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Analysis of Spatial Changes in Mangrove Area with Satellite Interpretation of Landsat in Pasaman Barat Regency, West Sumatera Province

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Abstract.
The mangrove area in the coastal is a unique ecosystem that is influenced by tidal activities. The physical condition of mangroves often changes, because of various activities occurring in this area, especially in Pasaman Barat Regency. This study was conducted from September 2019 to March 2020. This study aims to analyze the distribution of mangrove areas in 2019 and changes that have occurred from 2009-2019 in Pasaman Barat Regency. By using a survey method based on the interpretation of Landsat satellite imagery which is analyzed descriptively. The results of the study are the distribution of mangrove areas in the Pasaman Barat Regency in 2019, are located is Sungai Beremas Subdistrict with an area of 844.06 ha with a dominant densevegetation density, Sungai Aua Sub-district and Sasak Ranah Pasisie Sub-district with an area of 96.18 ha which has a medium-dense vegetation density, and in the Kinali Sub-district with an area of 332.20 ha which has a dense vegetation density. Then mangrove change from 2009-2019 in Sungai Beremas Sub-district has lossabout 57.01 ha or 6.33%, the same condition has loss the area in Sungai Aua Sub-district and Sasak Ranah Pasisie Sub-district covering an area of 25.66 ha or 21.06%, and then in the Kinali Sub-district is known that the added in the area of the mangrove area is 38.54 ha or 13.12%. The vegetation found was dominated by *Rhyzophora apiculata, Rhyzophora mucronata, Rhyzophora stylosa, Soneratia alba, Bruguiera gymnorhiza and Nypa frutican.*

Keywords: *GIS, Landsat Image, Mangrove coverage, NDVI, Distribution, Change, Pasaman Barat Regency*

1. Introduction

Mangroves that are scattered throughout the world, around 46% of the total are found to have disappeared, the various benefits of the mangrove ecosystem consist of the role of physical factors, ecological factors, and social factors so that the mangrove ecosystem is an important ecosystem in coastal areas, i.e as a livelihood of the population, mitigating warming globally, natural disaster mitigation in the form of tsunamis and coastal defense provided by the existence of these natural resources has a very important meaning in coastal areas [1-4]. It is estimated that Indonesia's total mangrove area is around 4.25 million ha (hectares), which represents about 20% of the world's mangroves. As the island of Sumatra, i.e in the area of Mandeh, Koto XI Tarusan Pesisir Selatan Sub-district, West Sumatra Province also experienced a decrease in the mangrove area, reaching 24.16% (19.12 ha), while in Bungus Beach, Teluk Kabung, the City of Padang also experienced management of

the mangrove area which decreased by 25.23% from 2009 as large as 80.71 ha and in 2019 only 60.35 ha were found over 10 years. As nationally, almost 50% of Indonesia's mangroves have been lost and degraded from various factors [5-7].

Various interests overlap in this area, land conversion continues to occur, including for clearing land in the fields of fisheries, agriculture, and plantations, and pressure for land expansion for settlers and the development of various infrastructure sectors from the government. [8] explains that most of the islands of Java and Sumatra, more than 200,000 ha of mangrove forests at the end of 1960 have been lost, as they have been systematically exploited since 1800 for the development of brackish water shrimp pond cultivation and harvesting of wood products. Various efforts to protect and improve mangrove areas are a tough task that must be carried out for the realization of a mangrove ecosystem sustainability, which has very important roles and functions in coastal areas. So from that, to maintain and plan to preserve this mangrove area, the latest data in the form of mangrove area coverage is needed so that it can be used as initial data for planning its sustainability program. One of the programs that help in making mangrove cover is the remote sensing method, which studies and determines the mangrove area as land cover with certain criteria.

Remote sensing can be used as an alternative in analyzing a mangrove area, by analyzing information in the form of time criteria and specific area coverage, as well as in access to where it is difficult to reach. Various studies and research results have found a better method for analyzing mangroves, one of which is land cover classification, with a high and satisfactory level of accuracy up to 83-88.9%. Then to determine the presence of vegetation with non-vegetation can also be done by applying vegetation techniques, i.e vegetation techniques, i.e Normalized Difference Vegetation Index (NDVI) So that it can be used in assessing changes in mangrove cover properly [9-13].

The large potential of the mangrove area, for this we need a database in the form of area coverage and changes in the area, so that it can be used as initial data to analyze efforts to create the sustainability of mangrove areas. The purpose of this study is expected to provide information on the distribution and change analysis of mangrove areas in Pasaman Barat Regency.

2. Methodology

The research was carried out in the coastal area in Pasaman Barat Regency, starting from September 2019 to March 2020.

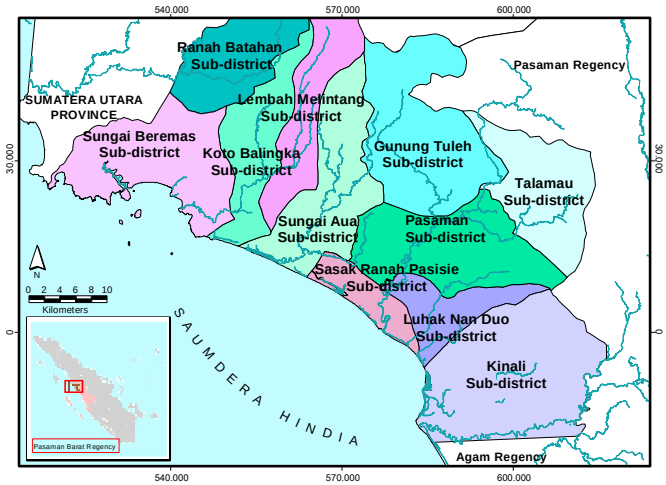

Figure 1. Map of the research location

The Landsat satellite data used are Landsat 5^{TM} 2009 (acquisition 1 December) and Landsat 8^{OLI} 2019 (March 31 acquisition). Path/Row 128/60. The application in this processing uses Er-mapper and Arcview-Gis as data analysis. The data analysis procedure in detecting land cover is the method Optimum Index Factor (OIF), which can provide the best combination of bands so that it provides a

good interpretation in determining land cover studies. Using the equation against the Standard Deviation with the Correlation Coefficient of the 3 bands combined [14,15].With an RGB composite that sharpens the cross-section of mangrove cover with other covers, Image classification is carried out using a *Supervised Classification Method* using the *Maximum Likelihood Standard* calculation algorithm. The assessment of vegetation uses the NDVI method so that it separates vegetation from non-vegetation [16].

NDVI value of the image.

$$\text{NDVI} = \frac{(NIR-RED)}{(NIR+RED)} \quad (1)$$

Description :
NIR = Near Infrared
Red = Red (red band)

The canopy density of this vegetation can be classified into the criteria according to the Ministry of Forestry in 2005[17], that the canopy density score is divided into dense canopy density, medium canopy, and rare canopy with the NDVI value of the image according to Tabel 1 below:

Tabel 1. Criteria for the NDVI value

Criteria	NDVI value
Spare	0.43≤ NDVI≤1
Medium	0.33≤ NDVI≤0.42
Dense	-1.00≤ NDVI≤0.32

Source: Ministry of Forestry, 2005

Detection of land cover area.

$$L = \sum p \times r \times 0{,}0001 \quad (2)$$

Description :
L = Area (ha)
$\sum p$ = Number of Pixels
r = Landsat 30x30m resolution
0.0001 = Convert $m^2$to Ha

Covered change detection.

$$V = \frac{N2-N1}{N1} \times 100\% \quad (3)$$

Description :
V = Change Rate (%)
N1 = Area of Initial / Base Year (ha)
N2 = Area of Year n (ha)

3. Results and Discussion

3.1. Land cover classification

The determination of the combination of land cover bands is carried out based on the Optimum Index Factor (OIF) method, with a more effective combination based on the standard deviation value and the correlation coefficient of the number of bands used [14]. Seven bands of Landsat satellite imagery are used to form 35 band combinations.

Tabel 2.OIF values and sequence of combinations of Landsat 8 imagery in 2019

Combination	∑ Std	∑ Correlation of metrics	OIF value	Order
RGB 156	202,038	2,490	81,140	1
RGB 256	199,384	2,480	80,397	2
RGB 125	187,821	2,390	78,586	3
RGB 157	195,498	2,500	78,199	4
RGB 257	192,844	2,480	77,760	5
RGB 456	194,024	2,520	76,994	6
RGB 356	196,942	2,570	76,631	7
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Figure 2. Composite combination RGB 561

The highest value of the composite band formed from these 35 combinations is the RGB 156 combination, which consists of several composites, i.e RGB 165, RGB 561, RGB 651, RGB 516, RGB 615. For this reason, the RGB 561 composite provides better color gradations as seen on land. brownish-yellow and the water body is dark black, then it can provide good information on the land cover of the study area. The classified land cover classes can be mapped well, based on the accuracy results obtained that the overall accuracy is 88% and the Kappa statistical value is 85%. The land cover that has been identified can be explained in accordance with the National Standardization Guidelines Number 8 of 2007 concerning "Classification of the land cover" Indonesian National Standard (RSNI-3), according to the explanation of Tabel 3 below:

Tabel 3. Classification of land cover classes

No.	Land Cover Class	Information
1.	Mangroves	Vegetation that grows in transitional areas of land and sea which is influenced by water salinity levels, with the dominant mangrove plants
2.	Body of water	All water appearances, both rivers (freshwater) and sea waters
3.	Open field	Land that is not overgrown with any vegetation, in the form of open land or sand
4.	Forest	Vegetation overgrown by all types of forest plants, from low to highlands
5.	Plantation	Land overgrown by plants with a change of planting or a harvest period of at least 2 years
6.	Residential building	Land that is used as the place where the human environment is built

3.2. Distribution of the mangrove area of Pasaman Barat Regency

The distribution of mangrove areas in the district. West Pasaman in 2019 can be found in 4 sub-districts, i.e Sungai Beremas Sub-district, Sasak Ranah PasisieSub-district, Sungai Aur Sub-district,and Kinali Sub-district. The total area of mangrove areas can be identified with a total of 1,272.44 ha, as can be seen in the following Tabel 4 below:

Tabel 4. Extent of the mangrove area of West Pasaman Regency in 2019

No.	Location	Area (ha)
		2019
1.	Sungai Beremas Sub-district	844.06
2.	Sasak Ranah Pasisie & Sungai Aur Sub-district	96.18
3.	Kinali Sub-district	332.20
	Total	1,272.44

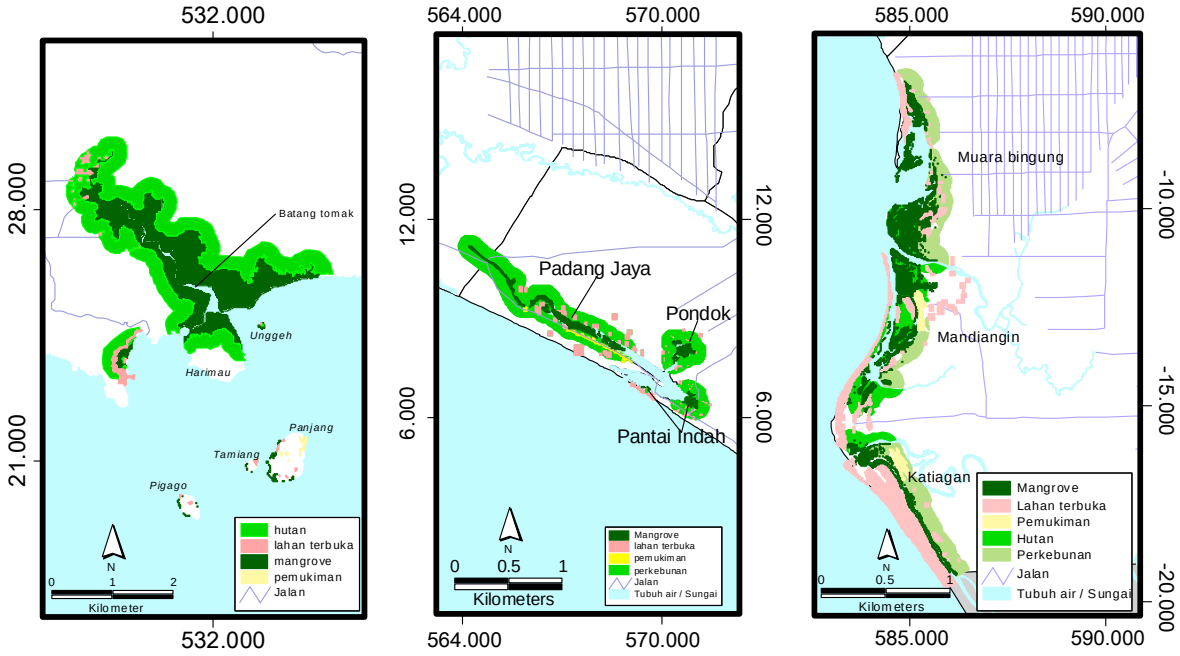


Figure 3. Cover of mangrove area in Pasaman Barat Regency 2019 at (a) Sungai Beremas Sub-district, (b) Sasak Ranak Pasisie Sub-district & Sungai Aua Sub-district, and (3) Kinali Sub-district

Distribution of mangroves in the district. Beremas River with an area of 844.06 ha, was found to grow in the Batang Tomak estuary with an area of 768.19 ha, Harimau Island and Unggeh Island with an area of 63.63 ha, Pigago Island with an area of 1.89 ha, Tamiang Island 0.63 ha, Pangka Island has an area of 1.98 ha and Panjang Island has an area of 7.74 ha.With an NDVI value of 0.11 - 0.52 which is classified as a spare to dense canopy density. Among the types of mangroves that can be found are *R. apiculata, R. Stylosa, R. mucronata, C. tagal, S. alba, S. ovata, S. caseolaris, B. gymnorhiza, B. sexsengula, N. fruticans, L. littorea , X. granatum, A. alba, B. parviflora, S. hydrophyllacea, A. corniculatum.* As for in the Sasak Ranah Pasisie Sub-district and Sungai Aua Sub-district have been found to grow along the river estuary originating from Batang Sialang, located in Nagari Maligi which can be mapped with a mangrove area of 96.18 ha. The mangrove areas were found to be in good condition with moderate to dense crown density values, which had an NDVI value between 0.31 to 0.48. As for the distribution of

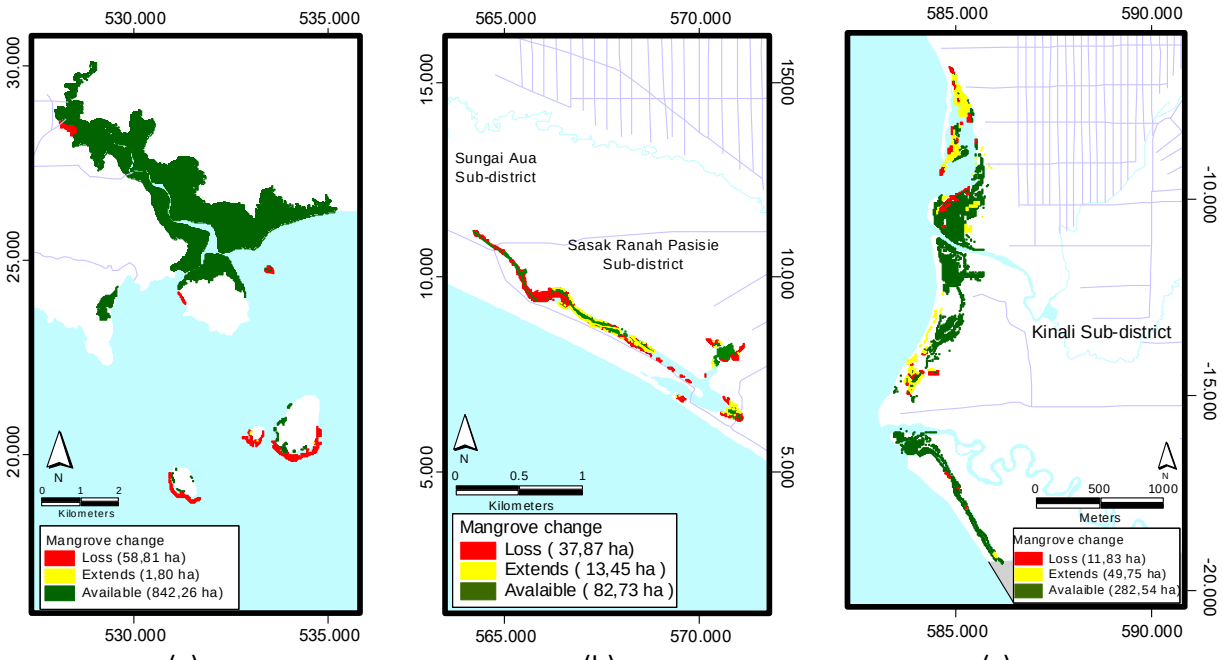
mangrove areas, i.e in Jorong Padang Jaya covering an area of 66.52 ha, Jorong Pondok 18.54 ha, and in Pantai Indah 11.12 ha. The vegetation was dominated by *R. apiculata, R mucronata, B. gymnorhiza, S. caseolaris, N. Fruticans, T. catappa and A. Ebracteatus.* Distribution locations in the Kinali Sub-district can be found in Nagari Katiagan-Mandiangin which is a village that is also on the coast of West Pasaman which is directly adjacent to the Agam Regency West Sumatra Province. The area of the mangrove area reaches 332.20 ha, which is in the Jorong Katiagan location of 54.85 ha, at Jorong Mandiangin 119.31 ha and in Muara Bingung 158.04 ha. The types of mangroves found in this location, *S. alba, R. apiculata, R. mucronata, N. frutican and T. catappa* that grew in good conditions, showed a dense crown density with identification of NDVI values between 0.38 - 0.55.

3.3. Changes in land cover in the mangrove area of West Pasaman Regency

The mangrove area in West Pasaman Regency from 2009-2019 has generally decreased in the area. The results of satellite imagery interpretation show that the area of mangrove vegetation in 2009 was 1,319.26 ha and decreased 1,272.44 ha in 2019. Based on the area data from this interpretation of multi-temporal satellite imagery, the area of mangrove areas experienced land degradationan area of 44.13 ha ranges from the percentage decline of 3.35% over the last 10 years.

Tabel 5. Changes in the area of mangroves West Pasaman Regency 2009 - 2019

Location	Area (ha)		2009-2019 Changes coverred	
	2009	2019	(Ha)	(%)
Sungai Beremas Sub-district	901.07	844.06	-57.01	-6.33%
Sasak Ranah Pasisie & Sungai Aua Sub-district	121.84	96.18	-25.66	-21.06%
Kinali Sub-district	293.66	332.20	38.54	13.12%
Total	1,316.57	1,272.44	-44.13	-3.35%



(a) (b) (c)

Figure 4. Physical changes in mangrove cover in Pasaman Barat Regency at 2009-2019in (a) Sungai Beremas Sub-district, (b) Sasak Ranak Pasisie Sub-district & Sungai Aua Sub-district, and (3) Kinali Sub-distric

Changes in mangroves in Sungai Beremas Sub-district during the last ten years from 2009-2019 have decreased with a percentage of an area decline of 6.33% or 57.01 ha.The decline in mangrove area also occurred in Nagari Maligi, which is administratively located in Sasak Ranah Pasisie Sub-district, i.e in Muara Maligi from Batang Sialang, which is an area of 27.64 ha or 22% from 2009.While in the Kinali Sub-district can be seen that the change in an area that occurred in the form of an increase in mangrove areas from 2009-2019 was 38.54 ha or 13.12%.

4. Conclusion

The distribution of mangrove areas in West Pasaman Regency is predominantly located in the coastal areas along the West Pasaman coastline. The mangrove vegetation area is located in Sungai Beremas Sub-district, Sasak Ranah PasisieSub-district, Sungai Aur Sub-district,and Kinali Sub-district. The area of mangrove areas in 2019 is 1,272.44 ha, which can be found in 7 families, 17 species including *R. stylosa, R. apiculata, R. mucronata, B. gymnorhiza, B. sexsengula, B. parviflora, C. tagal, S. alba, S. ovata, S. caseolaris, T. catappa, L. littorea, S. hydrophillacea, N. fruticans, A. cornicullatum, A.ebracteatus,* and *A. Ilicifolius.* Sungai Beremas Sub-district is a mangrove area with an area in 2019 in the Batang Tomak estuary, Harimau island& Unggeh island, Panjang island, Tamiang island, Pigago island, and Pangka island. Condition of mangrove area in Sungai Beremas Sub-district has decreased in the area from 2009-2019 to reach 57.01 ha. The same condition in Sasak Ranah Pasisie Sub-district and Sungai Aua Sub-district has also experienced a decrease in the area of 25.66 ha for 10 years, while mangroves are scattered in Jorong Padang Jaya, Jorong Pondok, and in Pantai Indah. While in the Kinali Sub-district mangrove area is known to have increased in area from 2009-2019, i.e an area of 38.54 ha,which is scattered in several locations, i.e Jorong Katiagan, Jorong Mandiangin, and Muara Bingung. The cause of the decline in mangrove area comes from natural factors in the form of climate that causes abrasion and strong winds, land-use change to plantations and anthropogenic activities (residents) of the communities around the mangrove vegetation area. Meanwhile, the planting program from the provincial Forestry Service provided an increase in the distribution area of mangroves in the Kinali Sub-district.

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