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Analysis of Changes in Mangrove Land Cover in West Langsa District, Langsa

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Abstract: This study aims to analyze changes in land cover and mangrove crown density in Langsa Barat District for the period 2000-2020. The method used in this study is the maximum likelihood classification (MLC) to determine changes in mangrove land cover while determining mangrove density using the NDVI equation. Based on the results of the analysis of changes in mangrove land cover there was an increase and decrease in area. In 2000 the area of mangrove land was 1,039.17 ha, then increased in area in 2005 amounted to 1.325,59 ha (27.56%). In 2010, the mangrove area decreased by 1.145,22 ha (15.75%). In 2015, the mangrove area increased to 1,357.10 ha (18.50%), and finally, in 2020 there was an increase in the mangrove area to 2.027.05 ha (49.37%). While the analysis of mangrove crown density using NDVI value from 2000 to 2020, the highest crown density value was in 2020 with the category of the dense crown density of 1,509.40 ha (74.46%), while the medium crown density value was recorded in 2020 namely 517.49 ha (25.53%). Meanwhile, the lowest sparse category canopy density value was recorded in 2020 with an area of 0.17 ha (0.01%).

Keywords: Mangrove; NDVI; Remote Sensing; West Langsa District

Introduction

Indonesia is one of the largest archipelagic countries in Southeast Asia and has a very large number of coastal areas with a coastline of 95,181 km. This value makes Indonesia the fourth longest coastline in the World. The large potential of coastal natural resources owned by Indonesia with a diversity of ecosystems in it, one of them is the mangrove ecosystem. Coming from the world's mangrove area of 15.9 million hectares, 27% is more or less located in Indonesia with an area of around 4,251 million hectares (Hartini, 2013).

Mangrove forests are highly productive communities of woody plants that grow in tropical and subtropical regions. Mangrove forests are very important for the people, ecology, and economy of coastal areas (Zhu et al., 2021). Mangroves can be defined as a group of plants consisting of different species and tribes, but with the same ability to adapt to habitats that are affected by tides. In addition, mangrove forests are a breeding ground for marine biota, protect coastal communities from natural disasters, provide sediment stabilization from sea-land interactions, filter for land pollutants, serve as food producers, medicines, and building materials and increase the value of biodiversity for local communities (Maryantika & Lin, 2017).

In fact, the existence of mangrove forests has been threatened globally by deforestation due to human activities, especially industrial activities, residences, and cultivation (Maryantika & Lin, 2017). This is due to the lack of public understanding of the importance of mangrove ecosystems in maintaining environmental sustainability which is still insufficient. In addition, ecosystems provide economic benefits such as brackish water cultivation, shrimp ponds, tourism, pharmaceutical production, building materials, wood, and other non-timber products (Maulani et al., 2021).

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While the biological benefits of mangroves function as a nursery ground, feeding ground, and spawning ground (Annisa et al., 2019). The role and function of mangroves have been continuously decreasing in quality and quantity along with the development of land use and changes in land cover carried out by some humans relatively quickly in an area (Long & Giri, 2011).

In the last ten years, many researchers have made observations about land cover change, estimates of the causes of land use change, and modeling predictions of land cover change (Hua-lou et al., 2000). Land use and land cover (LULC) recently emerged as a topic of interest in various fields, research fields. Industrialization, population growth, and migration to cities are considered the most influencing factors in land use change around the world (Dwiprabowo et al., 2014), as happened in the city of Langsa.

The existence of mangrove forests in Langsa City has had a major impact on the economic growth and development of the people in Langsa (Setiawan & Zaitunah, 2016). Mangrove forests protected by local regulations or *Qanuns* in Langsa serve as ecotourism for the local community (Andiny & Safuridar, 2019). Many of the mangrove forests in Langsa have changed their function into gardens, converted into ponds and residences as well as illegal logging to make charcoal. On the other hand, the existence of supporting data to monitor mangrove management in West Langsa District is still very minimal. Most of the data on mangroves in the West Langsa district is still attributable, uneven, and still minimal in publications. Therefore, to obtain the distribution area and density of mangroves in West Langsa District, Langsa by using remote sensing technology.

Remote sensing and Geographic Information Systems (GIS) can be used to monitor changes in mangrove land cover. This is because this technology has several advantages, including it is cheaper and easier to obtain, has a temporal resolution (repetition) that can be used for monitoring purposes, has a wide range and can reach remote locations, the data format is digital, then it can be used and displayed freely (Widyantara & Solihuddin, 2020). Remote sensing can be used in monitoring mangrove vegetation based on two important characteristics, namely mangroves contain green leaf matter (chlorophyll) and mangroves grow on the beach. The optical properties of chlorophyll are very distinctive, i.e. chlorophyll absorbs the infrared spectrum and reflects strongly in the red spectrum.

The use of remote sensing technology is one method that is widely used to map and determine the condition of an area using the classification method. Classification is designed to reduce thematic information by grouping phenomena based on criteria (Hendrawan et al., 2018). Thematic information from the results of image classification needs to be assessed for the accuracy of the information content, so an accuracy test is needed. to determine whether the data can be used or not (Danoedoro, 1996). High spatial resolution imagery has an impact on the enhancement of overall accuracy in assessing land cover classification (Akar et al., 2017). This is proven by research by Chen et al. (2015) stated that the method of classification maximum *likelihood* on satellite imagery with a spatial resolution of 30 m gains overall accuracy of 63.1%. Remote sensing is an essential data source for estimating vegetation cover over large areas (Barati et al., 2011). Remote sensing can be used in monitoring mangrove vegetation based on two important properties, namely, mangroves have green leaf substance (chlorophyll) and mangroves grow in coastal areas (Barati et al., 2011).

According to research (Maryantika & Lin. 2017), remote sensing data provides a high variety of spectral information and can identify changes in land cover and mangrove forest density. This is caused by the geographical location of mangrove forests which are in the transitional area of land and sea providing a distinctive recording effect when compared to other land vegetation objects. One of the satellites that can be used to detect mangrove forests is *Landsat 7* and *Landsat 8*. To analyze image data in determining mangrove vegetation using *Landsat 8* with a 564 composite while *Landsat 7* uses a combination of bands 7, 4, 2 and 7, 5, 3 with a SWIR-2 filter (increasing soil moisture, identifying vegetation types and cirrus clouds), NIR (emphasizing content and margins of biomass) and Green (the upper part of vegetation that is useful for assessing that vegetation) (Purwanto et al. 2014). This study aims to analyze changes in land cover and density of mangrove crowns in the West Langsa District.

Method

Research Location

This research was conducted from January to April 2022 in West Langsa District, Langsa City. The data collection activities were carried out between January and February and the data were analyzed from March to April. The general condition of the study area was between 4.470750° -4.5020° North latitude and 97.9605 97.9773° East longitude with flat land topography and an altitude of 0-29 MASL, as shown in Figure 1.

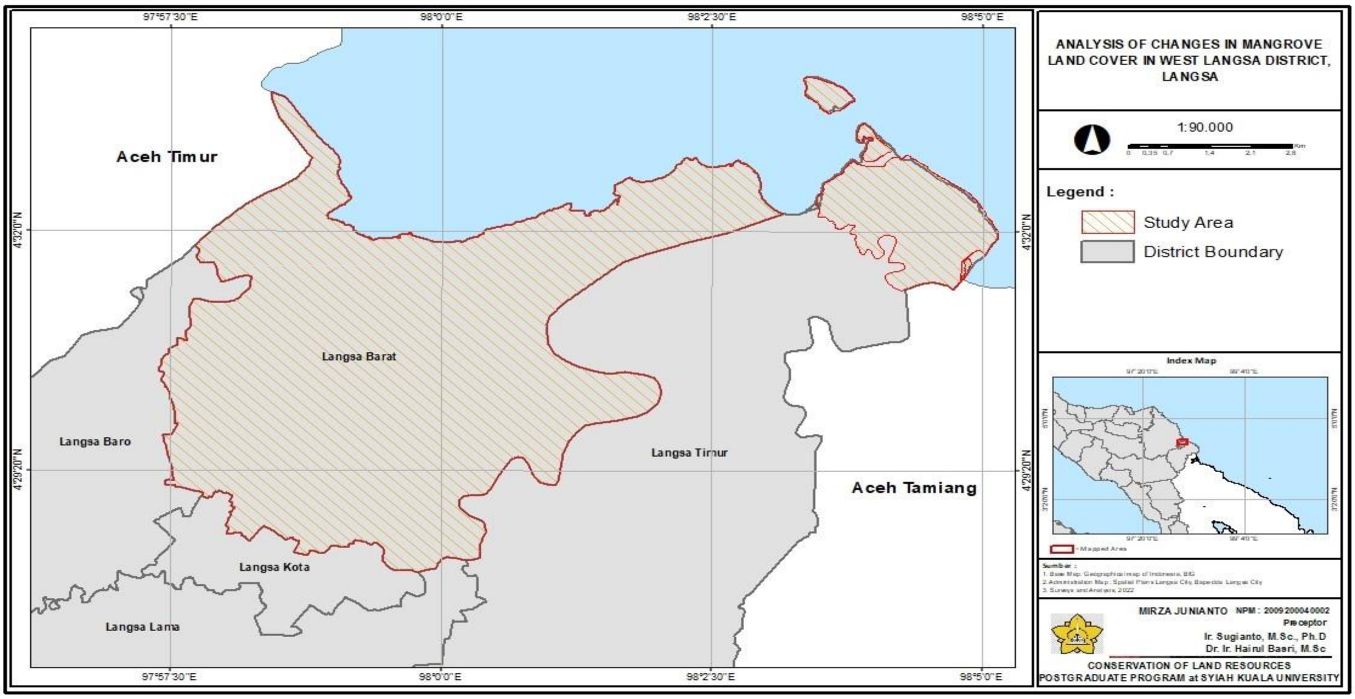


Figure 1. Map of the Research Area

Materials and Tools

The materials used are *Landsat 7 ETM* and *8 OLI path path 129/57* acquisitions in 2000 and 2010 for *Landsat 7* and 2015-2020 for *Landsat 8* and administrative maps of Langsa City. While the tools used were computers equipped with ArcGIS 10.8 and ANVI 5.0 software. Values was used as the criteria as shown in Table 1. While the NDVI equation used is as follows:

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

Descriptions:
NIR: Spectral value of the Near Infrared band
RED: Spectral value of the red channel

Table 1. Criteria for Mangrove Density Level Based on NDVI Value

NDVI Value			Vegetation Density
-1.00	-	0.32	Sparse
0.32	-	0.42	Moderate
0.42	-	1.00	Dense

Source: Irawan et al (2019)

Data analysis

Changes in mangrove land cover were analyzed qualitatively and quantitatively. In qualitative analysis, changes in mangrove land cover are presented spatially in the form of maps of the distribution of mangrove land cover. A map of mangrove land cover in the year of observation is presented by providing information on where there has been a change in mangrove land cover either addition or reduction using the Maximum Likelihood Classification (MLC) method.

Quantitatively, monitoring of changes in mangrove land cover was identified based on changes in the area in each year of observation. Calculation of the area of mangrove land cover was carried out using the calculate geometry function in the ArcGis 10.8 software. While the analysis of crown density using the Normalized Difference Vegétation Index (NDVI) method. Assessment of mangrove canopy density.

Result and Discussion

Analysis of Changes in Mangrove Land Cover

Analysis Changes in mangrove land cover in this study were carried out from 2000 to 2020 in Langsa Barat District. Information on the area of mangrove land cover was obtained by observing every year based on visual interpretation of remote sensing data. In 2000 the area of mangrove cover in West Langsa District was 1,039.37 hectares. Meanwhile, in 2005 the area of mangrove land cover increased to 1,325.95 hectares; in 2010, it decreased to 1,145.22 hectares. Concurrently, in 2015 the area of mangrove land cover again increased by 1,357.10 hectares. The trend of the increasing area continued in 2022, with an area of 2,027.05 hectares (49.37%). Information on the area and changes in the area of mangrove land cover can be seen in table 2 below:

Table 2. The Area of Mangrove Land Covered from 2000-2020 in West Langsa District

Year	Mangrove Land Cover Area (ha)	Changes (%)	Information
2000	1,039.17		-
2005	1,325.59	27.56	Increase
2010	1,145.22	15.75	Decrease
2015	1,357.10	18.50	Increase
2020	2,027.05	49.37	Increase

Source: Results of Data Processing and Analysis (2022)

Based on Table 2, the change in mangrove area from 2000 to 2020 increased in the area, except in period 2005-2010. The overall mangrove area was scattered in every village in West Langsa District with a variety of data presentations. The mangroves located in *Teulaga Tujuh* Village in 2000 had the highest area among the thirteen other villages. This is due to where most of the mangroves in *Teulaga Tujuh* Village have the status of a Protected Forest area, Production Forest, and Conversion Production Forest. Also, Based on the Decree of the Minister of Environment and Forestry number 580/MenIhK/Setjen/Set.1/12/2018 concerning the Aceh forest area. Presenting a map of the distribution of mangrove land cover simultaneously in different observation years allows us to know changes in the distribution of mangrove land cover as shown in Figure 2.

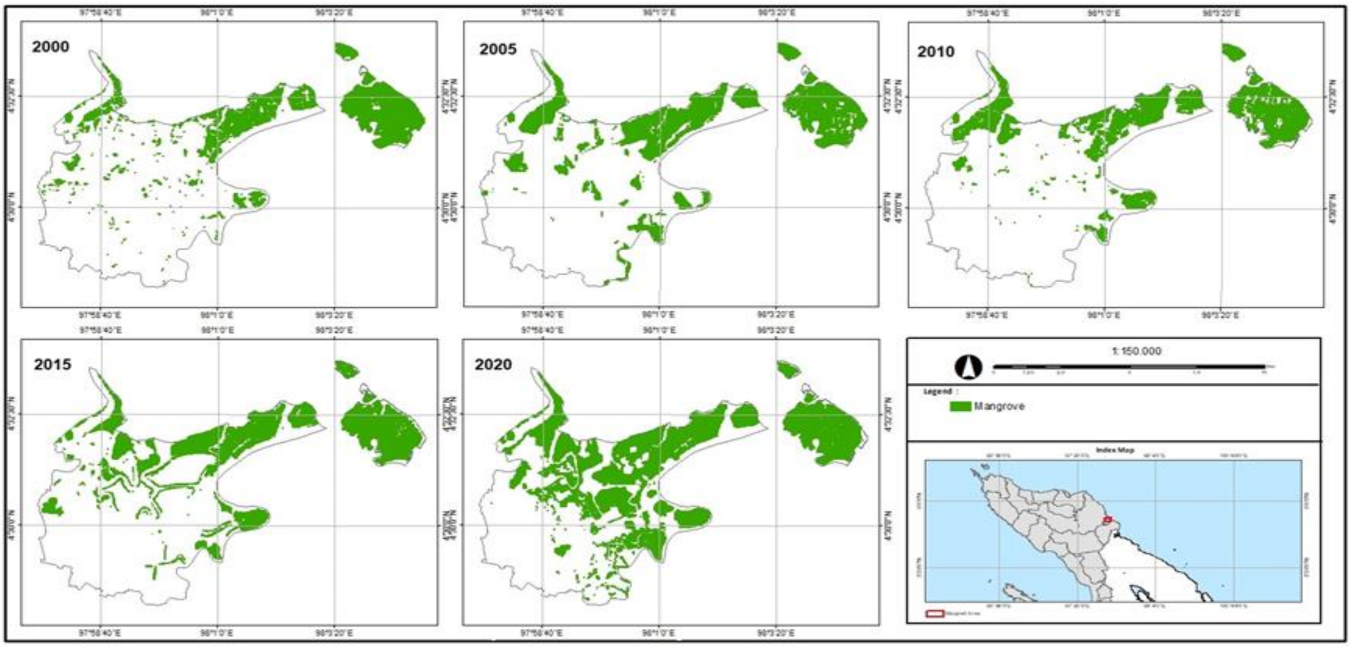
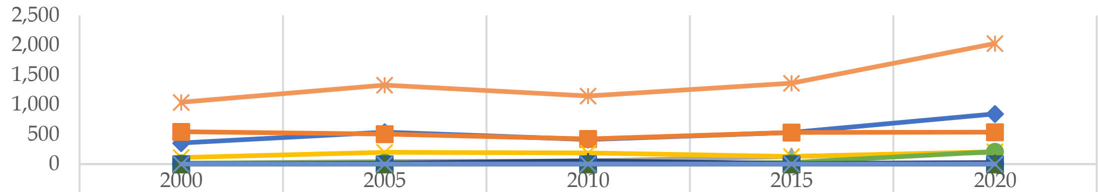


Figure 2. Map of Changes in Mangrove Land Cover for the Period 2000 - 2020

The decrease in the area of mangrove land in the 2005-2010 period was caused by the conversion of land into residences. According to Syamsu et al. (2018) changes in the area, distribution, and density of mangroves are strongly influenced by changes in land use, especially changes in mangrove land into residential areas. This is in line with the population data in West Langsa District which continues to increase every year. In 2005, with a population of 28,275 people, it increased in 2010 to a population of 30,583 (Central Bureau of Statistics, 2010 & 2011). In addition, the decline in mangrove land area was triggered by illegal logging activities in mangrove forests and natural conditions. The natural damage that often occurs in mangrove ecosystems is due to events caused by nature such as the occurrence of high waves which cause erosion and abrasion of mangrove forests (Armanda et al., 2021).

The distribution of mangroves in *Kuala Langsa* Village in 2010 - 2015 has increased covering an area of 532.39 ha, similarly, with *Teulagapuh* Village, *Simpang Lhee* and *Sungai Pauh* increased in mangrove area. This was due to the rehabilitation and revitalization of mangrove forests, especially on damaged mangrove land. To support the rehabilitation and revitalization of mangrove forests, nursery and mangrove plant nurseries programs are then planted in coastal areas where the quality of the environment is declining is needed (Sari et al., 2018). In addition, the government, community, and environmental activist Non-Governmental Organizations (NGOs) planting mangrove programs have also contributed to changes in the increase in the area of mangroves in Langsa Barat District. This is in line with Kurniawansyah et al. (2022), the cumulative growth of the mangrove sector was due to several mangrove planting programs originating from the local government or NGOs which were successfully planting and increased the area each year.

Meanwhile, the area of mangrove land in *Lhok Banie* Village area was reduced the overall area of mangrove land. The trend of increasing mangrove area will still occur in 2020 when the overall distribution of mangroves has increased in area in each village. *Kuala Langsa* Village is one of the thirteen villages was the highest increase in the mangrove area, namely 843.90 ha or an increase of 311.51 ha. Meanwhile, *Lhok Banie* Village increased littlest in the area of 2.35 ha. Overall, the distribution of mangroves in villages in West Langsa District can be presented in Figure 3.



	2000	2005	2010	2015	2020
Kuala Langsa	354.48	536.70	413.81	532.39	843.90
Teulaga Tujuh	544.05	505.19	422.68	531.74	535.30
Simpang Lhee	14.73	39.28	53.70	129.76	196.15
Seuriget	109.97	199.53	185.81	130.07	207.41
Lhok Banie	1.21	0.36	7.52	-	2.35
Sungai Pauh	12.88	27.97	7.29	22.99	209.86
Sungai Pauh Tanjong	0.99	16.55	54.41	8.79	25.78
Sungai Pauh Pusaka	0.63	-	-	1.35	6.31
Sungai Pauh Firdaus	0.18	-	-	-	-
Serambi Indah	0.05	-	-	-	-
Matang Seulimeng	-	-	-	-	-
PB. Beuramo	-	-	-	-	-
PB. Teungoh	-	-	-	-	-
Total	1,039.17	1,325.59	1,145.22	1,357.10	2,027.05

Figure 3. Graph of the Distribution of Mangroves for each Village in Langsa Barat District Period 2000 - 2020

Analysis of Mangrove Canopy Density

The density value of mangrove vegetation was obtained through the NDVI (Normalized Difference Vegetation Index) analysis process, the aim is to determine the density of the mangrove canopy based on the presence of response of remotely sensed objects in the red and near-infrared radiation spectrum range. Based on the results of the NDVI analysis in West Langsa District in 2000-2020, differences in the density of mangrove vegetation were found as presented in Table 3.

Table 3. Area of the Density of Mangroves Based on NDVI Values in Langsa Barat Sub-District, the year 2000-2020

	2000		2005		2010		2015		2020	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Sparse	286.69	27.59	330.43	24.93	216.41	18.90	177.32	13.07	0.17	0.01
Moderate	98.56	9.48	171.91	12.97	132.86	11.60	135.93	10.02	517.49	25.53
Dense	653.93	62.93	823.25	62.10	795.95	69.50	1,043.84	76.92	1,509.40	74.46
Total	1,039.17	100	1,325.59	100	1,145.22	100	1,357.10	100	2,027.05	100

Source: Results of Processing and Data Analysis (2022)

Based on Table 3, the density of mangroves is sparse, medium and dense were in 2000, 2005, 2015, and 2020 with different area density values. In 2000, the area of sparse crown canopy density was 286.69 ha (27.59%), then the area increased in 2005 (330.43 ha or 24.93%), and decreased again in 2010 (216.41 ha or 18. 90%). The decline of sparse crown density still occurred in 2015 with an area of 177.32 ha (13.07%) and finally, in 2020 there was a decrease in the area of 0.17 ha (0.01%). On the other hand, Medium canopy density in 2000 had an area of 98.56 ha (9.48%), increased in 2005 to 171.91 ha (12.97%), and again decreased with an area of 132.86 ha

(11.60%) in 2010. Meanwhile, in 2015 it increased by 135.93 ha (10.02%) and increased again in 2020 (517.49 ha or 25.53%). The dense canopy density in 2000 with an area of 653.93 ha (62.93%) increased to 823.25 ha (62.10%) in 2005. In 2010, the area decreased to an area of 795.95 ha (69.50%) and increased in 2015 and 2020 with an area of 1,043.84 ha (72.69%) and 1,509.40 ha (74.46%). Changes in mangrove density Based on the NDVI value are shown in Figure 4.

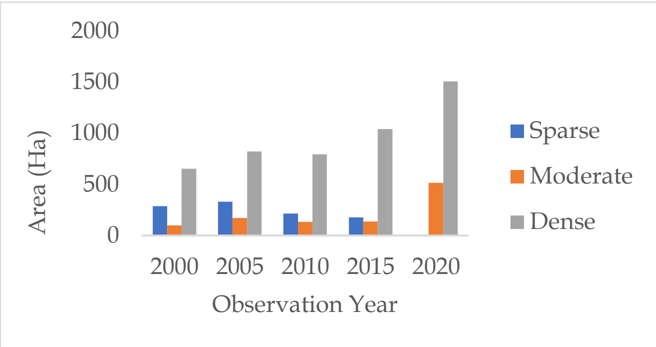


Figure 4. Graph of Changes in Mangrove Crown Density Based on NDVI Values for the Period 2000 - 2020

Based on Figure 4, The crown density of mangrove forests with sparse, medium, and dense increased and decreased through the period 2000-2020. During the period of observation, canopy density with sparse criteria decreased in area, namely from 2010-2020. This decline was influenced by land use and the conversion of mangrove land functions. According to Ratnasari & Sukojo (2018) decreased density values are caused by human activities such as the conversion of mangroves into ponds, docks, and eco-tourism and the utilization of mangrove trees directly. Mangrove forests with sparse canopy density were in almost the entire study area, to be precise in the western part, Central and South, especially in villages that were located more inland and the estuary edge area of Langsa Barat District. In general, mangrove with sparse crown density occurs in the outermost area of the mangrove area, due to this area is usually a replanting area and vulnerable to human activity directly and indirectly (Basyuni et al., 2012).

The condition of mangrove forests with medium crown density criteria over a period of 20 years has increased and decreased in density. The existence of mangrove forests with medium crown density was more widely on the edge to be exact in the north of West Langsat District. These conditions indicate mangrove forests located on the outskirts and directly adjacent to the sea tend to be in natural condition. The reduced area in the very sparse-density, sparse-density, medium-density, and dense-density classes is not only due to damage, but the change in the area occurs due to the transfer of the previously mentioned mangrove density to very dense in density (Fahreza et al., 2022).

The density of the dense canopy has increased in every year of observation. Overall, the dense crown mangrove forests were scattered in the western and northern parts of the West Langsa District. The increase in mangrove areas was the result of land rehabilitation activities carried out in the 2015-2020 period. According to Febrianto et al. (2022), the increase in mangrove density was due to mangrove restoration and rehabilitation activities. Therefore, this shows that the condition of mangrove vegetation in West Langsa District from 2015 - 2020 continues to increase in density. Also, this showed that sustainability was maintained and there was no threat to the mangrove ecosystem in West Langsa District both naturally and anthropogenic in that period. The condition of highest dense canopy density area was spread in *Kuala Langsa* Village with an area of 1,116.12 ha, as it was known that most of the mangrove area in *Kuala Langsa* has the status of a protected forests area and production forests. Spatially, the mangrove density map from 2000-2020 can be presented in Figure 5.

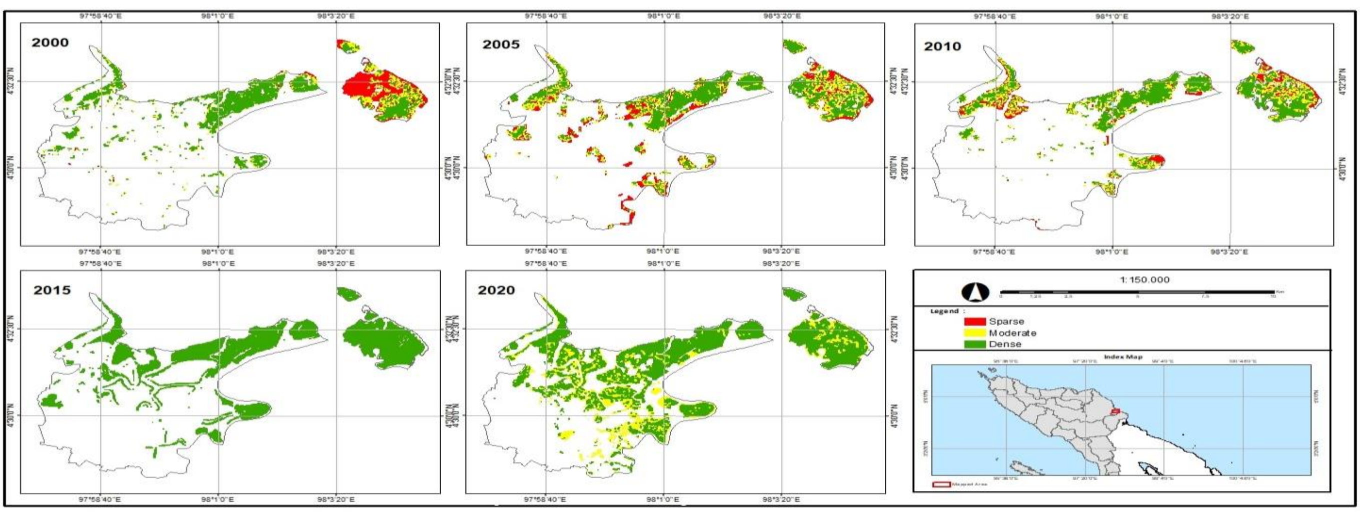


Figure 5. Mangrove Density Map Based on NDVI Values for the Period 2000 – 2020

Conclusion

Based on the results of the study, there were changes in mangrove land cover from 2000 to 2020. In 2000, the area of mangrove land was recorded at 1,039.17 ha, then increased in area in 2005 to 1,325.59 ha (27.56%). In 2010 the mangrove area decreased by 1,145.22 ha (15.75%). The dynamics of changes in the area of mangrove land still occur where in 2015 the area of mangroves increased to 1,357.10 ha (18.50%), and finally, the addition of mangrove area still occurred in 2020, where there was an increase in area to 2,027.05 ha (49.37%) or an increase of 669.96 ha from the previous year. While the analysis of mangrove canopy density based on NDVI values from 2000 to 2020, the highest crown density value was found in 2020 with a dense crown density category of 1,509.40 ha (74.46%). In 2020, the average crown density value is 517.49 ha (25.53%). Meanwhile, the lowest sparse category canopy density value was recorded in 2020 with an area of 0.17 ha (0.01%).

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