



Analysis of changes in mangrove land cover on the north coast of Aceh Besar

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ABSTRACT

The use of Geographic Information Systems (GIS) to generate digital data that provides information on the characteristics of an area and describes changes in land cover that can be used in a more effective and efficient sustainable manner. This study aims to analyze the mangrove land cover of the north coast of Aceh Besar over the last three decades, namely 2000, 2010, and 2020 in the Baitussalam sub-district, Mesjid Raya sub-district and Seulimeum sub-district. The research was conducted from June 2022 to September 2022 at the GIS Laboratory, Faculty of Marine and Fisheries, Syiah Kuala University. The research was conducted using a Geographic Information System (GIS) that utilizes high-resolution satellite imagery from Google Earth Pro. Mangrove land was digitized visually on screen, then data processing was carried out, and spatially analyzed. The results of the analysis of changes in mangrove land cover in the research area show that the Baitussalam and Mesjid Raya sub-districts had a decreasing trend of mangrove land between 2000 and 2010 and subsequently there was an increase in mangrove land cover from 2010 to 2020. Meanwhile, Seulimeum sub-district experienced a decreasing trend of land cover in 2000 until 2020. The decline in the trend of mangroves in various places is caused by the growth of the population using mangrove land as residential area. While the increase in mangrove land cover was due to the success of reforestation and pond land conversion. The results conclude that the mangrove land cover on the north coast of Aceh Besar is relatively stable with an increasing trend of growth.

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Introduction

Nearly a third of the world's mangroves have been lost due to mangrove logging over the past 50 years, along with coastal development and the development of shrimp ponds to support the recently booming fisheries export industry (Barbier, EB, 2014). With the global demand for shrimp that continues to increase (Anderson, 2019). Nearly a third of the world's mangroves have been lost due to mangrove logging over the past 50 years, along with coastal development and the development of shrimp ponds to support the recently booming fisheries export industry (Berbier, 2014). Data published by (WHO, 2019), in 34 years, the world has lost 30% of mangrove forests. Indonesia, the largest contributor to damage to mangrove ecosystems globally, is the worst-hit area on the east coast of northern Sumatra. The Ministry of

Research, Technology and Higher Education (2018) shows that 38% of the mangrove area on the east coast of northern Sumatra has disappeared in the last 30 years (Onrizal, 2012).

Several studies and research have been conducted to analyze the factors that cause changes in land use (Haryani, 2011). Mangrove function can be seen from several functions physically, ecologically, and socio-economically. Mangroves can physically absorb carbon on the earth's surface three times higher (Bhomia *et al.*, 2016), so they can mitigate global climate change (Cameron *et al.*, 2019). Ecologically, mangroves have a function as a natural habitat for marine creatures (Junialdi *et al.*, 2019).

One solution is to conduct a study using a Geographic Information System (GIS) to produce digital data that provides information about the

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characteristics of an area, as well as describes land cover changes that can be used sustainably. Characteristic detection in coastal areas requires GIS to process satellite data to obtain accurate information on spatial and temporal scales (Aini, 2021).

The temporal data used is land cover satellite imagery data for 2000, 2010 and 2020 which aims to see differences in mangrove land degradation every ten years for large areas. Remote sensing technology is very effective and produces accurate land cover maps (Andiko and Darmawan, 2019).

In monitoring land use and change, the use of remote sensing is a good method to use. Remote sensing satellite applications are able to provide data and information on land natural resources and marine natural resources regularly and periodically (Martono, 2008). In the field of mapping, Google Earth features are capable of measuring distances, areas, digitizing on screen, importing coordinate text data, and calculating distances and areas between points quickly (Hayati and Taufik, 2018).

Remote sensing is a science that utilizes technology to obtain information or natural phenomena through data in the form of recordings of objects, areas or phenomena being studied (Nur, 2021). These data records are collected using sensors installed on airplanes or satellites (Nur, 2021). Satellite imagery can be interpreted to obtain information or data according to certain interests such as research in various fields of science. Therefore, it is important to conduct this study with the aim of analysing changes in mangrove land cover over the last 30 years since 2000 in three sub-districts on the northern coast of Aceh Besar.

Materials and Methods

This study uses spatial and temporal quantitative methods. This research applies remote sensing technology using high-resolution imagery at three different time periods, namely 2000, 2010 and 2020. In this paper, the author focuses more on data on changes over time, so there is very little discussion of land cover classification. This paper looks more at land cover as comparative data over a certain period of time, where land cover is a material embodiment of the earth's surface from vegetation, landscapes, and cultural sensors generally obtained from the results of classification of satellite imagery which is widely used to analyze land use or dynamics of land change. in an area. The area of land cover and land classification is done by visually digitizing on a screen, where observation and identification of mangrove areas is directly on a

computer screen. Visual interpretation of the land cover area performs the digitization process, first doing a visual interpretation of the land cover area in the research area. The research implements spatial-temporal quantitative methods, namely the process of mapping and calculating land area based on spatial and multi-time. The data used in this research comes entirely from Google Earth. By using the Google Satellite Maps Downloader and Arc GIS software, the image interpretation process is done manually using the on-screen digital method. This method was chosen because manual land class assessment is still possible to do on high-resolution imagery, which in this case is provided by Google Satellite Maps Downloader which already provides digitization facilities directly through the "add Polygon" feature. This can facilitate the process of interpretation and digitization without the need to download the image first. The digitized results are then stored in KML (Keyhole Markup Language) format which can be converted into SHP files (Shapefiles), so that they can be further processed using Arc GIS software.

The steps taken are to access satellite imagery data from the Google Earth Pro software and interpret the desired spatial and temporal data for analysis. Data obtained from satellite imagery is then digitized based on visual observations and according to the required year by utilizing historical features and zooming in and zooming out. The digitized results are then polygonised so that interpretation and analysis can be carried out properly. Furthermore, ArcGIS was applied for the map layout process and calculating the area of each land class per year of observation. The first thing to do is to open the previously digitized KML database file. Convert files from KML to SHP. The process of calculating the land area is carried out because the attribute data is already available. In the area of land to be calculated, the geometric features of the area are used to calculate the area of the land class.

Data on the area of land for each land class in each year of observation were analysed and then graphs were made that presented the trend of changes in the land area according to the research objectives. The results of the digitization are then laid out, adding attributes according to cartographic rules, resulting in a land cover map per sub-district which is the object of research.

Location and time of research

The research location for changes in mangrove cover is in the northern coastal area of Aceh Besar, starting from the coast of Baitussalam sub-district to Seulimeum sub-district, which is hereinafter referred to as the study area (Figure 1). Data processing at the GIS laboratory, Faculty of Maritime and Fisheries, Syiah Kuala University, Banda Aceh City. The time for this research is from June to August 2022.

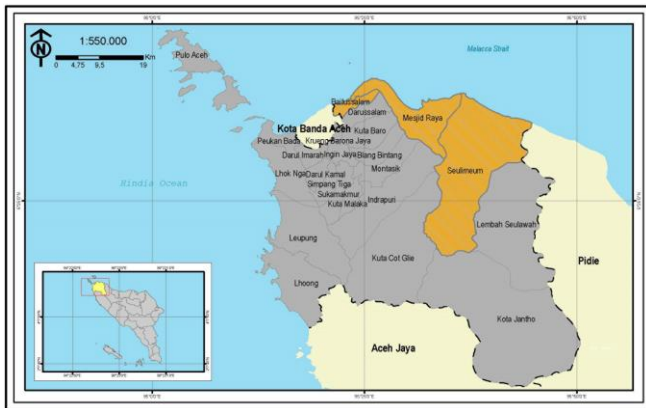


Figure 1. Research Location.

Data analysis

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Overlay analysis has been carried out between data years, where it can be seen that the calculation of the table attribute data is presented in the Percentage of Land Cover Change Table in each Region. By overwriting land change data for 2000 with 2010, and data for 2010 with 2020.

Results

The results of using the ArcGIS software resulted in several sub-district land covers being observed which can be seen in Table 1 through Table 3 below. While the results of the analysis of the percentage change in land cover can be seen in

Table 4 to Table 6 below. The results show that each sub-district analysed has different land cover and the trends presented.

Table 1. Land cover area of Baitussalam sub-district.

Land Classes	Area in the year 2000 (Ha)	Area in the year 2010 (Ha)	Area in the year 2020 (Ha)
Mangrove	43.6	40.63	89.35
Water body	0.85	24.18	12.4
Open Land	11.21	16.94	8.79
Settlement	2.41	4.85	22.75
Fish Pond	94.93	73.8	17.49
Vegetation	7.39	0.01	9.63

Table 2. Land cover area of Mesjid Raya sub-district.

Land Classes	Area in the year 2000 (Ha)	Area in the year 2010 (Ha)	Area in the year 2020 (Ha)
Mangrove	53.77	7.82	82.12
Water body	1.60	3.22	0.05
Open Land	0.01	50.14	2.46
Settlement	0.51	2.24	2.23
Fishpond	57.21	49.68	18.81
Vegetation	0.01	0.01	7.44

Table 3. Land cover area of Seulimeum sub-district.

Land Classes	Area in the year 2000 (Ha)	Area in the year 2010 (Ha)	Area in the year 2020 (Ha)
Mangrove	37.41	30.91	23.36
Water body	0	0	1.04
Open Land	1.14	1.17	0
Settlement	0	0	0.66
Fish Pond	0	0	0.30
Vegetation	0	6.48	13.20

Table 4. The percentage of land cover change in Baitussalam sub-district.

Land Classes	Percent Change in 2000-2010 (%)	Percent Change in 2010-2020 (%)
Mangrove	-2.97	48.72
Water body	23.33	-11.78

Open Land	5.73	-8.15
Settlement	2.44	17.9
Fishpond	-21.13	-56.31
Vegetation	-7.38	9.62

Table 5. The percentage of land cover change in Mesjid Raya sub-district.

Land Classes	Percent Change 2000-2010 (%)	Percent Change in 2010-2020 (%)
Mangrove	-45.946	74.294
Water body	1.617	-3.166
Open Land	50.13	-47.68
Settlement	1.728	-0.009
Fishpond	-7.532	-30.865
Vegetation	0	7.425

Table 6. The percentage of land cover change in the Seulum sub-district.

Land Classes	Percent Change 2000-2010 (%)	Percent Change in 2010-2020 (%)
Mangrove	-6.505	-7.548
Water body	0	1.041
Open Land	0.029	-1.169
Settlement	0	0.661
Fishpond	0	0.295
Vegetation	6.479	6.718

Discussion

Changes in mangrove land cover in Baitussalam Sub-district

Time series satellite imagery from Google Earth has recorded the appearance of the condition of the coastal area of the Baitussalam sub-district in 2000, 2010 and 2020. The area and percentage of land cover classes in this area are shown in [Table 1](#) and [Table 4](#) and [Figure 2](#) below, where the percentage land changes from 2000 to 2010 Baitussalam sub-district, which experienced another significant change was the water body land class where from 2000 to 2010 it increased by 23.33% while pond land and mangrove land decreased respectively by 2.97% and 21.13 %. Compared to 2010 to 2020, several land classes have experienced an increase, namely mangroves by 48.72%, and settlements by

17.9% while other land classes have experienced a significant decrease, namely ponds by 56.31%.

[Figure 2](#) shows the trend of changing land classes in Baitussalam sub-district, in 2000, 2010 and 2020. The trend of changing mangrove land from 2000 to 2010 has decreased by 2%, but from 2010 to 2020 there has been a significant increase of 30%. Meanwhile, in the water body and open land classes, the opposite is seen with mangrove land, where from 2000 to 2010 the water body and open land classes experienced an increase of 15% and 4% respectively.

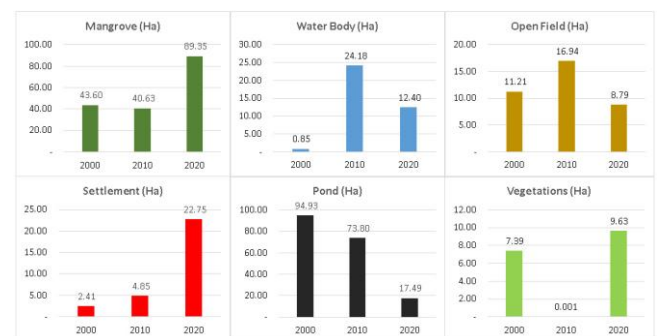


Figure 2. Comparison of changes in land cover class area in Baitussalam Sub-district in 2000, 2010 and 2020

The tsunami had the effect of changing the morphology caused by two main factors, namely the successive subsidence of the land due to tectonics and the transportation of massive sediment during the propagation of the tsunami waves. The impact of this change in coastal morphology then intervenes in the condition of the land cover of the affected area, namely heavy damage to productive land and infrastructure ([Rozanda et al., 2012](#)). In addition to the mangroves, the pond area has also experienced a reduction in area of 13%, but it is possible that after this incident there will be a lot of construction of aid houses around the coast of this area so that residential land has increased by 2%.

The pattern of land change is an increase in the area of some land use components and at the same time there is a reduction in the area of other land use components ([Muh, 2013](#))

From 2010 to 2020, it can be seen that mangrove land has begun to show a significant increase in growth, namely 30% as water bodies and open land decrease by 7% and 5% respectively. Pond land also experienced a significant decrease of 30%. The increase in the area of mangrove land was caused after the tsunami disaster. There are many efforts to restore mangrove ecosystems, one of which is replanting in mangrove areas by the

government and also by non-governmental organizations.

Mangrove rehabilitation is one of the priority programs during the rehabilitation and reconstruction of areas affected by the December 26, 2004 earthquake and tsunami in Aceh and Nias. Several months after the devastating natural disaster, various programs and activities for mangrove rehabilitation, such as mushrooms that grow in the rainy season, were carried out by various government agencies and non-governmental organizations (NGOs), both from within and outside the country.

This condition is illustrated by a rough calculation by Wibisono and Suryadiputra (2006) from various sources, it was noted that more than 29 million mangrove seedlings had been planted in a period of 1.5 years. The results of the assessment conducted by the author and by Wibisono and Suryadiputra (2006) showed similar results, namely that a small proportion of the mangrove rehabilitation programs were successful, but most were not successful until the end of 2006 (Onrizal, 2012).

Mangrove forests can thrive in river estuary areas. The meeting of fresh water from river water and salt water causes the area to become brackish water. This condition allows mangrove vegetation to thrive and causes the formation of mangrove forests in the area (Purwanto et al., 2014).

The land use change map in the Baitussalam sub-district is shown in Figures 3, 4 and 5.

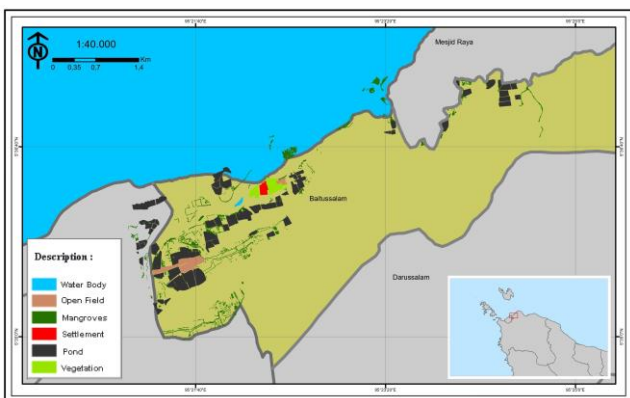


Figure 3. Coastal Land Cover in Baitussalam Sub-district in 2000

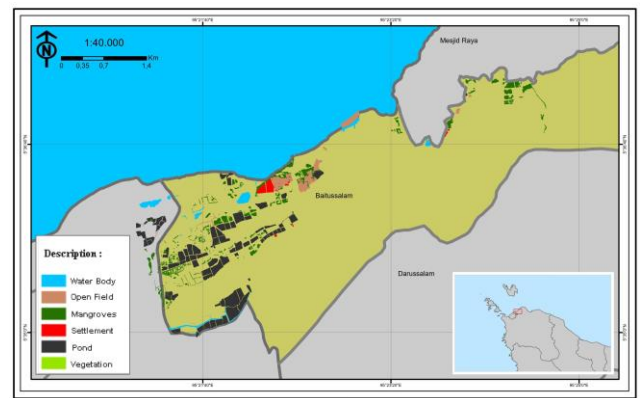


Figure 4. Coastal Land Cover in Baitussalam Sub-district in 2010

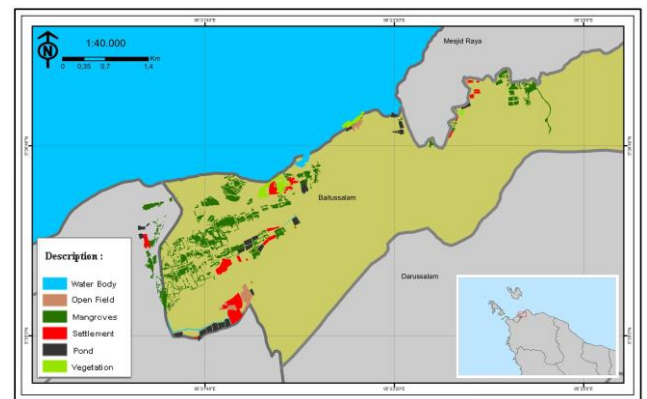


Figure 5. Coastal Land Cover in Baitussalam Sub-district in 2020

Mangrove land cover in Mesjid Raya Sub-district

The results of land digitization that has been carried out show the trend of land change in the coastal area of Mesjid Raya sub-district in the 2000 to 2010 range (Figure 6). In this decade, mangrove land has decreased by 45.95%, pond area has decreased by 7.53% as the land class of water bodies and open land have increased by 1.62% and 50.13% respectively, a significant increase in open land due to the tsunami disaster is the same as in Baitussalam district.

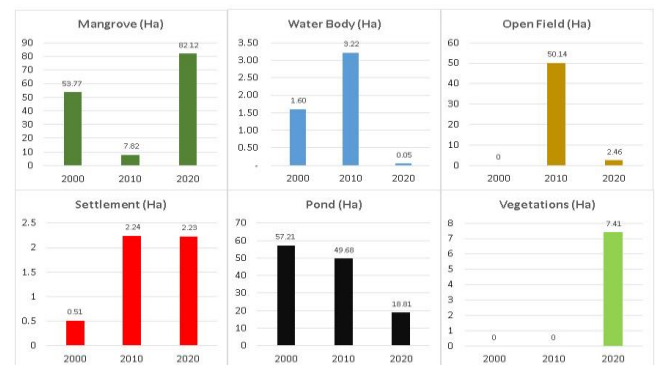


Figure 6. Comparison of Changes in Land Cover Area in Mesjid Raya Sub-district in 2000, 2010 and 2020

The post-tsunami impact was felt for humans and the surrounding environment, with the destruction of human settlements and environmental ecosystems, especially the coastal areas of Sumatra Island which experienced massive destruction.

The vulnerable period from 2010 to 2020 is that mangrove land will experience a fairly large upward trend, namely 70.29% as other land classes decline, such as open land, which decrease by 47.68%, ponds also decrease by 30.87% and water bodies decrease by 3.17%. The increase in mangrove land is inseparable from government and non-government efforts in efforts to replant mangroves in coastal areas which are slowly showing positive results. This mangrove forest rehabilitation activity is not only carried out by the local government independently, but the government has received assistance from international agencies or NGOs that provide assistance in the implementation of mangrove forest rehabilitation programs.

Mangrove planting has been carried out in various coastal locations, especially in former ponds, former mangrove habitat which has been damaged both by human activities and by tsunami waves along the banks of rivers that empty into the sea. This rehabilitation is carried out to re-green mangrove areas that have been damaged and minimize the intrusion of sea water on land and reduce the occurrence of coastal abrasion (Suriani and Bahagia, 2012). Mangroves can develop on their own, namely in places where there are no waves, the first physical condition that must be found in mangrove areas is minimal water plants. Information is often found regarding the increasing damage to mangrove ecosystems caused by high levels of exploitation, weak coordination and program synchronization between sectors, weak law enforcement and low public awareness of the functions of mangrove ecosystems

The map of land change in the Mesjid Raya sub-district is shown in Figures 7, 8 and 9.

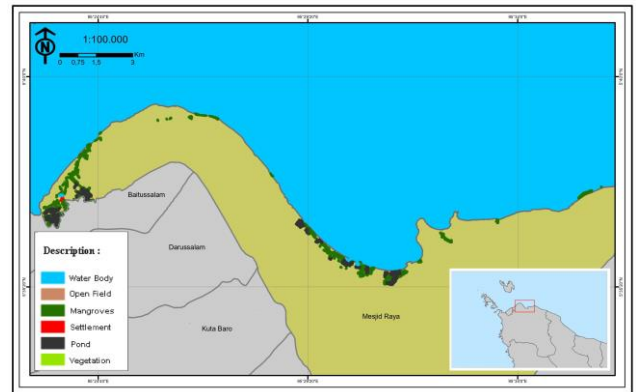


Figure 7. Coastal Land Cover in Mesjid Raya Sub-district in 2000.

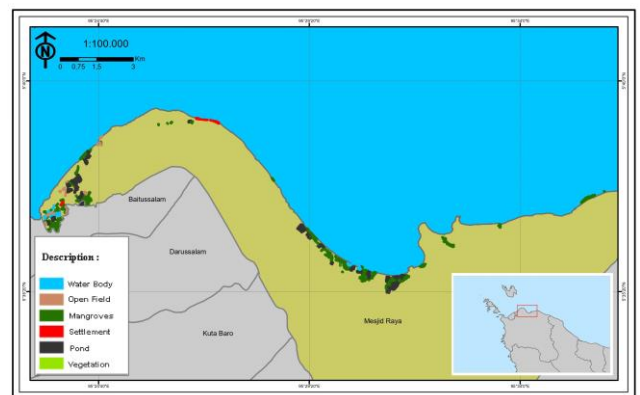


Figure 8. Coastal Land Cover in Mesjid Raya Sub-district in 2010.

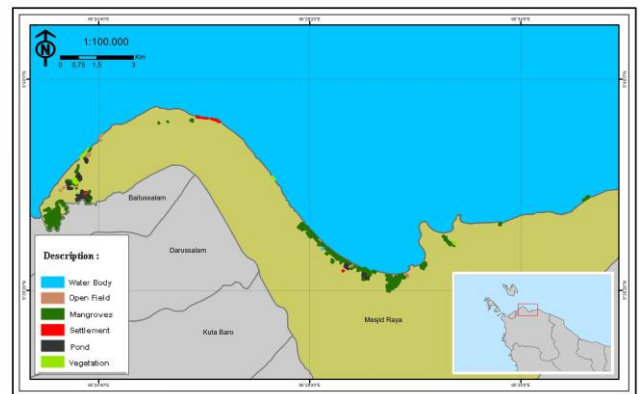


Figure 9. Coastal Land Cover in Mesjid Raya Sub-district in 2020.

Mangrove land cover in Seulimeum Sub-district

The results of land digitization that has been carried out temporally show that the coastal conditions of Seulimeum Sub-district (Figure 10) were dominated by mangrove land cover in 2000 of 97% and slightly decreased in area to 80% in 2010 then decreased again in 2020, only 60% of the total area remained. study area cover.

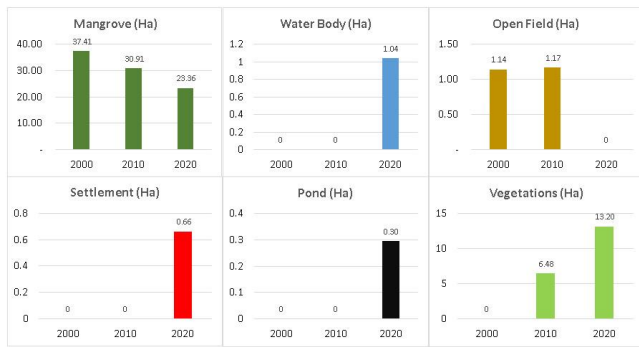


Figure 10. Comparison of Changes in Land Cover Area in Seulimeum Sub-district in 2000, 2010 and 2020.

This decrease only affects the increase in land vegetation of other plants besides mangroves. It is estimated that mangroves have experienced degradation due to logging and exploitation and land conversion by local communities with increasing vegetation of other plants at that location. Development activities made the biggest contribution to the decline in the area of mangroves, namely the extraction of wood for commercial purposes and the transition of allotment of ponds and agricultural areas, especially rice and coconut (Noor et al., 2012). The area of mangroves has a significant effect on fishery resources. This means that fish, shrimp and crab/crab products are affected by the area of the mangrove forest, and the wider the mangrove forest, the higher the production of fish and shrimp (Malau et al., 2018).

Mangrove forest management which aims to reduce damage to mangrove ecosystems in West Langsa District. There needs to be a policy (Regional Regulation) that regulates the pattern of utilization of ecosystems in forest areas, to reduce the rate of reduction in the area of mangrove forests (Setiawan and Zaitunah, 2016).

To minimize abrasion and intrusion of sea water, planting mangroves in pond cultivation patterns needs to be continuously socialized considering the ecological benefits of mangroves are so important, apart from being beneficial from an economic aspect (Salim et al., 2017).

The land use change map in the Seulimeum sub-district is shown in Figures 11, 12 and 13.

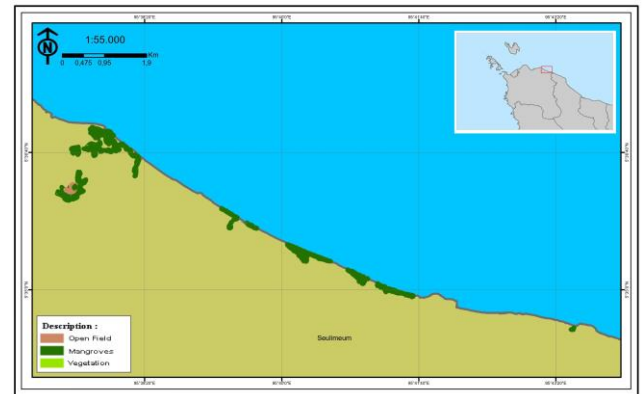


Figure 11. Coastal Land Cover in Seulimeum Sub-district in 2000.

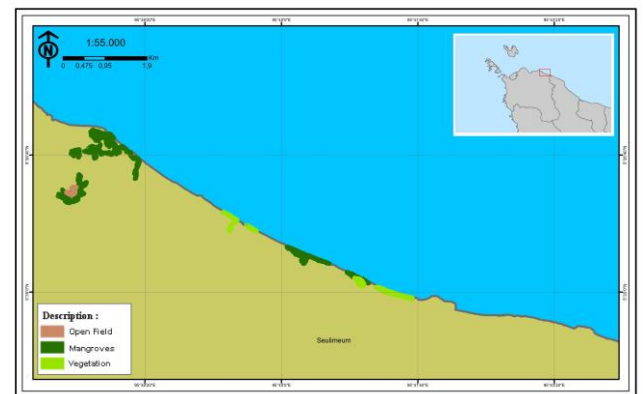


Figure 12. Coastal Land Cover in Seulimeum Sub-district in 2010.

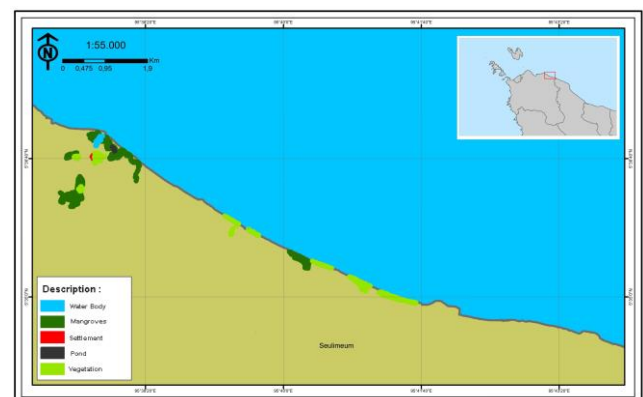


Figure 13. Coastal Land Cover in Seulimeum Sub-district in 2020.

Conclusion

Based on the results of this study, it can be concluded that the development of mangrove land cover in 2000, 2010 and 2020 on the north coast of Aceh Besar Sub-district experienced changes varying in the three sub-districts. Baitussalma and Mesjid Raya sub-districts tended to decline during the 2000 to 2010 timeframe due to the influence of the 2004 tsunami disaster, then recovered again during the 2010 to 2020 vulnerable time. until 2020.

The results of time series analysis of mangrove land cover in the study area show differences at

each predetermined temporal time, where in 2000 mangrove land still controlled nearly half of the area of the study area in each sub-district. However, in 2010 mangrove areas were drastically reduced in these three sub-districts due to the 2004 tsunami that hit Aceh. Whereas in 2020 it can be seen that the area of mangroves has increased in two sub-districts, namely the Baitussalam sub-district and Mesjid Raya, on the other hand, in the Seulimeum sub-district, the percentage area has continued to decrease.

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