI rating can be used as a basis for categorizing the health of the mangrove vegetation. The greenness intensity demonstrates that the chlorophyll content in the vegetation is good. The results of mangrove density mapping are shown in **Figure 3**.

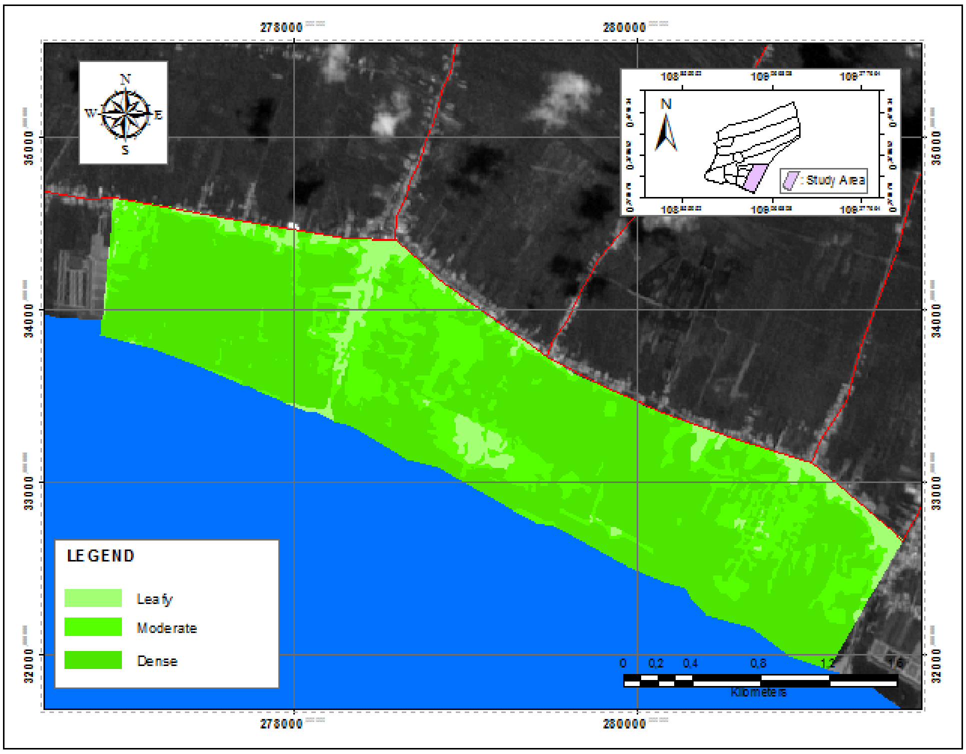

Figure 3. Mangrove Vegetation Density

Figure 4 shows the results of observations made on artificial objects in the mangrove area in the research area. This area is used by the community for mangrove tourism

p-ISSN 2460-0768 e-ISSN 2597-6044
https://doi.org/10.20961/ge.v10i2.72707

Figure 4. Mangrove Forest Used for Tourism

Mangrove vegetation health in the village of Bakau Kecil, Mempawah Timur District, Mempawah Regency, was classified using Sentinel-2A data in 2020 and processed using the Normalized Difference Vegetation Index (NDVI). A higher density index value reflects healthier vegetation than one with a lower vegetation density value. The mangrove vegetation appears to be in very good (very good) health, according to the density value of 0.43-1 on the vegetation index. A vegetation value of 0.33 to 0.42 (Moderate) indicates that the health of the mangrove vegetation is good, and a vegetation index value of -1 to 0.32 (rare) indicates that the health of the vegetation is poor (bad). These findings support the generalization that data derived from Sentinel 2A images can be used to track vegetation or plant growth, particularly in the case of mangrove plants, as well as the health of an area.

The health of the Mangrove Vegetation can also be seen from composite channels 8 – 4 – 3, coloured infrared bands. The composite channel 8 – 4 – 3 shows that Mangrove vegetation with very good health has a dark red colour, while those in good health have a slightly pale red colour, while those with poor health have a pale red colour. A composite image of 8 – 4 – 3, which shows the level of health of the mangrove vegetation in the study area, can be seen in **Figure 5**.

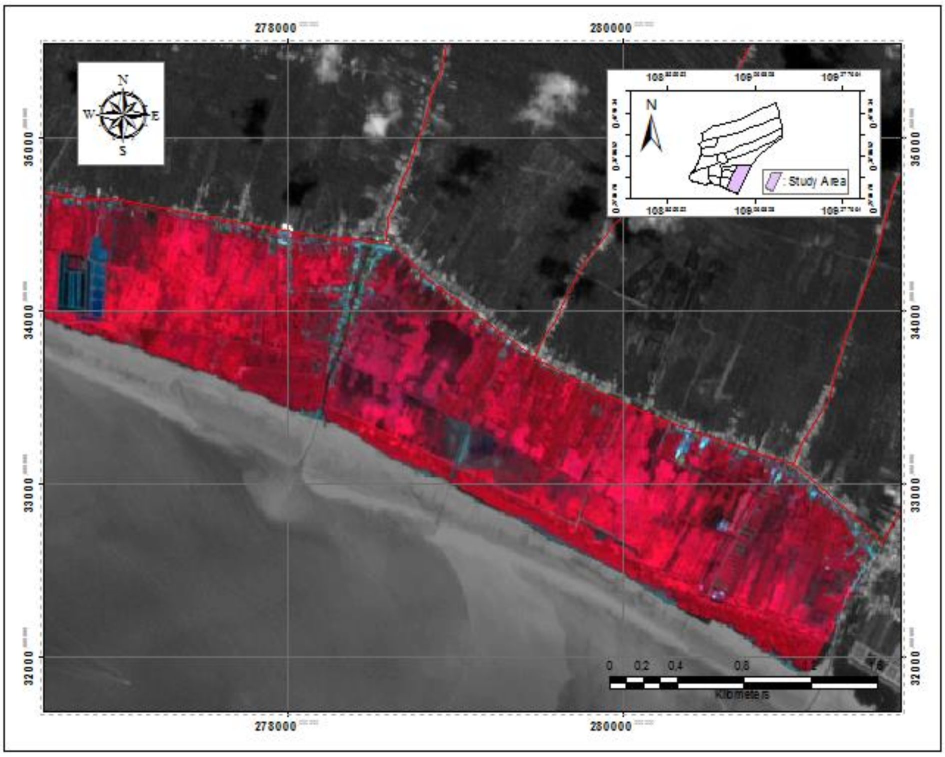

Figure 5. The Level Health of The Mangrove Vegetation

Health Quality NDVI Pixel Area Percentage

Table 1 lists the results of the analysis of the Mangrove Health Index based on the percentage of pixel area based on the NDVI value.

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

Health Quality	Pixel Area (Ha)	Pixel (%)
Very Good	310,92	68,88
Good	108,25	23,98
Bad	32,24	7,14
Total	451,41	100

The mangroves in the village of Bakau Kecil have varying densities when viewed from the pixel frequency obtained, according to the data in the table above. Through image data, the percentage of the mangrove health area can be determined from this density. Very good mangrove health is represented by a pixel area percentage of 68.88%, good health by a pixel area percentage of 23.98%, and poor health by a pixel area percentage of 7.14%. As a result, when looking at the percentage of the village, Bakau Kecil's mangrove vegetation is in very good condition.

CONCLUSIONS

Remote Sensing Technology today has developed very rapidly. Remote Sensing is indicated by the increasing number of satellite images that can be obtained or accessed for free or paid. In addition, with supporting technology in the form of Geographic Information Systems, various benefits are also increasingly varied in their applications in various fields. One of the images that can be accessed for free is Sentinel-2A Image. Sentinel-2A imagery in this study can be applied to NDVI and plant health analysis. Even in other applications, the Sentinel-2A image can correlate the estimated production of certain plants with several transformations of the vegetation index.

The classification of NDVI estimation and plant health is made easier with the aid of the Geographic Information System, a research technique that emphasizes the spectral approach. Based on the study's findings, it can be seen that: 1) band 8 and band 4 composite results in the classification of objects in the vegetation area, and 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, 2) the health level of mangroves is very good with a pixel area percentage of 68 point 88 percent, and good health has a pixel area per pixel area of. The mangrove vegetation in the village of Bakau Kecil is therefore in very good health when viewed from the percentage area.

ACKNOWLEDGMENTS

The authors thank the local government of Mempawah district, the village government of Bakau Kecil, the Institute for Research and Community Service, and IKIP PGRI Pontianak has permitted to conduct of this research.

REFERENCES

Akbar, M. R., Arisanto, P. A. A., Sukirno, B. A., Merdeka, P. H., Priadhi, M. M., & Zallesa, S. (2020). Mangrove vegetation health index analysis by implementing NDVI (normalized difference vegetation index) classification method on sentinel-2 image data case study: Segara Anakan, Kabupaten Cilacap. *IOP Conference Series: Earth and Environmental Science*, *584*(1), 12069.

Andriansah, R., Ulqodry, T. Z., & Ningsih, E. N. (2020). *ANALISIS KONDISI MANGROVE BERDASARKAN NDVI (NORMALIZED DIFFERENCE*

VEGETATION INDEX) DAN TUTUPAN KANOPI MENGGUNAKAN CITRA SENTINEL-2 DI PULAU PAYUNG, MUARA SUNGAI MUSI, BANYUASIN, SUMATERA SELATAN. Sriwijaya University.

Ardiansyah, D. M., & Buchori, I. (2014). Pemanfaatan citra satelit untuk penentuan lahan kritis mangrove di Kecamatan Tugu, Kota Semarang. *Geoplanning: Journal of Geomatics and Planning*, *1*(1), 1–12.

Cárdenas, N. Y., Joyce, K. E., & Maier, S. W. (2017). Monitoring mangrove forests: Are we taking full advantage of technology? *International Journal of Applied Earth Observation and Geoinformation*, *63*, 1–14.

Collins, D. S., Avdis, A., Allison, P. A., Johnson, H. D., Hill, J., Piggott, M. D., Hassan, M. H. A., & Damit, A. R. (2017). Tidal dynamics and mangrove carbon sequestration during the Oligo–Miocene in the South China Sea. *Nature Communications*, *8*(1), 1–12.

Danoedoro, P. (2012). Pengantar penginderaan jauh digital. *Penerbit Andi, Yogyakarta*.

Friess, D. A., & Webb, E. L. (2014). Variability in mangrove change estimates and implications for the assessment of ecosystem service provision. *Global Ecology and Biogeography*, *23*(7), 715–725.

Hamilton, S. E., & Casey, D. (2016). Creation of a high spatio-temporal resolution global database of continuous mangrove forest cover for the 21st century (CGMFC-21). *Global Ecology and Biogeography*, *25*(6), 729–738.

Ishtiaque, A., Myint, S. W., & Wang, C. (2016). Examining the ecosystem health and sustainability of the world's largest mangrove forest using multi-temporal MODIS products. *Science of the Total Environment*, *569*, 1241–1254.

Jennings, S. B., Brown, N. D., & Sheil, D. (1999). Assessing forest canopies and understorey illumination: canopy closure, canopy cover and other measures. *Forestry: An International Journal of Forest Research*, *72*(1), 59–74.

Jia, M., Wang, Z., Wang, C., Mao, D., & Zhang, Y. (2019). A new vegetation index to detect periodically submerged Mangrove forest using single-tide sentinel-2 imagery. *Remote Sensing*, *11*(17), 2043.

Kamal, M., Hartono, H., Wicaksono, P., Adi, N. S., & Arjasakusuma, S. (2016). Assessment of Mangrove Forest Degradation Through Canopy Fractional Cover in Karimunjawa Island, Central Java, Indonesia. *Geoplanning: Journal of Geomatics and Planning*, *3*(2), 107–116.

Kehutanan, D. (2005). Pedoman inventarisasi dan identifikasi lahan kritis mangrove. *Direktorat Jenderal Rehabilitasi Lahan Dan Perhutanan Sosial Departemen Kehutanan. Jakarta*.

Khakhima, N., Putra, A. C. P., & Widhaningtyas, T. U. (2018). ESTIMATING MANGROVE FOREST DENSITY USING GAP FRACTION METHOD AND VEGETATION TRANSFORMATION INDICES APPROACH. *Geoplanning: Journal of Geomatics and Planning*, *5*(1), 35–42.

Kuenzer, C., Bluemel, A., Gebhardt, S., Quoc, T. V., & Dech, S. (2011). Remote Sensing of mangrove ecosystems: A review. *Remote Sensing*, *3*(5), 878–928.

Lee, T.-M., & Yeh, H.-C. (2009). Applying remote sensing techniques to monitor shifting wetland vegetation: A case study of Danshui River estuary mangrove communities, Taiwan. *Ecological Engineering*, *35*(4), 487–496.

Masitha, M. (2017). Pendugaan Kerapatan Mangrove Dengan Algoritma Normalized Difference Vegetation Index (NDVI) dan Green Normalized Difference Vegetation Index (GNDVI) Michelia Masitha. *Bogor Agricultural*.

Noor, Y. R., Khazali, M., & Suryadiputra, I. N. N. (2006). *Panduan pengenalan mangrove di Indonesia*. Ditjen PHKA.

Nordhaus, I., Toben, M., & Fauziyah, A. (2019). Impact of deforestation on mangrove tree diversity, biomass and community dynamics in the Segara Anakan lagoon, Java, Indonesia: A ten-year perspective. *Estuarine, Coastal and Shelf Science*, *227*, 106300.

Nurmalasari, I., & Santosa, S. H. M. B. (2018). Pemanfaatan Citra Sentinel-2A untuk Estimasi Produksi Pucuk Teh di Sebagian Kabupaten Karanganyar. *Jurnal Bumi Indonesia*, *7*(1), 228868.

Richards, D. R., & Friess, D. A. (2016). Rates and drivers of mangrove deforestation in Southeast Asia, 2000–2012. *Proceedings of the National Academy of Sciences*, *113*(2), 344–349.

Umarhadi, D., & Syarif, A. (2017). Regression model accuracy comparison on mangrove canopy density mapping. *Intern Confer on Scien and Techn*, *2*(7), 1–10.

Wachid, M. N., Hapsara, R. P., Cahyo, R. D., Wahyu, G. N., Syarif, A. M., Umarhadi, D. A., Fitriani, A. N., Ramadhanningrum, D. P., & Widyatmanti, W. (2017). Mangrove canopy density analysis using Sentinel-2A imagery satellite data. *IOP Conference Series: Earth and Environmental Science*, *70*(1), 12020.