

MANGROVE DENSITY ANALYSIS USING LANDSAT 8 THE OPERATIONAL LAND IMAGER (OLI) A CASE STUDY BENGKULU CITY

*Abditama Srifitriani¹, Parwito², Supriyono¹, Lola Oktalia¹

¹ Geography Education Study Program, Prof. University Dr. Hazairin SH

² Agrotechnology Study Program, Ratu Samban University

¹ Geography Education Study Program Student, Prof. Dr. Hazairin SH

Email: abditamasrifitriani@gmail.com

*Corresponding Author, Received: Sep 18, 2020, Revised: Oct 15, 2020, Accepted: Nov 15, 2020

ABSTRACT. The change in crown density is an indication for monitoring its quality. The use of satellite imagery on remote sensing data in the form of Landsat has been carried out. Along with the development of the Landsat series satellite imagery, in this study, Landsat 8 OLI image processing was carried out on May 27, 2019, to analyze the distribution and density of mangroves using vegetation index analysis on the West Coast of Bengkulu City. The mangrove identification stages were carried out using the composite band RGB 564, then the mangrove and non-mangrove objects were separated using the unsupervised classification method. The next step is to analyze mangrove density using the NDVI formula. The results showed that the mangrove area on the West Coast of Bengkulu was 155.24 Ha. The analysis of the vegetation index in the mangrove area showed that dense density classes dominated the mangrove density conditions

Keywords: Density, Mangrove, NDVI, Landsat



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1. INTRODUCTION

The sustainability of mangrove forests requires density data to support it. The existence of forests can be determined through remote sensing based on spatial data with the density of irrigation in the canopy [1]. Mangrove forest areas are generally located on the coast and live and thrive in locations that have a relationship with tidal influences in seawater [2] and river flow [3].

Mangrove forests are the primary ecosystem that supports life activities in coastal areas and plays an essential role in maintaining the balance of the environment's biological cycle [4]. The potential of natural wealth needs to be managed and utilized optimally to support the implementation of national development and improve the welfare of the community so that it can develop the sustainability of the coastal economy by managing mangrove forests as an ecotourism are [5].

Information on the actual, factual, and fast density of mangrove forests can be obtained through GIS-based satellites (Geographic Information System) to identify potential resources in coastal areas and oceans. GIS technology has several advantages, such as the price, which is relatively cheap and easy to obtain, the existence of a temporal resolution (Moity, Delgado, & Salinas-de-leo, 2019)

so that it can be used for monitoring purposes (Iii, Brown, & Flynn, 2019)), has complete coverage and can reach remote areas, the form of the data is digital so that it can be used for various purposes and displayed as desired. The use of remote sensing data in research, among others, is used for research on coastal and ocean development models [6].

Many kinds of research on mangrove density analysis assisted by Landsat images have been carried out, but this research is to correct and develop methods for deleting Landsat images. Some of the results of research carried out starting from the activity of assessing the degradation of the mangrove canopy density conducted by [8] obtained data on the distribution of mangroves around lagoons and along with river flows [9]. The distribution of mangroves is 5% -68%, which decreases in crown density each year. The method used is image analysis with composite band RGB 564, then classified and field observations. In contrast, the research analysis uses image data processing through reflectant analysis to obtain canopy density data [6], [10]–[12].

NDVI (Normalized Difference Vegetation Index) mangrove density analysis using Landsat satellite image data. NDVI values are calculated using the formula $NDVI = (IR-R) / (IR + R)$, where the IR value is the infrared part of the electromagnetic

spectrum, and the R-value is the red part of the electromagnetic spectrum [13]. NDVI values indicate the vegetation area [14]. Identification of vegetation density can be made quickly by interpreting Landsat images using NDVI transformations [15]. The level of vegetation density can be determined by using the NDVI technique, which is a spectral sharpening image transformation to analyze matters related to vegetation [16][17].

Mapping mangrove density using the NDVI vegetation index from Landsat 8 imagery with rare density classes having a pixel value range from 0.4765 to 0.6128, medium density classes having a pixel value range of 0.6128 to 0.7093, and dense or dense density having a pixel value range of 0.7093 to 0.7947 [18]. Mangrove density with NDVI values obtained at pixel values and data inventory on mangrove land area values must be analyzed and carried out in the Bengkulu area.

The research that has been carried out has identified the distribution of mangroves in Enggano Island. The findings of the research on the distribution of mangrove vegetation on the Southeast side of Enggano Island are in Tanjung Kaana, Tanjung Kanuhojo, Enggano Bay, Kiowa Bay, Kaohabi Cape, Labuho Bay, and Labuho Cape. The area of mangrove

forest from 2009-2016 experienced an increase in 22.545 Ha with mangrove area in 2009 of 1147,680 Ha and 2016 of 1170,225 Ha ([12], The research conducted has not identified the potential of the coastal mangrove in Bengkulu City.

Research on mangrove density on the coast of Bengkulu City assisted by Landsat imagery is not organized in spatial data. So this study identifies the extent of mangrove vegetation density and its distribution based on spatial data. The data used to analyze it is the Landsat 8 imagery of the 2019 recording year. The data analysis used is NDVI, then field observations are made with the pixel value in the image as a result of the classification of mangrove distribution. This research aimed to analyze the canopy density level of the coastal mangrove distribution in Bengkulu City.

2. METHOD

2.1. Time and Location

The research was conducted on May 20, 2019, by identifying a study on the distribution of mangroves in Bengkulu City. The Landsat image data analysis result showed that identified Bengkulu mangroves on the West Coast of Bengkulu City

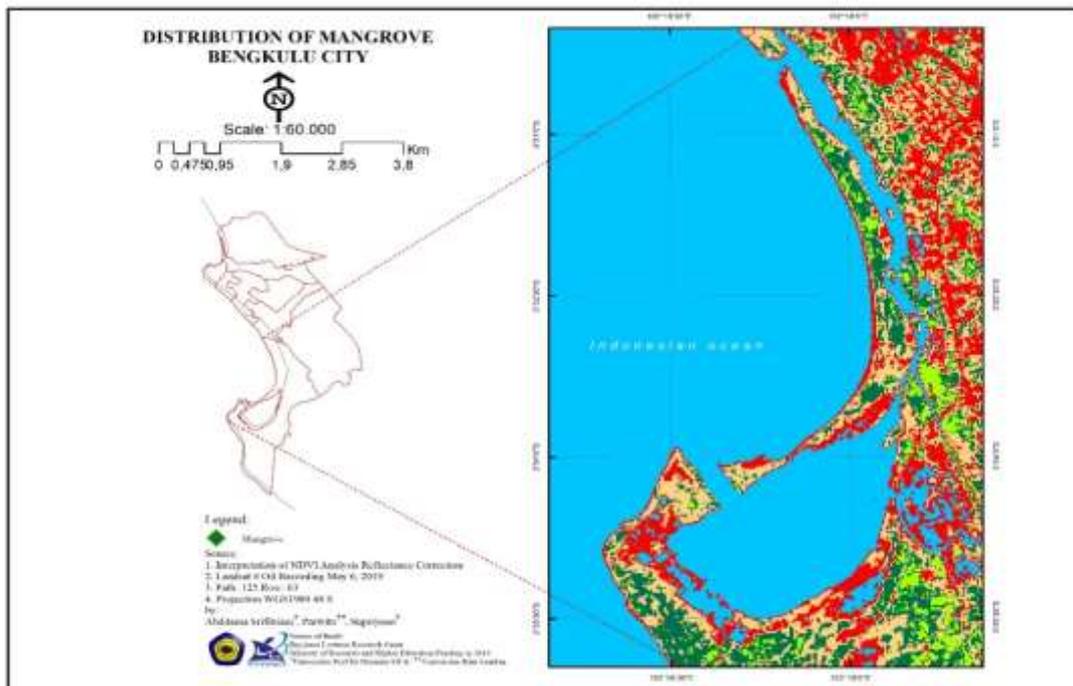


Fig. 1. Location Map of Coastal West Coast of Bengkulu City

2.2. The Tools and Materials

The tools and materials used in this study are as follows. In this research, Materials and tools needed are GPS, compass, camera, meter, tally sheet inventory data, stationery, calculating means, a computer with geographic information system

(GIS) software, machetes, and other supporting devices. The data analysis used is the Landsat 8 OLI (Operational Land Imager) path / raw 125/63 Landsat imagery data used to map mangrove forests. Landsat 8 OLI can be explained as follows.

Table 1. Bands and Wavelengths in Landsat

Band	μm	Resolusi	Aplikasi	
1	0.43-0.45	Coastal	30 m	Coastal/aerosol
2	0.45-0.51	Blue	30 m	Visible Wave
3	0.53-0.59	Green	30 m	
4	0.64-0.67	Red	30 m	
5	0.85-0.88	Near Infrared	30 m	
6	1.57-1.65	*SWIR 1	30 m	Vegetation Analysis
7	2.11-2.29	*SWIR 2	30 m	Better Resolution
8	0.50-0.68	Panchromatic	15 m	
9	1.36-1.38	Cirrus	30 m	Cloud Analysis
10	10.6-11.19	**TRS 1	100 m	Earth Temperature Analysis
11	11.5-12.51	**TRS 2	100 m	

*Short Wave Infrared, **Thermal Infrared Sensor

There are several new specifications attached to this Landsat band, especially in bands 1, 9, 10, and 11. Band 1 (ultra blue) can capture lower electromagnetic wavelengths than the same band on Landsat 7, making it more sensitive to reflectance differences in seawater or aerosol [19]. This band excels at distinguishing aerosol concentrations in the atmosphere and identifying seawater appearance characteristics at different depths. The detection of cirrus clouds is also better with the installation of band 9 on the OLI sensor, while the thermal band (bands 10 and 11) is very useful for detecting differences in the surface temperature of the earth with a spatial resolution of 100 m [20]

2.3. Landsat Processing and Analysis Methods

The stages of research carried out by digital image processing include geometric correction, radiometric correction, image classification, and NDVI value extraction. The Rupa Bumi Indonesia Map (RBI) is used to correct geometric Landsat imagery, explained in detail in image processing. Determination of sample plots in the form of shape, size, and number of plots will be used to collect forest physics data in the field. The research was started by downloading Landsat 8 imagery at <http://earthexplorer.usgs.gov>, after the image data is available, the image data is processed using geographic information system (GIS) software, the image is composed according to Red, Green, Blue (RGB). The image pixels are grouped, which is commonly called image classification. Image classification, mangrove and non-mangrove vegetation will be separated; it is necessary to validate by checking the actual field conditions and comparing them with the mangrove conditions obtained from Landsat 8 imagery. Mangrove distribution display information can already display based on the process that has been carried out.

Field data collection was carried out through forest stand measurement surveys. Several stand variables that must be measured in the field are woody plants, including tree diameter at breast height (DBH), tree species and tree height, dead plants, undergrowth, and litter as well as soil organic layer [21]–[24]. The scope of this research is only on the top surface so that the tree roots are not counted. For the mangrove ecosystem, the diameter of the sample trees used is 1.1 -67.1 cm, where a

maximum tree of 10 cm is found in the biomass allometric model for mangrove tree species from the origin of post-logging or rehabilitation planting. The measured tree height is the total tree height, which is the shortest distance from the top of the tree to the projection point on the flat plane and the size of the tree free of branches, namely the shortest distance from the fact-free of components to the end of projection on the plane. The horizontal distance between the ruler and the tree must be measured carefully.

The processed Landsat 8 image was analyzed by transformation using the Normalized Difference Vegetation Index (NDVI) using ArcGIS 10 software, the distribution of mangroves that had been processed was overlaid with the NDVI algorithm [25], from this process, the distribution of mangroves would be obtained and classified based on their density, then Landsat 8 imagery that has been processed with the NDVI algorithm is displayed on the mangrove distribution map and mangrove density map. To prove the results obtained, carried out a field survey as data validation. The field survey is also to determine the condition of the mangroves, surrounding buildings, and the nearest settlement location. The Normalized Difference Vegetation Index (NDVI) is a standard method used in comparing the level of the greenness of vegetation derived from satellite images and is a combination of penile technique and image reduction techniques. This NDVI transformation is one of the standard products of NOAA (National Oceanic and Atmospheric Administration), a weather satellite that has a polar orbit but pays special attention to the global phenomenon of vegetation. Various studies on changes in vegetation coverage on the African continent have used this transformation. The standard formula for calculating the NDVI value is in Equation [18], [26]–[28]. Collecting field data in the form of measurements of tree diameter at breast height and stand height. Estimation of actual mangrove density in the field is determined based on the allometric equation selected according to the forest characteristics from the image analyzed using the NDVI value. The formulas used in the NDVI transformation are:

$$NDVI = \frac{NIR - Red}{NIR + Red} \quad \dots \dots \dots (1)$$

Note: NIR = Band 4 (Near infrared)
 Red = Band 3 (Red)

3. RESULTS AND DISCUSSION

Distribution of Mangrove Vegetation Area
 The results of classification processing by digital means provide a clearer picture of mangrove vegetation's distribution around the object of research and more logic with real conditions in the field. According to [4] the object information generated by the classification results is more detailed and detailed. The spectral value of the image can distinguish between mangrove and non- mangrove land objects. Also, it can determine the image of coral reef objects

where can penetrate the spectral reflection from the water (Silitonga et al., 2018). Therefore, digital classification can result in more and better types for extracting the desired object. Map of Satellite Image Classification Results At the time of data processing, an interesting thing was found: the presence of several terrestrial vegetation with the range of Digital Number (DN) values identical to mangroves. This is thought to be due to the existence of a type of plant that has the same chlorophyll content as mangrove vegetation [20].

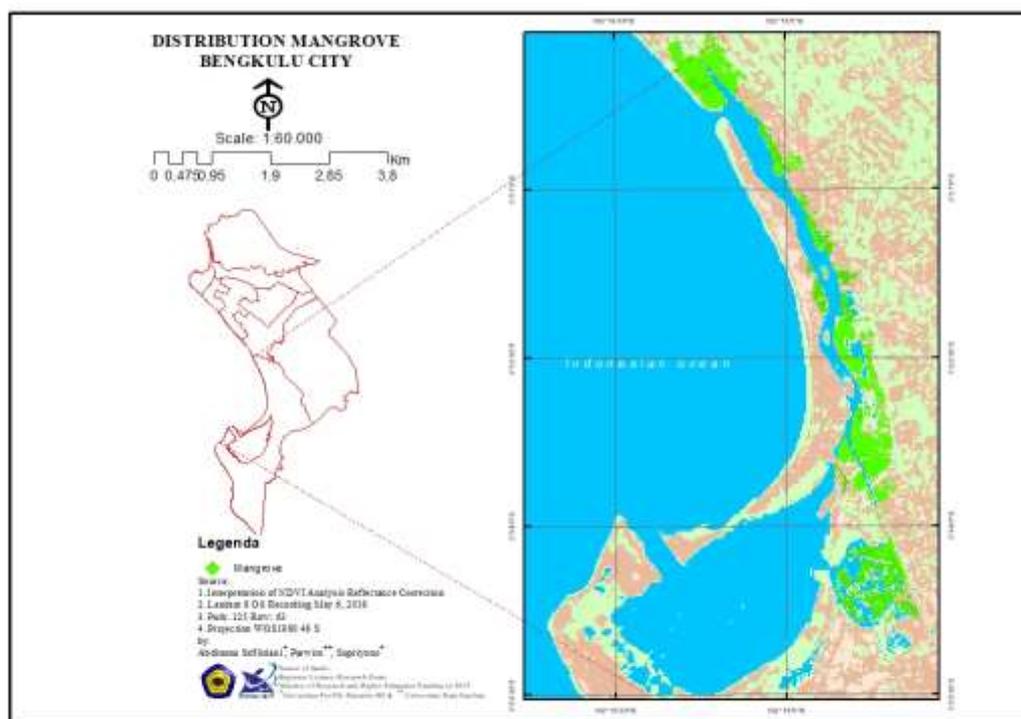


Fig. 2. Distribution of West Coast Coastal Mangrove City of Bengkulu City

The area of terrestrial vegetation is 255.24 ha. The separation between mangroves and non-mangroves must be adjusted to the mangrove habitat, namely in the area of the river estuary and towards the sea [29]. Besides, the separation of mangroves from non-mangroves is adjusted to the respective RGB results in the image. The classification is then reclassified into three classes: water, mangroves, non-mangrove vegetation, and coral reefs (Figure 3). Mangrove Vegetation Distribution Map on the South Side of the West

Coast of Bengkulu City. After processing Landsat image data in 2019, founded that mangrove vegetation on the South Side of the West Coast of Bengkulu City was 214.62 Ha in 2015 [30] and increased by 42.62 Ha to 255.24 Ha in 2019.

Map of Comparison Results of Mangrove Vegetation in 2015 with 2019. The increase in the area of mangrove vegetation in the South West Coast of Bengkulu City, precisely in the area of the Mangrove Tourm Pulau Baii Bengkulu area, shows that the mangrove condition is still

maintained and has not experienced pressure or damage and the creativity of the Karangtaruna community in preserving it in conservation nurseries mangroves. This is following the opinion of [31] in his writings on Wetland Conservation, which states that the mangrove ecosystem on the South Coast of the West Coast of Bengkulu City has special uniqueness, namely (1) as a mangrove tourism park Wonderful Bengkulu, (2) complete connectivity;

mangroves, coral reef seagrass beds, and (3) preserved sustainability. Vegetation can flourish if there are several rivers in the area. The confluence of freshwater from these rivers and saltwater from the Indian Ocean causes the area to become a brackish water area. The above conditions allow mangrove vegetation to thrive, which causes the formation of mangrove forests.

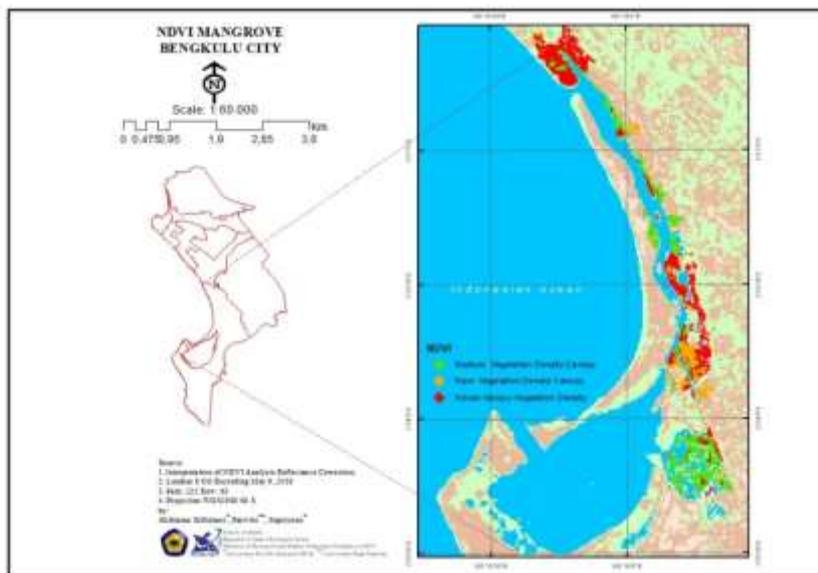


Fig. 3. Bengkulu NDVI Mangrove

The map of mangrove distribution on the West Coast of Bengkulu City is presented in Figure 3. The map of the digitization results of the West Coast of Bengkulu City is processed using ArcGIS software, which is then overlaid with the image of the West Coast of Bengkulu City with 564 composites. The digitization map is cut based on the position of the mangrove distribution shown in the composite image. 564 using the polygon cut tool. In Figure 3, you can see the distribution of mangroves on the 2.

west coast of Bengkulu City. Calculating the value of the Maximum Index Factor (OIF) on the 453 composite shows the same thing, namely, the habitats of mangrove forests on the West Coast of Bengkulu City are mostly in coastal areas which are flat to the mainland, with the largest area having mangrove forests is Sagulung district. Interpretation with these composites provides more contrast in the color of mangroves and non-mangroves to be represented at the mangrove density level in Table

Table 2. The Normalized Difference Vegetation Index (NDVI)

NO	NDVI Value	Density Class	Area	Percentage
1	-0,05-0,02	Vegetation density Sparse	39,06	15,30
2	0,02-0,17	Medium Vegetation Density	93,42	36,60
3	0,11-0,27	Dense vegetation density	122,76	48,10
Σ			255,24	100

Based on the value obtained from the NDVI calculation, a mangrove density map of the West Coast of Bengkulu City has been overlaid with the results of digitizing the West Coast of Bengkulu City. In Table 2, it can be seen that the density of mangroves on the West Coast of Bengkulu City is dominated by green, green is the density of rare classes with a value range of -0.05 to 0.27, and the density of medium and dense levels is only found in a few points such as in the southern part of the West Coast of Bengkulu City. Mangrove density is

obtained from the calculation of the NDVI algorithm using ArcGIS 10. The NDVI algorithm calculation uses band 3 and band 4 Landsat 8 imagery because these wavelengths are substantial differences in object reflection on vegetation and soil, so that it is useful as an estimator of the vegetation density index. Mangrove density is divided into three parts, namely: dense, medium, and sparse. The mangrove density value of the West Coast of Bengkulu City can be seen in Table 2.

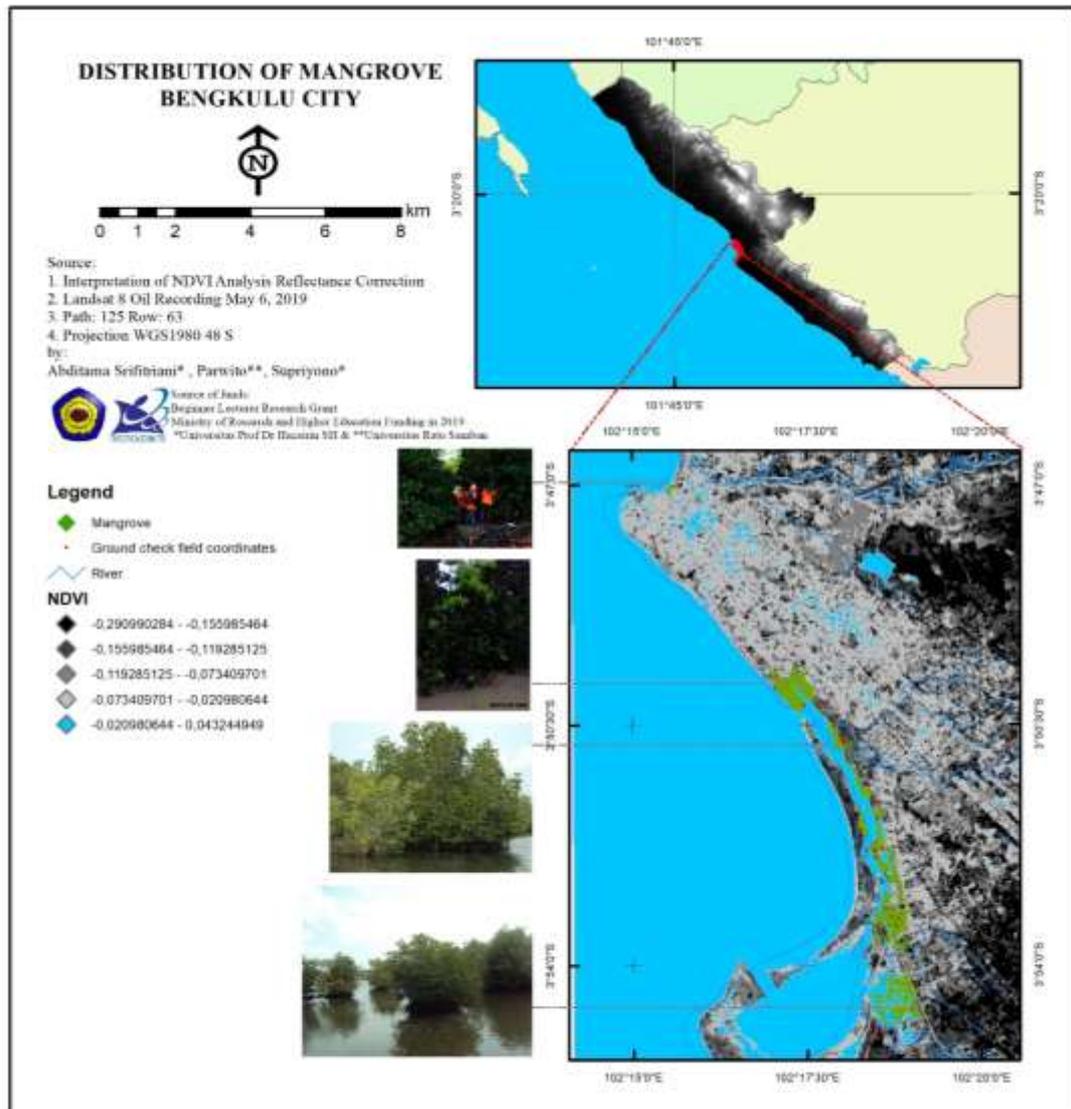


Fig. 4. Mangrove Field Appearance

Dense or dense densities, it is estimated that they are natural mangroves that have indeed grown for a long time in the area, but not all dense densities are natural mangroves. There are also mangroves resulting from land conversion with dense density. Likewise, at medium density. It is difficult to distinguish between natural and artificial mangroves; it is estimated that land conversion to mangrove land has been going on for a long time, causing artificial mangrove forests to resemble natural mangrove forests [32]. It is also suspected that at the time of replanting mangroves, the distance between mangroves was not too far away so that the converted mangroves became dense (Kresnabayu et al., 2019). At infrequent density, mangroves that have just grown naturally and resulted from the conversion are more dominant. The low image resolution of Landsat 8 imagery also makes it difficult to distinguish between natural and artificial mangroves.

To make it easier to analyze mangroves area, numbering is used in each area as in Figure 5. Based on the research conducted [1], [5] on the West Coast of Bengkulu City, 9 types were found, namely *R. apiculata*, *S. alba*, *B. gymnoriza*, *X. granatum*, *A. alba*, *H. tiliaceus*, *L. littoreae*, *C. tagal* and *A. aureum*. The diversity of species on the West Coast of Bengkulu City is high. The results of field validation showed the same thing, the mangrove species on the West Coast of Bengkulu City were also dominated by *rhizophora apiculata*, *rhizophora mucronata*. Each sub-district on the West Coast of Bengkulu City has a different mangrove area. Mangrove plants will grow in river flows [20] to the limit of seawater entry into the land and have relatively muddy soil types or until the final limit the tidal effects of seawater on protected beaches. In these blocks, some are in the form of primary mangrove ecosystems, secondary

mangroves, and some are in the way of areas with potential for mangrove planting [33].

Mangrove forests can actually be used for eco-tourism. The strategy for developing and processing mangrove forests on the West Coast of Bengkulu City through eco-tourism is based on three aspects: technical aspects, social aspects, and institutional aspects [34]. Technical elements that affect mangrove forest management: a) Types of mangrove plants, b) Mangrove planting patterns. c) Mangrove planting techniques. The social aspects of mangrove forest management include a) Total population and population density. b) Community participation in mangrove management. c) Public awareness in managing and maintaining mangrove forests. Mangrove conservation efforts with community participation are the key to success in mangrove conservation. This concept can be applied to the West Coast of Bengkulu, the industry, and tourism [30] Then the last one is the institutional aspect that affects mangrove forest management, including a) Support for Government Regulations. b) Government Support c) Participation of BLH and Higher Education circles.

4. CONCLUSION

Mangrove forests are the primary ecosystem that supports life activities in coastal areas and plays a vital role in maintaining the balance of the environment's biological cycle. The analysis of Landsat 8 OLI image data and validation of field observation data show the accuracy that the distribution and area of mangrove forests in the west coast of Bengkulu City is 255.24 ha, with a sparse to thick canopy density level of -0.05 to 0.27. This method can be used as an alternative in identifying mangrove vegetation information on the map. Mangroves on the west coast of Bengkulu City are dominated by *rhizophora apiculata*, *rhizophora mucronata* and are still relatively good.

5. ACKNOWLEDGMENTS

The author would like to thank DRPM Kemenristekdikti for providing grant funding for this research activity in 2020. The author also thanks Universitas Prof. Dr. Hazirin SH Bengkulu through LPPM for assisting in the research process. Then in the data collection and data analysis in the authors also say thank you to various parties who can not mention the authors one by one.

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