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Dynamics of changes in the land cover of mangrove by historically time from 1989 to year 2019 in 9 subdistricts in Langkat Regency, North Sumatera

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Abstract

Indonesia has problems in environmental management, including land use and damage to the coastal environment. This study aims to identify and to analyze the extent of coastal environmental damage through the dynamics of changes in mangrove land use in 9 subdistricts of Langkat Regency, North Sumatra, historically (1989-2019). This study used quantitative approach by conducting field survey methods to identify species diversity and to know the mangrove cover area by using Multitemporal Series Landsat Image at spatial resolution of 30 m. The qualitative approach through PSR (Pressure-State-Response) was used to understand the dynamics of changes on mangrove cover area in Langkat Regency. In this area, 25 real mangrove species and one associated mangrove species was identified. In 1989, mangroves were 36,362.40 Ha. In 2019, mangrove area was reduced by 28,702,0402 Ha. This study showed that the dynamics trend of mangrove cover change in 30 years from 1989-2019 indicated a high rate of land subsidence. In 1989-1999 showed a decrease of 9,638 ha, then in 1999-2009 the areas indicated an increase by 3,314 ha while decreased again in 2009-2019 with an insignificant amount of 1,237 ha. These were caused by aquaculture land, field clearing, and natural conditions.

Keywords : forest conservation, mangrove, Langkat Regency, dynamic of change, land cover

Introduction

Indonesia is an archipelago with 7,870 named islands and 9,634 unnamed islands (Indah Nur Fitriani, 2018), as a country with the fourth most populous population globally, Indonesia has environmental management problems that cannot be avoided, including land use and damage to the coastal environment (Brotosusilo et al., 2020). Indonesia is a maritime country with a population living on the coast more than other Asian countries within the Association of Southeast Asian Nations (ASEAN) (Jhaveri et al., 2019).

Human activities in the coastal environment 30% higher than in urban areas. It occurs due to displacement of occupation using sea transportation, commerce, or tourism activitie that are superior in many coastal areas due to natural beauty and tourist object. These conditions will experience a threefold increase in 2040 in line with international trade and tourism destinations based on coastal activities. Meanwhile, the level of environmental damage in the coastal areas has a high vulnerability and is not realized by humans. Indonesia's level of mangrove damage has reached 67% and is not yet fully renewable (DasGupta & Shaw, 2017).

According to the world Conservation Agency, the fish catch for processed fish food production decreased by 40% in the catchment area globally. Due to reduced mangrove cover, only some countries in Asia continue to carry out mangrove conservation activities in of coastal area consistently (Fiona Nunan, 2020) .

Mangrove areas in Langkat Regency in 1989 had an area of 37,525,17 ha of mangrove forest and was the largest among districts in North Sumatra province, with a diversity of 38 species and 13 families and ecosystem services that ere important in meeting the needs of coastal community (Hamzah, 2020). Mangrove areas suffer significant environmental damage from ineffective management forms (Aswin et al., 2018). The area of Mangrove cover that has been degraded due to land conversion for various purpose without paying attention to environmental sustainability.

The purpose of this study is to identify the diversity of species in mangrove areas in Langkat Regency, analyze mangrove land use in 1989 and changes in 2019 in 9 subdistricts in Langkat Regency, and to determine the dynamics of changes in the area of mangrove and analyzed the causes by historically time from 1989 to year 2019 in 9 subdistricts in Langkat Regency.

METHODS

Survey design and data collection

Location for the research is Langkat Regency, North Sumatra, in 9 subdistricts namely Babalan, Besitang, Brandan Barat, Gebang, Pangkalan Susu, Pematang Jaya, Secanggung, Sei Lepan and Tanjung Pura. Distribution of mangroves from 9 subdistricts can be seen in figure 1.

Research is using the quantitative approach with survey field methods and the qualitative approach with PSR methods. Surveys conducted in November 2013, June 2017 and May 2019. Google Earth imagery was used to plan field work by gathering information about mangrove species, growth status, and the surrounding environment. A total of 70 field observation were made, with 9 points located in the mangrove ecosystem and 110 points on other types of land cover other (built-up areas, agricultural land, other forest, aquaculture ponds, water bodies, empty land, and tidal sand plains, oil palm plantation and land, settlement) were identified within the selected study area.

Landsat image series of multitemporal the resolution spatial 30m is used to collecting data and determine the extent of mangrove cover in long term (1989-2019). 31 clouds-free Landsat images, including 21 Landsat Thematic Mapper (TM), Enhanced Thematic Mapper Plus (ETM +), and 9 image Landsat Operational Land Imager (OLI) image, were downloaded from the United States Geological Site Survey (USGS) Center for Earth Resources Observation and Science (Liao et al., 2019). Most of the images were obtained at tide levels of less than 2 m, when most mangrove were non inundated.

Radiometric calibration and atmospheric correction were performed on Landsat images using the FLAASH modules (Chen et al., 2017), in Environment for Visualizing Images (ENVI) software (version 5.3, Boulder, CO, USA). Georeferenced Landsat OLI imagery from 2017 was used as the master "Spatial Reference Set" to correst the Landsat time series for 1989, 1994, 1999, 2004, 2008, and 2014. The imagery listed together has a low mean root mean square error

(RMSE) less of 0.5 pixels. SVM classification technique was applied to separate mangroves from non-mangrove areas in the selected object reserve (Giri, 2016).

This machine operation method place on optimal hyperplane that maximizes the margin between two classes in a high dimensional space and has been successfully applied to the land cover classification from remote sensing image (Lesiv et al., 2018) In this study, the radial basis function (RBF) was applied, the penalty factor was 100 and the Gamma function was 0.02.

The visual inspection result was carried out through a combination of data field and Google Earth imagery and are used to assess the mapped mangrove areas completeness and reliability by applying the SVM classifier to the OLI 2017 Landsat image. In the next step, mangrove and non-mangrove areas are digitized from historical Landsat images (1989, 1994, 1999, 2004, 2008, 2014, 2019) using a map of the 2017 Landsat OLI mangrove as a contextual reference base. The 2017 classified image year is used for digital visual of mangrove forest in the image of previous years. This result is believed to be accurate because the field survey was conducted simultaneously with the 2017 image acquisition and validate the mapped mangrove areas (Bey et al., 2016).

Pressure-state-response approach is used to understand the dynamics of mangrove cover changes in Langkat Regency, can be seen in figure 2.

This approach explores the driving factors for changes in mangrove areas caused by human activities and natural factors. The leading causes of area change include land clearing for aquaculture, development, waste disposal. high tourism activity, mangrove mortality, and other natural phenomena such as sea-level rise, tropical storms, and climate change. From several studies of coastal areas in Asia, such as Thailand, the Philippines, and China as tidal ecosystems. mangroves are highly stressed due to climate change, rising sea surface temperatures, and drought (Catherine E. Lovelock et al., 2015). Using satellite remote sensing results can provide insight to project environmental pressures, changes in area size, and ongoing trends that result in changes in mangrove cover in the selected study area (Muhtadi et al., 2016).

Result and Discussion

Geographical Conditions

Langkat Regency is a coastal area in North Sumatra with topographical conditions ranging from plains to coasts, undulating, hilly to mountains in the river's upper reaches with an altitude of 01,200 m above sea level, with a coastline of 110 km. Northeast part along the Malacca Strait coast, flat conditions with several hills in Pematang Jaya Subdistrict and Gebang Subdistrict with an altitude of 0-4 m above sea level, the Northeastern part is a tidal flat from river sedimentation. In the rainy season, several rivers in western Langkat overflow and carry sediment from land to sea. This condition causes the mangrove ecosystem to be centered on the Eastside, namely in Pematang Jaya Subdistrict, Besitang, Pangkalan Susu, Brandan Barat, Sei Lepan, Babalan, Gebang, Tanjung Pura, and Secanggang. Langkat has 6,263.29 Km2 (626,329 Ha) with 23 subdistricts, 240 villages and 37 urban villages (Asbi & Rauf, 2019).

The Langkat region boundary, namely the northern part, is Aceh Province and the Malacca Strait, South borders Karo Regency, West borders Aceh Province, and East borders Deli Serdang Regency Binjai City. The Langkat Regency area includes a protected forest area covering an area of

±266,232 Ha (42.51%) and a cultivated land area covering an area of ±360,097 Ha (57.49%). The protected forest area consists of the Gunung Leuser National Park (TNGL) natural conservation area covering an area of ±213,985 Ha. Northeast area covering an area of ±,520 Ha. A buffer area of ±7,600 Ha. Mangrove forest area covering ±20,200 Ha and other areas ±14,927 Ha (Badan Pusat Statistik Kab & Langkat, 2016) .

Single-type tides with mean height (MSL) of 145.23 cm and the highest sea level (HHWL) of 200.34 cm. sea waves are determined by the wind gusts based on the season. The east wind causes high waves of up to 0.8-1.3 m and occurs in June and July. It has become the community's knowledge not to carry out activities at sea and plant mangroves. (Mohammad Basyuni et al., 2018).

Mangrove Ecosystem and Land Use in Langkat Regency

Mangrove ecosystem is a form of tidal water type forest rich in vegetation and ecosystem services for human life. Apart from playing a role in protecting coastal defenses from waves, mangrove forests are a habitat for fish and crab species and other animals that live in the area. Damage to mangroves due to land clearing for aquaculture, oil palm fields, and the use of residences that do not pay attention to the area design will affect the quality of mangrove forests on the coast. Mangroves are a unique ecosystem found on shallow beaches, estuary areas, bays, deltas, and sheltered coastal areas.

Right mangrove density conditions also affect vegetation's richness and the types of ecosystem services in the mangrove area. Based on the identification of species diversity in the mangrove ecosystem in the Langkat Regency, 26 species were identified, 25 real mangrove species, and one associated mangrove species. The distribution of mangrove species diversity is presented in table 1.

By looking at the species diversity of mangrove types available in the mangrove ecosystem area in Langkat Regency, it is a finding that this coastal location can be used as a means of education for academics and researchers, the potential for diversity and richness of this ecosystem can be an opportunity for the use of ecotourism for the local economy. Coupled with local understanding of the immigrant community in accessing tourist sites, such as preserving the environment by not littering, paying attention to the carrying capacity of the environment in traveling are several factors that affect the decline in the quality of the mangrove environment. Mangrove forests in Langkat Regency also provide ecosystem services that humans can use besides fish, crabs, shrimp, and other aquatic biota types. Wood and fruit in several types of mangrove plants can be used for industrial needs, both pharmaceutical and property. Moreover, mangroves also play a role as an ecosystem regulation where mangrove roots will break large waves and protect the coast from abrasion. It is seeing the many uses of mangrove forests in addition to providing services.

The use of land in the district must also pay attention to the condition of regional spatial policies, meaning that as a buffer area on the coast, the existence of mangrove forests has an essential value in maintaining the sustainability of the lives of coastal communities, apart from being a place to live for the community's needs for food availability, educational locations and protected areas as beneficiaries. Natural resources need to pay attention to land. use conditions. Based on the data that the author has processed, here is an overview of land use and use in 9 subdistricts in Langkat Regency in 1989, which is presented in figure 3. Based on the results

of satellite image depiction, the results of land use in 9 subdistricts of subdistricts are obtained, the land use was presented in table 2.

Based on data in 1989, land use in 9 subdistricts in Langkat Regency still fulfills the proportion of feasibility and adequate environmental carrying capacity with the percentage of buffer areas such as forests and water absorption areas 40% of the total area (Lestari & Trihadiningrum, 2019). The total condition of protected forest in 9 subdistricts has an area of 45,027.00 Ha. Mangroves are in an area of 36,362.40 ha, and plantation land is 26,027.06 Ha. Moreover, while for the fulfillment of residential land 5,250.81 Ha, rice fields 21219.05 Ha, and aquaculture 3,186.13 Ha. From this illustration, it can be seen that land use is still under control.

In 2019, satellite imagery results provided an overview of land use results in 9 subdistricts in Langkat Regency with results as in figure 4. Based on the land interpretation results in 2019, the following is the tabulation of land use in 9 subdistricts in Langkat Regency, shown in table 3.

Table 3 data shows that the increase in the natural forest's total area increased by 221.36 Ha. In this case, the Langkat Government's forestry management was considered successful. The Karang Gading conservation program is a community-based natural forest area management program with program achievement. In the form of expansion of natural forest cover (M. Basyuni & Sulistiyono, 2018) . The mangrove area was reduced by 7,573.11 Ha. This condition illustrates the increase in aquaculture activities in the 1999-2009 period, which occurred in almost all Langkat Regency subdistricts, based on economic motives and job opportunities for coastal communities. The area of plantations has increased by 1,704.88. The results of observations and field interviews confirm the findings that the number of oil palm plantations carried out on the coast results from the conversion of several mangrove lands into plantation lands that have occurred since oil palm plantation activities on the island of Sumatra (Poedjirahajoe et al., 2019). The amount of land use for settlements does not show a large number. The number of land for settlements only increased by 1.92 Ha. It is in line with the control of areas and permits for building construction in coastal areas based on Regional Regulation No.7 of 2013 concerning Management of Coastal and Small Islands. The regulation states that for constructing buildings in the buffer zone, complete construction documents and the establishment's legality are required. It is a strengthening of environmental management to increasing the number of buildings or establishing new residential areas in the coastal area of Langkat.

Dynamics of Changes in Mangrove Land Cover and Changes in Coastlines in Langkat

Based on the comparison between 1989-2019, there was a significant decrease in mangrove area in Langkat Regency, while this study found that during the last 30 years 1989-2019, there had been changes in mangrove cover area which were influenced by two critical factors, namely anthropocentric and natural conditions. In 1989, the total area of mangroves in Langkat Regency in general still reached 36,308363.6 ha. At the time of measuring 2019, the land area had become 28.702,0402 ha. A map of research related to districts with mangrove forests in Langkat Regency can be seen in figure 5.

Langkat Regency has 23 subdistricts, but for subdistricts with mangrove forest areas, only in 9 subdistricts. The potential of mangrove forests in Langkat Regency intersects with the economic interests and socio-cultural life of the community, where the coastal area is an area with high

environmental vulnerability, where port activities, population movement, and disaster-prone areas are conditions that occur in almost all parts of Indonesia (Chien et al., 2017). Based on the satellite image, the mangrove area in 9 subdistricts is presented in table 4. In the table of the total area of mangrove cover in 9 subdistricts in Langkat Regency, the district with the largest area is in Pangkalaan Susu Sub-district and the smallest amount is mangrove forest in Sei Lapan Sub-district, the rate of change in mangrove land area for 30 years occurred in vulnerable years 1989- 1999, the main factor in the change in mangrove cover occurred in almost all subdistricts. The dominant factor influences decreasing mangrove cover area in land use for aquaculture activities and land clearing for oil palm plantations.

From this data area, it can be seen that during 1989-1999 there has been a decrease in the area of mangrove land in Langkat Regency by 9,666.23 ha, the high enthusiasm of coastal communities in obtaining economic income that is more than from fishing, shrimp and milkfish pond cultivation activities have become community business activities. By opening mangrove land to make pond holes, this condition triggers a reduction in mangrove cover area (Fitzgerald, 2000). Based on previous research results, namely the vulnerable years 1989-1999, Langkat Regency became aquaculture activities as a new economic source. This event occurred in almost all subdistricts. The income level from shrimp, trumpet crab, and milkfish reached a more stable and adequate income. It is just that this condition worsens the environment due to the effect of the pond industry, which is not environmentally friendly, and the contamination by-products of the ponds damage the mangrove ecosystem.

The decrease in the total area of mangrove land cover on the Langkat Regency coast directly impacts the community's economic income, where the income level of people who work as fishermen decreases by 20-30% of their annual income. This condition is the reason that the results of fishing are unstable. Making people do oil palm plantation activities and move from villages to nearby cities in search of life, from here the social dynamics of the movement of coastal communities to urban areas becomes a phenomenon consisting of a decrease in economic income which also affects rural social aspects. As a regulatory function, mangroves play a role in breaking waves, so they do not reach land. Changes in the area due to land conversion into various land uses also contributed negatively to the shoreline changes. In Langkat Regency, changes in the coastline after 30 years of measurement did not show significant changes. The Landsat interpretation described the conditions of changes in the coastline in Langkat Regency between 1989- 2019, as in figure 6.

Based on the results of Landsat the map of the coastline in Langkat Regency can be illustrated that changes in the coastline that were quite visible in 1989-1999 were that in Pematang Jaya Sub-district it decreased by 30 % and Pangkalan Susu Sub-district decreased by 25%, in general in all subdistricts in regency seen changes in coastline occurred in 2009-2019 the number of changes in coastline increased by 30%.

Based on the Pressure-State-Response in observing the phenomenon of changes in mangrove area (Liao et al., 2019). There are three pillars of analysis in seeing these conditions, where based on the results of field observations and in-depth interviews with the community on the object of research, the PSR analysis is shown in figure 7.

Overall, the phenomenon of cover change often occurs in economic and institutional factors. Most cases, such as in several Asian countries, such as changes in mangrove cover in Thailand, Vietnam, and China, are more caused by human activities in river deltas and home industry activities that contribute to waste and environmental pollution the sea (Derraik, 2002). Institutions are sufficient to determine the sustainability of a mangrove area because the pattern of decision-making and programs will be implemented if each party realizes their roles and functions in the program's success.

CONCLUSION

Mangrove ecosystem in the Langkat Regency, 26 species were identified, 25 real mangrove species, and one associated mangrove species.It is a finding that this coastal location can be used as a means of education for academics and researchers, the potential for diversity and richness of this ecosystem can be an opportunity for the use of ecotourism for the local economy. Based on data in 1989, mangroves are in an area of 36,362.40 ha, land use in 9 subdistricts in Langkat Regency still fulfills the proportion of feasibility and adequate environmental carrying capacity with the percentage of buffer areas such as forests and water absorption areas 40% of the total area. In 2019, mangrove area was reduced by 7,573.11 Ha. This condition illustrates the increase in aquaculture activities in the 1999-2009 period, which occurred in almost all Langkat Regency districts, based on economic motives and job opportunities for coastal communities. This study reveals that in Langkat Regency, the dynamics of mangrove ledge cover dynamics are caused by land-use factors in three designations; 1) Aquaculture land, clearing fields, and 3) Natural conditions. This study shows that the dynamic trend of mangrove cover changes in 1989- 2019 has a high decrease in 1989-1999 at 9.638 ha. The total area has increased again in 1999- 2009 by 3,314 ha and decreased again in 2009- 2019 with an insignificant amount of 1,237 ha.

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References (Times New Roman 12, align left, bold)

1. Asbi, A. M., & Rauf, R. A. (2019). Effect of Mangrove Forest Existence on Social, Economic and Local Wisdom Aspects of Coastal Communities in Jaring Smooth Village, Secanggang District, Langka Regency. *Jurnal Ilmiah Universitas Batanghari Jambi*, *19*(3), 666. https://doi.org/10.33087/jiubj.v19i3.709
2. Aswin, R., Lilik, P. B., Yudi, S., Ketut, & Wikantika. (2018). *Study of Land Cover Change in the Mangrove Ecosystem of the East Coast of Surabaya*.
3. Badan Pusat Statistik Kab, & Langkat. (2016). Profil Kabupaten. *Profil Kabupaten Langkat*, 144.
4. Basyuni, M., & Sulistiyono, N. (2018). Deforestation and reforestation analysis from land-use changes in North Sumatran Mangroves, 1990-2015. *IOP Conference Series: Materials Science and Engineering*, *309*(1). https://doi.org/10.1088/1757-899X/309/1/012018
5. Basyuni, Mohammad, Gultom, K., Fitri, A., Susetya, I. E., Wati, R., Slamet, B., Sulistiyono, N., Yusriani, E., Balke, T., & Bunting, P. (2018). Diversity and habitat characteristics of macrozoobenthos in the mangrove forest of Lubuk Kertang Village, North Sumatra, Indonesia. *Biodiversitas*, *19*(1), 311–317. https://doi.org/10.13057/biodiv/d190142

6. Bey, A., Díaz, A. S. P., Maniatis, D., Marchi, G., Mollicone, D., Ricci, S., Bastin, J. F., Moore, R., Federici, S., Rezende, M., Patriarca, C., Turia, R., Gamoga, G., Abe, H., Kaidong, E., & Miceli, G. (2016). Collect earth: Land use and land cover assessment through augmented visual interpretation. *Remote Sensing*, *8*(10), 1–24. https://doi.org/10.3390/rs8100807
7. Brotosusilo, A., Nabila, S. H., Negoro, H. A., & Utari, D. (2020). The level of individual participation of community in implementing effective solid waste management policies. *Global Journal of Environmental Science and Management*, *6*(3), 341–354. https://doi.org/10.22034/gjesm.2020.03.05
8. Catherine E. Lovelock, D. R. C., Friess4, D. A., Guntenspergen, G. R., Krauss5, K. W., , Ruth Reef1, 2, 6, Rogers7, K., Saunders2, M. L., Sidik8, F., & , Andrew Swales, Neil Saintilan, L. X. T. & T. T. (2015). *forests to sea-level rise*. https://doi.org/10.1038/nature15538
9. Chen, B., Xiao, X., Li, X., Pan, L., Doughty, R., & Ma, J. (2017). A mangrove forest map of China in 2015 : Analysis of time series Landsat 7 / 8 and Sentinel-1A imagery in Google Earth Engine cloud computing platform ISPRS Journal of Photogrammetry and Remote Sensing A mangrove forest map of China in 2015 : Analysis of . *ISPRS Journal of Photogrammetry and Remote Sensing*, *131*(August), 104–120. https://doi.org/10.1016/j.isprsjprs.2017.07.011
10. Chien, L. K., Huang, W. P., Hsu, C. H., Hsieh, C. C., & Fang, C. Y. (2017). Coastal disaster risk assessment and designation of protection zoning in Taiwan using GIS. *WIT Transactions on the Built Environment*, *170*, 173–184. https://doi.org/10.2495/CC170171
11. DasGupta, R., & Shaw, R. (2017). *Participatory Mangrove Management in a Changing Climate: Perspectives from the Asia-Pacific*. *February 2017*, 336. https://doi.org/10.1007/978-4-431-56481-2
12. Derraik, J. G. B. (2002). The pollution of the marine environment by plastic debris : a review. *Marine Pollution Bulletin*, *44*, 842–852.
13. Fiona Nunan, D. C. (2020). *Women and fi sheries co-management : Limits to participation on Lake Victoria*. *224*(November 2019). https://doi.org/10.1016/j.fishres.2019.105454
14. Fitzgerald, W. J. (2000). Integrated mangrove forest and aquaculture systems in Indonesia. *Mangrove-Friendly Aquaculture: ProceedingsProceedings of the Workshop on Mangrove-Friendly Aquaculture Organized by the SEAFDEC Aquaculture Department, January 11-15, 1999, Iloilo City, Philippines*, *2000*, 21–23.
15. Giri, C. (2016). *Observation and Monitoring of Mangrove Forests Using Remote Sensing : Opportunities and Challenges*. https://doi.org/10.3390/rs8090783
16. Hamzah, A. H. P. (2020). The Co-Management Concept in the Mangrove Environment Management Approach in Lubuk Kertang Village, Brandan Barat, North Sumatra. *Jurnal Manajemen Dan Sains*, *5*(April), 129–135. https://doi.org/10.33087/jmas.v5i1.160
17. Indah Nur Fitriani. (2018). *The Phenomenon of Outermost Small Islands and Indonesian Administrative Regions (Nontext Supplementary Book for Ips Learning in Junior High Schools) Beautiful*. *6*(1), 24–32.
18. Jhaveri, N. J., Tech, T., & Dung, N. K. (2019). Mangrove Collaborative. *January 2018*.
19. Lesiv, M., See, L., Bayas, J. C. L., Sturn, T., Schepaschenko, D., Karner, M., Moorthy, I., McCallum, I., & Fritz, S. (2018). Characterizing the spatial and temporal availability of very high resolution satellite imagery in Google Earth and Microsoft Bing Maps as a source of reference data. *Land*, *7*(4), 1–18. https://doi.org/10.3390/land7040118
20. Lestari, P., & Trihadiningrum, Y. (2019). The impact of improper solid waste management to plastic pollution in Indonesian coast and marine environment. *Marine Pollution Bulletin*, *149*(August),

110505. https://doi.org/10.1016/j.marpolbul.2019.110505

21. Liao, J., Zhen, J., Zhang, L., & Metternicht, G. (2019). *Understanding Dynamics of Mangrove Forest on Protected Areas of Hainan Island , China : 30 Years of Evidence from Remote Sensing*.
22. Muhtadi, A., Siregar, R. H., Leidonald, R., & Harahap, Z. A. (2016). *Ecological status of mangrove of Sembilan Island , Langkat Regency , North Sumatra Province*. *5*(3), 151–163. https://doi.org/10.13170/depik.5.3.5656

No	Family	Spesies	Local Name	Stasiun				
				1	2	3	4	5
1.	Acanthaceae	*Acanthus ilicifolius*	Jeruju hitam	-	-	-	□	□
2.	Pteridaceae	*Acrostichum aureum*	Paku laut	-	-	-	□	□
3.	Myrsinaceae	*Aegiceras cornilatum*	Teruntun	-	-	-	□	-
4.	Myrsinaceae	*Aegiceras floridum*	Mange	□	-	□	□	-
5.	Avicenniaceae	*Avicennia alba*	Api-api	□	-	-	-	-
6.	Avicenniaceae	*Avicennia lanata*	Api-api	-	□	□	-	-
7.	Avicenniaceae	*Avicennia marina*	Api-api putih	□	-	□	□	-
8.	Avicenniaceae	*Avicennia officinalis*	Api-api ludat	□	-	-	-	-
9.	Rhizophoraceae	*Bruguiera cylindrica*	Tanjang Putih	□	-	□	□	-
10	Rhizophoraceae	*Bruguiera gymnorhyza*	Tanjang merah	□	□	-	□	-
11.	Rhizophoraceae	*Ceriops decandra*	Tengar	□	□	□	□	□
12.	Rhizophoraceae	*Ceriops tagal*	Mentigi	□	□	□	-	□
13.	Euphorbiaceae	*Excoecaria agallocha*	Buta-buta	-	-	-	□	□
14.	Combretaceae	*Lumnitzera littorea*	Teruntum	-	-	□	□	□
15.	Combretaceae	*Lumnitzera racemosa*	Teruntum	-	-	-	-	□
16.	Arecaceae	*Nypa fruticans*	Nipah	□	-	□	□	□
17.	Rhizophoraceae	*Rhizophora apiculata*	Bakau minyak	□	□	□	□	□
18.	Rhizophoraceae	*Rhizophora mucronata*	Bakau hitam	□	□	□	-	□
19.	Rhizophoraceae	*Rhizophora stylosa*	Bakau	□	□	□	□	-
20.	Rubiaceae	*Scyphiphora hidrophidacae*	Prepat	-	□	□	□	□
21.	Molluginaceae	*Sesuvium portucastrum*	Gelang laut	-	□	-	-	-
22.	Sonneratiaceae	*Sonneratia alba*	Prepa/pedada	□	□	-	□	□
23.	Sonneratiaceae	*Sonneratia caseolaris*	Prepat/pedada	-	□	-	□	-
24.	Sonneratiacea	*Sonneratia ovata*	Kedabu	-	-	□	□	-

	e							
25.	Meliaceae	*Xylocarpus granatum*	Nyiri hutan	□	□	□	-	-
26.	Meliaceae	*Xylocarpus moluccensis*	Nyiri batu	□	-	-	-	-
		Total Spesies		15	12	14	17	12

23. Poedjirahajoe, E., Sulistyorini, I. S., & Komara, L. L. (2019). Mangrove conservation land suitability analisys based on environmental carrying capacity in Lombok Bay East Kalimantan, Indonesia. *Journal of Environmental Treatment Techniques*, *7*(4), 717–721.

Table 1. Mangrove Species Diversity in Langkat Regency (Source: Field Research, 2019)

Table 2. Land use in 9 subdistricts in Langkat Regency, 1989 (Source: Field Research, 2019)

Utilization of land in 9 subdistricts in Langkat Regency in 1989 (Ha)									
	Babalan	Besitan	Brandan Barat	Gebang	Pangkalan Susu	Pematang Jaya	Secanggung	Sei Lapan	Tanjung Pura
Natural Forest	0.00	35,024.76	0.00	0.00	0.00	0.00	0.00	10,002.24	0.00
Mangroves	1,975.52	1,418.72	3,164.56	4,090.02	7,925.47	467.13	7,900.71	123.32	9,296.95
Plantation	963.74	3,761.12	1,000.51	5,543.48	1,202.40	4,402.56	5,971.47	2,984.26	197.53
Settlement	573.13	116.82	6.30	775.98	189.79	0.00	667.31	397.65	2,523.83
Swamp	0.00	0.00	0.00	0.00	0.00	537.80	0.00	0.00	0.00
Rice fields	4,054.53	2,186.10	0.00	4,317.52	0.00	1.44	5,697.34	1,147.79	3,814.33
Bush / Thicket	0.00	18,684.82	241.79	0.00	9,182.33	2,036.60	23.98	5,239.06	648.81
Pond / dam	176.67	0.00	13.93	115.18	570.10	46.23	2,264.01	0.00	0.00
Open Land	0.00	18,684.82	0.00	0.00	239.87	25.63	246.21	679.02	26.23
Moor / field	299.36	8,012.02	3,763.68	928.27	3,550.38	4,523.64	873.33	10,380.94	467.19
Body of Water	287.62	375.26	564.56	1,332.51	518.71	206.76	951.97	101.25	1,416.35

Table 3. Land use in 9 subdistricts in Langkat Regency in 2019 (Source: Field Research, 2019)

Utilization of land in 9 subdistricts in Langkat Regency in 2019 (Ha)								
	Babalan	Besitan	Brandan Barat	Gebang	Pangkalan Susu	Pematang Jaya	Secanggang	Sei Lapan

Natural Forest	0.00	35,197.56	0.00	0.00	0.00	0.00	0.00	10,050.80
Mangroves	854.98	553.51	2,647.50	3,100.56	8,344.73	995.74	7,133.22	91.49
Plantation	968.65	3,779.96	1,168.93	6,837.91	1,199.96	4,420.46	6,002.29	3,068.67
Settlement	576.04	117.41	6.33	779.95	165.80	0.00	670.75	399.67
Swamp	0.00	0.00	0.00	0.00	0.00	540.49	0.00	0.00
Rice fields	4,295.52	2,197.05	0.00	4,303.78	0.00	1.45	6,132.90	1,153.61
Bush / Thicket	0.00	19,366.65	243.02	0.00	9,257.06	2,055.63	24.10	5,253.19
Pond / dam	1,651.61	0.00	508.99	768.18	1,244.11	46.46	3,283.68	0.00
Open Land	0.00	568.00	0.00	0.00	232.14	25.76	247.48	682.43
Moor / field	300.89	8,279.58	4,335.21	933.02	3,887.16	4,629.47	877.83	10,466.31
Body of Water	289.08	393.31	548.69	995.91	499.93	189.51	951.75	91.49

Table 4. Map of the area of mangrove land cover in Langkat Regency 1989-2019 (Source: Field Research, 2019)

Subdistrict	1989		1999		2009		
	m2	Ha	m2	Ha	m2	Ha	
Babalan	19,548,657.34	1,954,8657	9,928,168.14	992.8168143	4,405,948.38	440.5948	8,549
Besitang	14,188,031.14	1,418,8031	7,048,458.21	704.8458215	9,689,599.24	968.9599	5,535
Western Brandan	31,603,869.04	3,160.3869	16,031,180.14	1603.118014	22,257,780.46	2,225.7780	26,47
Gebang	40,900,903.34	4,090,0903	22,942,727.81	2294.272781	37,483,098.08	3,748,3098	31,00
Pangkalan Susu	79,266,856.16	7,926.6856	62,293,156.26	6229.315626	84,496,702.23	8,449,6702	81,98
Pematang Jaya	4,671,627.93	467.1628	8,843,756.84	884.3756837	10,769,004.17	1,076,9004	10,13
Secanggung	78,713,480.81	7,871.3481	55,489,015.92	5548.901592	73,429,615.56	7,342.9616	71,71
Sei Lepan	1,219,559.71	121,9560	1,616,180.85	161.6180848	932,799.48	93.2799	932,7
Tanjung Pura	92,970,650.55	9,297,0651	82,057,122.30	8205,71223	55,930,267.60	5,593,0268	50,68

TOTAL AREA	363,083,636.02	36,308.3636	266,249,766.47	26,624.98	299,394,815.20	29,939.4815	287,0

Figure 1. The Landsat image coverage for the study area (Source: Field Research, 2019)

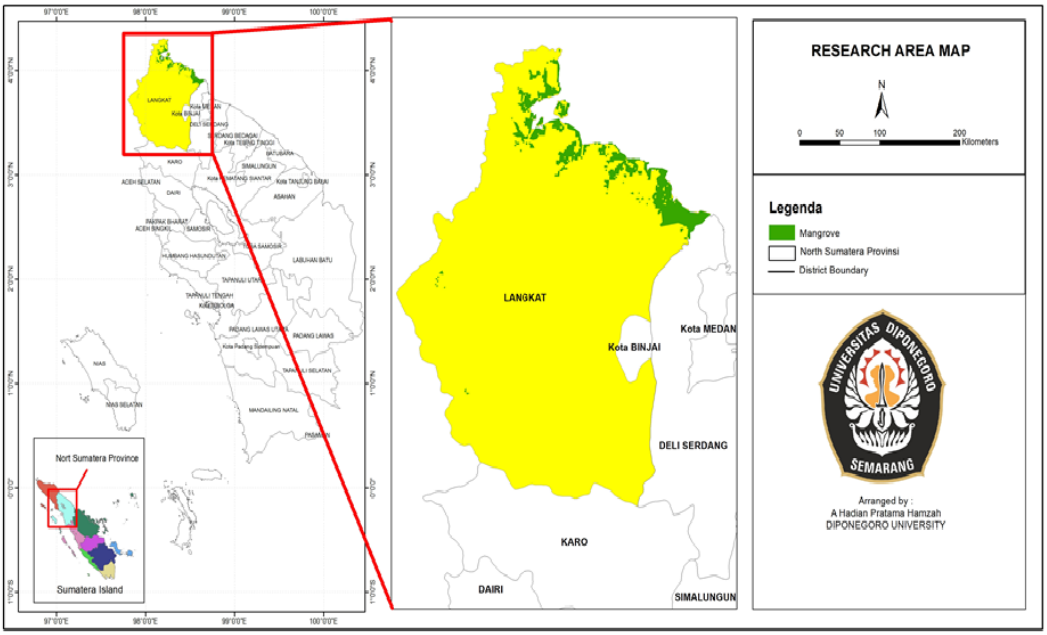

Figure 2. PSR approach (Source : Catherine E. Lovelock et al., 2015)

Figure 3. Land use in 9 subdistricts of Langkat Regency in 1989 (Source: Field Research, 2019)

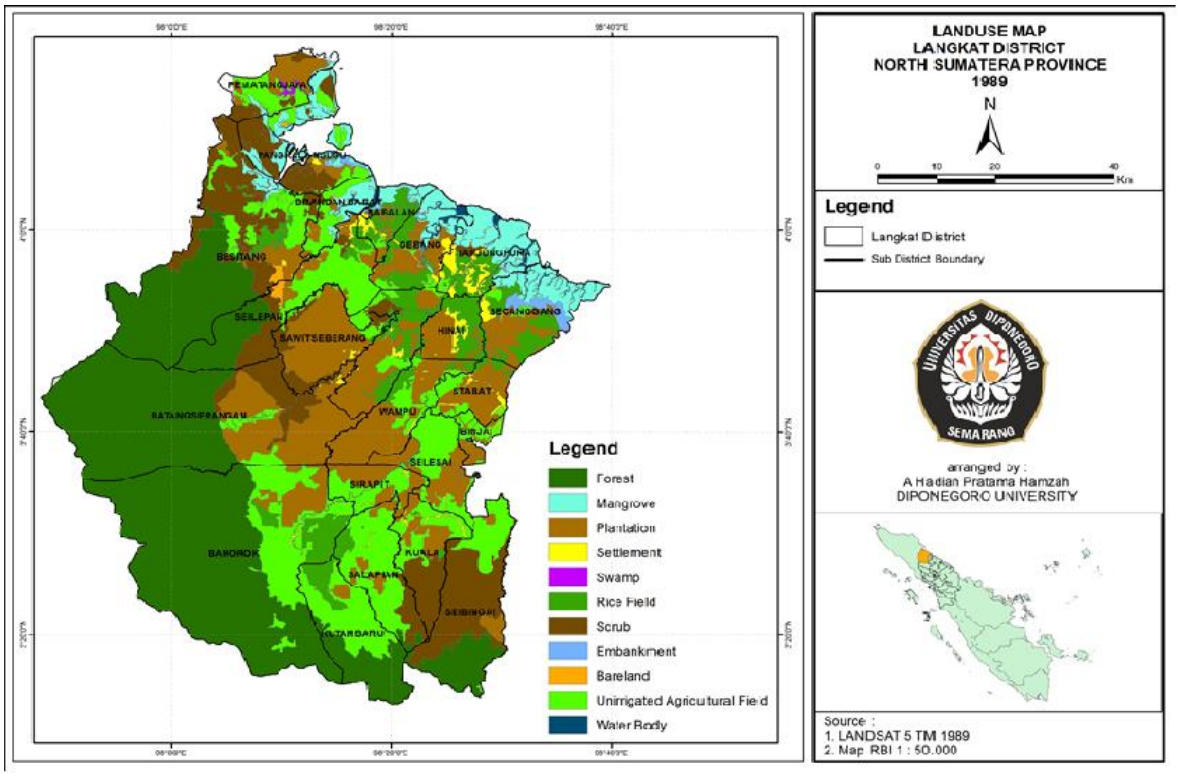

Figure 4. Land use in 9 subdistricts of Langkat Regency in 2019 (Source: Field Research, 2019)

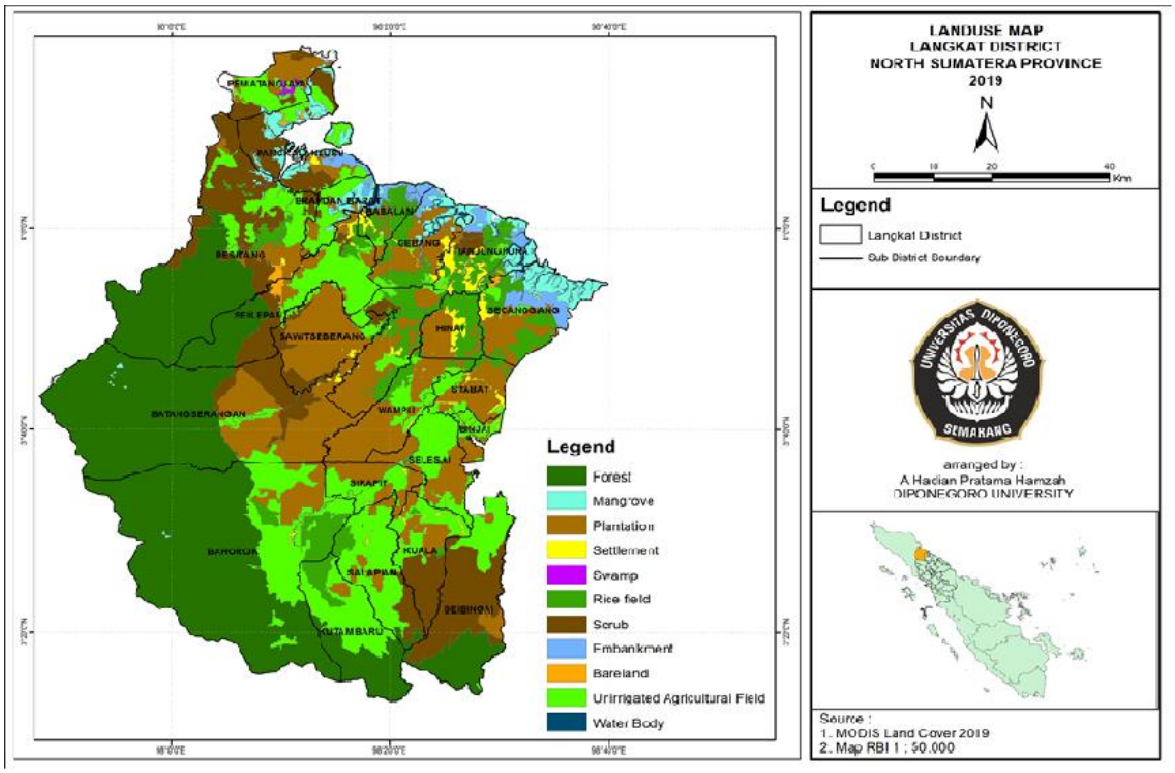

Figure 5. Map of mangrove forests in 9 subdistricts in Langkat Regency 1989-2019. (Source: Field Research, 2019)

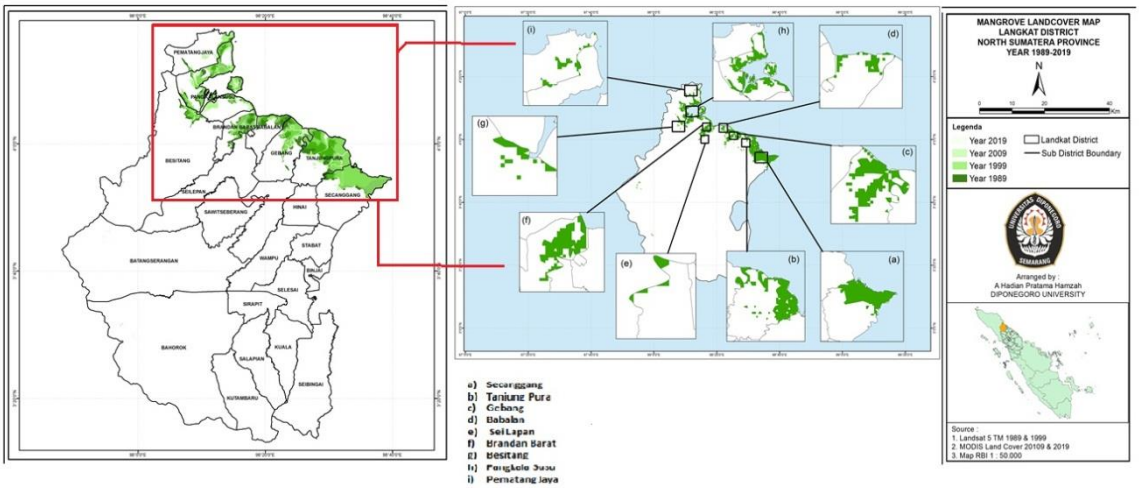

Figure 6. Langkat Regency coastline changes (Source: Field Research, 2019)

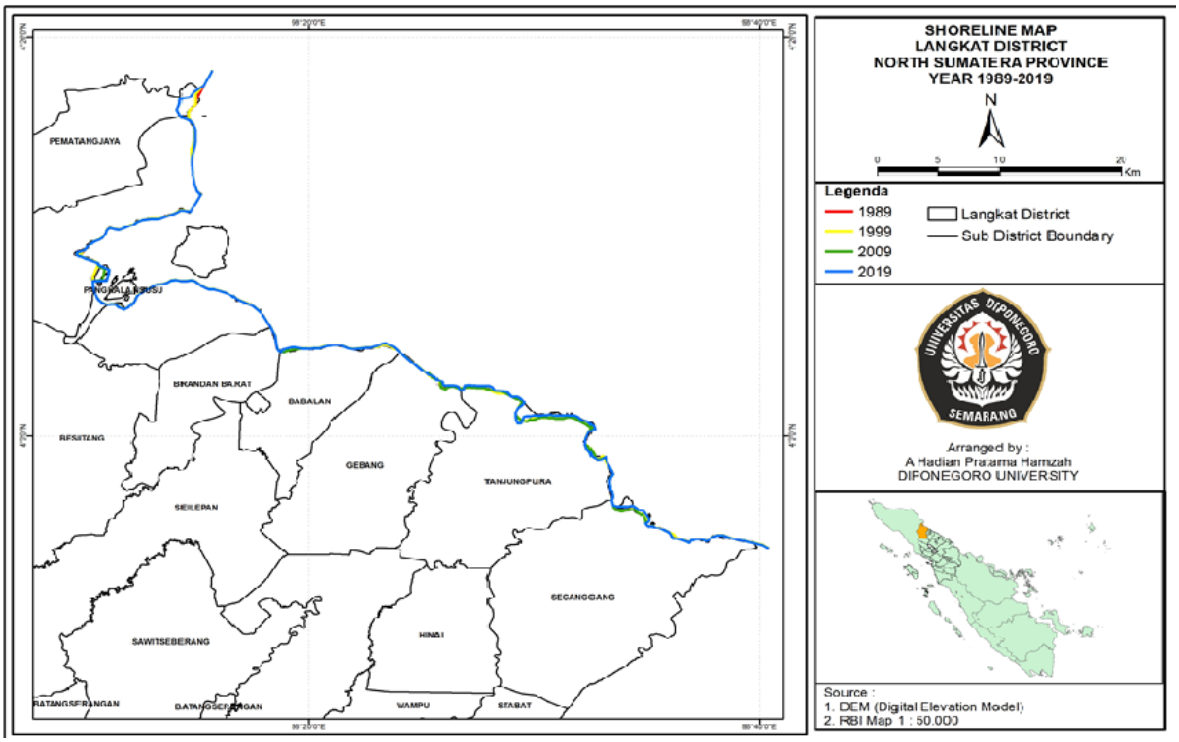

Figure 7. PSR Analysis of changes in mangrove cover area in Langkat Regency.
(Source: Field Research, 2019)


Responses
•Strengthening of the legal protection status of mangrove PAs
•Co-management of reserves
•Integrated Land use Planning
•Information and knowledge management
•Institutional strengthening
•Education and awareness raising
Pressures
•Population growth
•Pollution, wastewater disposal
•Tourism development
•Aquaculture
•Energy and Mining
•Inadequate use of biodiversity (over-harvesting, over-disturbance)
•Climate change and Severe Weather, geological events
•Invasive and exotic species
State
• Mangrove fragmentation
• Habitat loss, reduced coverage
• Mangrove habitat degradation