https://jurnal.unimed.ac.id/2012/index.php/tgeo/article/view/52747
https://doi.org/10.24114/tgeo.v13i1.52747 (Vol. 13 No. 1 – 2024)
e-ISSN: 2622-9528 p-ISSN: 2301-606X

Analysis Of Mangrove Land Cover In The Sawo Marine Conservation Area, North Nias District

Dayun Ifanda[1], Bejo Slamet[2,4], Rahmawaty[1,2], Yunasfi[2,4], Liana Dwi Sri Hastuti[3]
[1]Nature Resources and Environmental Management Study Program, Postgraduate School, Universitas Sumatera Utara, Indonesia
[2]Department of Forest Cultivation, Faculty of Forestry, Universitas Sumatera Utara, Indonesia
[3]Department Biology, Faculty of Mathematics and Natural Sciences Universitas Sumatera Utara, Indonesia
[4]Center of excellence for Mangrove, Universitas Sumatera Utara, Indonesia

Email:dayunifanda29@gmail.com

Received:	Revision:	Accepted:
November 07, 2023	July 20, 2024	July 30, 2024

Abstract

Sawo sub-district of North Nias Regency has a mangrove ecosystem that has been designated as a Regional Marine Conservation Area (KKLD) with an area of 29,230.85 ha. The 2005 earthquake and tsunami are reported to have caused damage to mangrove ecosystems due to rising land levels. The increase in land surface has resulted in the destruction of mangroves in this area. This impacts the sustainability of the mangrove ecosystem in this region and is important to study. This study aims to analyze changes in mangrove land cover after the tsunami in 2006 to 2022 and to analyze the impact of changes in mangrove land cover. The results found that mangrove land cover continues to experience a reduction in area; in 2006, an area of 139.78 ha continued to decline until the remaining 70.87 ha in 2022. This is due to the increasing population growth that causes mangrove forest degradation and land conversion into agricultural land, plantations, and infrastructure. The increase in population is a driving force, land clearing for settlements and plantations is a pressure factor (Pressures), land use change is a factor of existing conditions (State), and reduced mangrove land area is part of the impact (Impact). Coastal spatial planning and counseling to reforestation is a response (Response). Land conversion to other uses contributes to this area's continued loss of mangrove land.

Keywords: Mangrove; Land Cover; GIS; DPSIR

INTRODUCTION

Mangroves are a typical tropical and subtropical forest type that grows along beaches or estuaries influenced by tides (Dahuri, 2003; Buwono, 2017; Rahmad et al., 2020). Physically, mangrove forests protect the land from the effects of abrasion/erosion of waves. Chemically, mangroves function as filters for pollutants, especially organic materials, and also as a source of energy for the availability of detritus, which is a source of food for aquatic organisms and maintains productivity (Shinta et al., 2022; Putra et al., 2022).

Mangrove ecosystems are complex and dynamic. It is said to be complex because the ecosystem is filled with mangrove vegetation and is home to various species of aquatic animals and their populations (Julaikha and Sumiyati, 2017). Mangroves can protect the coast from abrasion, keep the shoreline stable, dampen waves and storms again, retain mud and trap sediments transported by surface flow, and act as a saltwater filter into freshwater (Utomo et al., 2017; Duryat and Rodiani, 2023).

Mangrove ecosystems provide biodiversity as a germplasm (genetic pool) and support the entire surrounding living system (Idrus et al., 2018). The ecological function of mangrove forests is important as a nursery ground, feeding ground, and spawning ground for various aquatic biota

(fish, shrimp, shellfish) living in coastal and offshore waters (Lisna et al., 2017; Koda, 2021).

Mangroves play an important role in coastal ecosystems, both physically, biologically, and economically, but the pressure of human activities threatens their sustainability (Nurhidayah et al., 2023). Utilizing mangrove resources that are not based on ecological benefits will threaten the ecosystem's sustainability capacity (Wardhani, 2011; Ramena et al., 2020). Economic factors often encourage maximum utilization of mangrove forests, which in turn can lead to overexploitation (Dasman et al., 2024). Utilization that is not accompanied by wise conservation is feared to cause a decline in resources, even causing extinction (Akram and Hasnidar, 2022).

Mangrove forest ecosystems in Indonesia are currently in a critical state because there is damage to about 68%, or 5.9 million hectares, of the total 8.6 million hectares (Majid et al., 2016). Excessive exploitation of mangrove forests is carried out for firewood, paper, charcoal, agricultural land, aquaculture, mining land, and settlements (Saidah et al., 2024). The drastic decline in mangrove areas is caused by a lack of understanding of mangrove ecosystems and the wrong assumption that mangrove ecosystems are worthless areas. This is one factor that encourages the conversion of mangrove land into other uses that are considered more economical (Pattimahu, 2010).

North Nias Regency is in the Nias Islands, North Sumatra Province. Its area is on the coast, so it has a long coastline. However, many coastal areas have experienced coastal abrasion. This abrasion was caused by the 2004 tsunami tragedy and the 2005 earthquake, which caused several coastal areas in North Nias Regency to experience land uplift, one of which was Sawo Sub-district (Medrofa, 2017).

.

Sawo Sub-district is an area in North Nias Regency with a fairly extensive mangrove ecosystem, especially in Sisarahili Teluk Siabang and Larasa Sawo Villages. Currently, the mangrove area in Sawo District has been damaged; not a few mangrove areas have dried up, which has caused the mangrove ecosystem to be damaged. According to data from the Sawo District Statistics Center in 2021, the villages of Sisarahili Teluk Siabang and Lasara Sawo continue to experience an increase in population every year. This increase in population results in increased demand for land for residential areas, agriculture, and infrastructure, affecting land demand. This will cause mangrove ecosystem degradation and land cover changes in the area.

The function of mangroves in an aquatic ecosystem is very important. The existence of mangrove ecosystems in the Sawo Marine Protected Area of North Nias Regency has not been analyzed, so it is important to research the sustainability analysis of mangrove ecosystems and study management strategies related to the existence of mangroves in the region.

This study aims to analyze changes in mangrove land cover after the tsunami from 2006 to 2022 and their impact using the driving force, pressure, state, impact, and response (DPSIR) framework.

RESEARCH METHODS

This research was conducted in December 2022. It is in the Sawo water conservation area in Sisarahili Teluk Siabang and Lasara Sawo, North Nias Regency, North Sumatra Province (Figure 1). The tools used in this research are GPS (Global Positioning System) as a coordinate point taker, ArcGis 10.8 software used to process land cover mapping data, stationery, and digital cameras as documentation

https://jurnal.unimed.ac.id/2012/index.php/tgeo/article/view/52747
https://doi.org/10.24114/tgeo.v13i1.52747 (Vol. 13 No. 1 – 2024)
e-ISSN: 2622-9528 p-ISSN: 2301-606X

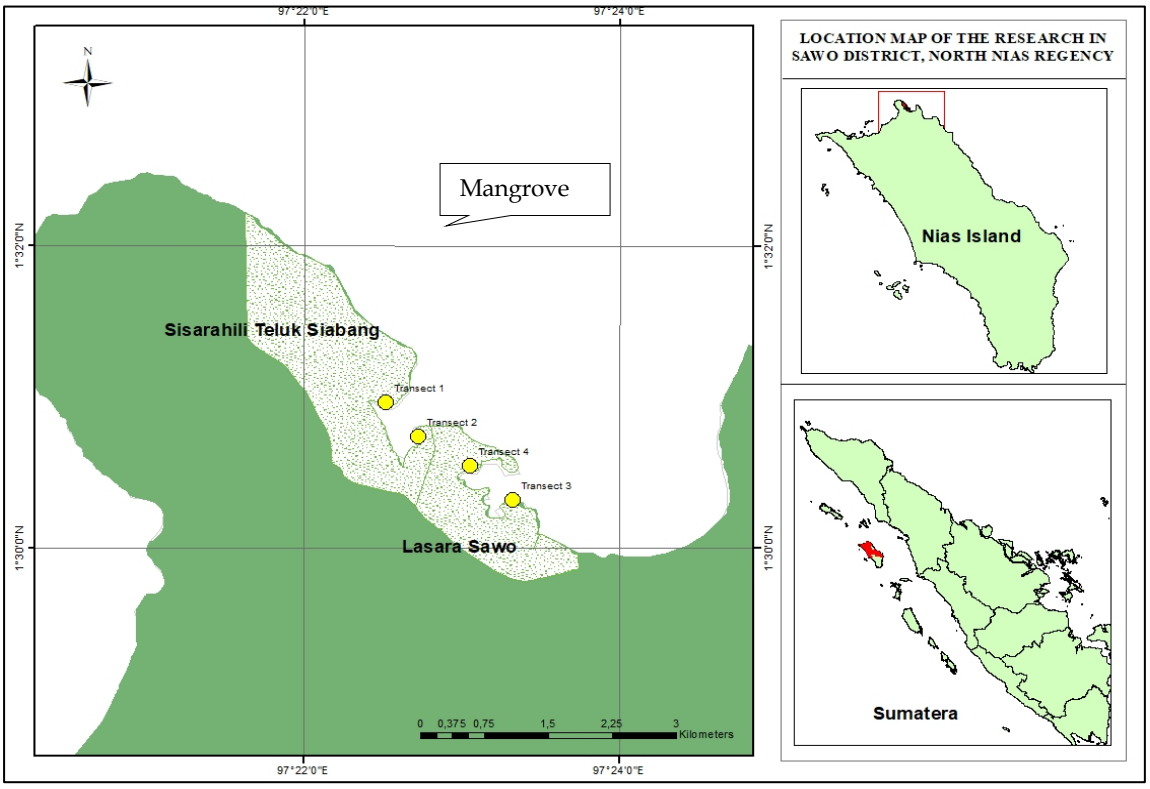

Figure 1. Research Location Map (Source: Data Processing, 2023)

The research objects used are the Indonesian Landform map, administrative map of North Nias Regency, Landsat 5 TM image, Landsat 8 OLI image, and Google Earth image. The data and data sources collected are presented in Table 1.

Table 1. Primary and Secondary Data in the Study

No	Data Name	Data Type	Source	Year
1	Field Data (*Ground truth*)	Primery	Field	2022
2	Citra Landsat 5 TM (2006)	Secondary	www.earthexplorer.usgs.gov	2006
3	Citra Landsat 5 TM (2011)	Secondary	www.earthexplorer.usgs.gov	2011
4	Citra Landsat 8 OLI path/row 129/57(2015)	Secondary	www.earthexplorer.usgs.gov	2015
5	Citra Landsat 8 OLI path/row 129/57(2022)	Secondary	www.earthexplorer.usgs.gov	2022
6	Peta Rupa Bumi Indonesia	Secondary	tanahair.indonesia.go.id	-
7	Map Administrasi on of North Nias Regency	Secondary	tanahair.indonesia.go.id	2022
8	Literature Related Research	Secondary	Literature Source	-
9	Interview Data	Primery	Community and Government	2022

(Source: Data Processing, 2023)

Image preparation includes image downloading, merging, checking, and cropping to fit the research area. This is done so that further analysis can be done properly. Image merging was done to unify the separate bands after uploading. Google Earth images were downloaded and stored, which were used for image validation or correction. The main data required was direct field observation to confirm land cover, which was used to check the validity of the land cover classification mapping. The following are the stages of the research flow (Figure 2).

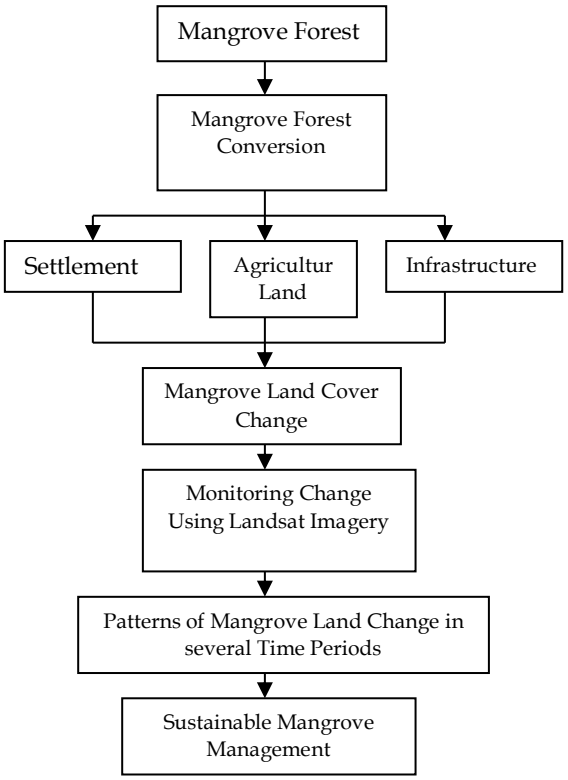

Figure 2. Research Flow Chart (Source: Data Processing, 2023)

Creating a land cover map using the guided image classification method. Guided classification is an image classification method that requires users to input information about land cover types during the process. The level of accuracy must be greater than 85%, after getting the results, a check will be made to test the validity. This validity test is a test conducted by analyzing the suitability of land use interpreted from imagery by checking directly in the field (Groud chek). The land use map is created by overlaying the land use map. Then, an accuracy test was conducted on land cover classification results using a contingency matrix, especially for kappa accuracy. Kappa accuracy is recommended because it uses all elements of the contingency matrix. Land use dynamics were analyzed by overlaying the maps with each other. The overlay results show land cover changes from 2006 to 2022.

RESULTS AND DISCUSSION

The results obtained from identifying land cover in Sisarahili Teluk Siabang Village and Larasa Sawo, covering an area of 507.70 ha, were carried out using the supervised classification method. Five types of land cover were obtained: water bodies, non-mangrove vegetation, gardens, open land, and mangroves. The classification results show changes in mangrove area from 2006-2022, as seen in Table 2.

https://jurnal.unimed.ac.id/2012/index.php/tgeo/article/view/52747
https://doi.org/10.24114/tgeo.v13i1.52747 (Vol. 13 No. 1 – 2024)
e-ISSN: 2622-9528 p-ISSN: 2301-606X

Table 2. Mangrove Land Cover Area in Sisarahili Teluk Siabang and Larasa Sawo Villages

No	Cover Type Land	Land Cover Area (2006) Ha	Land Cover Area (2011) Ha	Land Cover Area (2015) Ha	Land Cover Area (2022) Ha
1	Water Body	17,14	36,58	22,86	15,41
2	Non Mangrove Vegetation	127,48	126,15	128,73	108,70
3	Field	209,71	208,13	234,16	281,53
4	Open Field	13,59	15,38	20,61	31,19
5	Mangrove	139,78	121,44	101,34	70,87
	Total Area	507,70	507,70	507,70	507,70

Source: Data Processing (2023).

Table 2 shows that the largest land cover was mangrove in 2006, 2011, 2015, and 2022. The area of mangroves in 2006 was 139.78 ha and continued to experience a decrease in area in 2011 until the remaining 121.44 ha, in 2015 remaining 101.34 ha, and in 2022, only 70.87 ha. This was caused by the earthquake and tsunami that occurred in 2005, which decreased mangrove area due to damage to the mangrove ecosystem. This is in line with Medrofa's research in 2017, which stated that Sawo District is a coastal area that has experienced coastal abrasion processes. This abrasion was caused by the tsunami tragedy in 2004 and the earthquake in 2005, which caused several coastal areas in North Nias Regency to experience land rise, causing severe damage to mangroves and coral reefs.

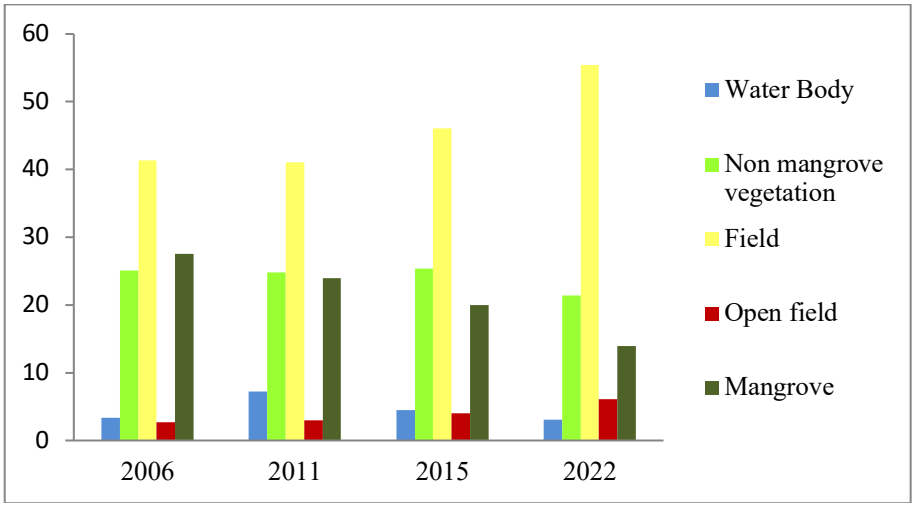

Figure 3. Land Cover Area in the Sawo Marine Conservation Area in the years 2006, 2011, 2015, and 2022 (Source: Data Processing, 2023)

Changes in land cover from 2006 to 2022 in the mangrove ecosystem of Sisarahili Teluk Siabang and Larasa Sawo villages were quite large, namely 70.87 ha. This shows that if there is land conversion at a certain location, the surrounding land will gradually change its function in a short time. Meanwhile, Yulius et al. (2014) argue that it is important to know changes in land cover to monitor changes in land cover to avoid land degradation. The land cover area changes to other land cover in the research location can be known by comparing land cover maps between 2006, 2011, 2015, and 2022 (Figure 4).

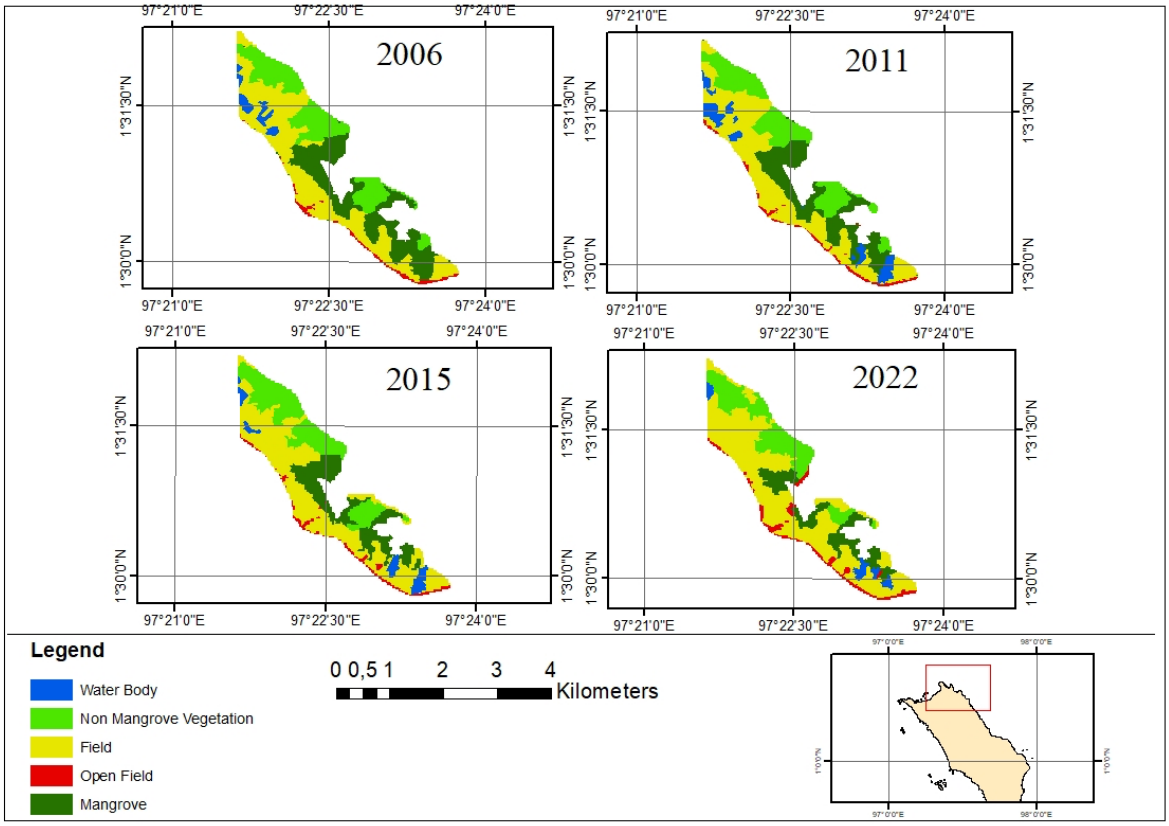

Figure 4. Land Cover Map 2006, 2011, 2015, 2022 (Source: Data Processing, 2023).

Changes to open land continue to increase in the area starting from 2006 with an area of 13.59 ha, in 2011 with an area of 15.38 ha, in 2015 with an area of 20.61 ha, and in 2022 with an area of 31.19 ha. This is because land is a very limited resource, so the very high demand for land will lead to land conversion (land use change). This is in accordance with the opinion of (Widiatmaka et al., 2015), who state that the socio-economic dynamics that occur in society will impact open land utilization, so the very high demand for land will lead to land conversion. Munibah (2008) argues that the relatively stable availability of land can lead to competition for land use, causing rapid changes in land use. Sometimes, humans convert the land for various uses, including converting paddy fields, plantations, and non-vegetated land. Kamusoko et al. (2009) The dominant factors most influential in the cover/use of vacant land are economic and social factors. Human life is inseparable from the socio-economic aspect, especially in fulfilling the needs of life.

The water body continues to decline until the remaining area of 15.41 ha in 2022 as well as non-mangrove vegetation which also decreased and only remained at 108.70 ha at the end of 2022, this is because the research location continues to increase land conversion into plantation and agricultural areas so that areas that should be water bodies or non-mangrove vegetation turn into agricultural land. According to (Ilmiha, 2023), Based on BPS North Nias data, the majority of workers in North Nias Regency work in the agricultural sector, namely 46,199 workers or nearly 78 percent of all workers, with details of 21,618 workers being male and the remaining 24,581 workers being female. Along with population growth and development activities, this has led to an increasing need for land used to carry out activities in the agricultural and non-agricultural sectors. This aligns with (Muslimah and Megawati's, 2008) statement that land

conversion continues to occur due to population growth. This is in accordance with the economic principle that users will always maximize the use of land for the benefit of their survival. Kamran et al. (2023) stated that population growth positively correlates with increasing development and negatively correlates with decreasing open land.

The increase in the area of land cover for plantations from 2006 was 209.71 ha to reach 281.53 ha in 2022, and this happened because plantation land, from an economic point of view, is more promising for the community, so people utilize their land to grow coconut crops which are the main agriculture for the people in North Nias. According to (Ragusta et al., 2011), coconuts are strategic products with a social, cultural, and economic role in Indonesian society. Coconut plantations are one of the products that have a very important role in people's lives, both economically and culturally - socially. The role of coconut is very important because coconut has the ability to produce continuously throughout the year and is ready to be sold to meet the needs of the farmer's family. Coconut plantations are also expected to be important in promoting regional growth.

Land cover changes that occurred within 16 years were quite large. The biggest change is the significant increase in open land from 2006 of 13.59 ha which continues to increase until it reaches an area of 31.19 ha in 2022. This is due to forest degradation and conversion in the mangrove ecosystem area in Sisarahili Teluk Siabang and Larasa Sawo villages. Human activities trigger mangrove forest degradation and conversion. Rapid population growth encourages people to cut down forests and convert mangroves to meet their daily needs. This is in accordance with the statement of (Zaitunah et al., 2018), which states that areas with dense populations, many human activities, and high accessibility can trigger and encourage people to change land use objectives. People want to convert forests to get new income.

DPSIR Analysis to Identify Land Cover Change Factors

The DPSIR framework was used to analyze the causes and impacts of land cover change and responses to these changes to identify the factors affecting land cover change. Five main indicators in the DPSIR framework were analyzed: driver, pressure, state, impact, and response. Driving forces/drivers are activities that are caused by humans and impact the environment. Driving force is an index that allows us to visualize the pressure of human activities on the environment and natural resources. The state or condition of the environment is an indicator that describes the quality and quantity of natural resources and the environment. Impact is an index that describes the environmental conditions that arise due to pressure, and response is an index that represents the level of stakeholder interest in environmental changes that occur (Rahmawaty et al., 2021).

Driving Force

Population growth is the driver of land cover change in Sisarahili Teluk Siabang Village and Larasa Sawo, North Nias Regency. The population in the two villages continues to increase, according to data from the Sawo District Statistics Center in 2010-2021. The increase in population is a driver of increasing human needs for food and other produced by land resources (Rahmawaty et al., 2020). This is in line with Liu et al. (2021), which states that the driving factors for increased development are human population growth, migration, and better economic opportunities, resulting in people moving in search of better opportunities.

Table 3. Population Increase in the last 12 years

No	Village	Total Population (Year)											
		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	Sisarahili Teluk Siabang	690	696	697	700	705	708	711	713	716	718	702	700
2	Larasa Sawo	1866	1883	1885	1892	1906	1914	1921	1928	1934	1940	2182	2205

Source: Statistics Center (2010-2021).

Pressures

The pressure faced by Sisarahili Teluk Siabang and Larasa Sawo Villages in North Nias Regency is land use change, which can cause various pressures on environmental sustainability, such as pressure on mangrove forest areas, pressure on biodiversity, both flora and fauna and pressure on forest ecosystem functions. This problem is related to the increasing population (Table 3.), which increases demand for land for various purposes. This is in accordance with the opinion of (Rahmawaty et al., 2020), which states that the increasing need for land is worried about threatening the existence of land resources. Increasing land needs will have an impact on increasing mangrove forest land clearing. Rasool et al. (2021) state that land use change not only changes the area and spatial dimensions but also causes a series of events that can ultimately result in the degradation of various ecosystems.

State

In Sisarahili Village, Teluk Siabang, and Larasa Sawo, North Nias Regency, the area of mangrove land cover continues to increase due to conversion to other land uses that have continued to increase in the last 16 years is the plantation area in 2006 with area of 209.71 ha to 281.53 ha in 2022. After the 2005 tsunami, open land increased from 13.51 ha in 2006 to 31.19 ha in 2022. Land use areas that decreased included mangroves, with an area of 139.78 ha (2006) and only 70.87 ha remaining (2022), and water bodies, with an area of 17.14 ha (2006) and only 15.41 ha remaining (2022). Non-mangrove vegetation has an area of 127.48 ha (2006) and only 108.70 ha remaining (2022). The area that continues to experience the largest decline is the mangrove area, with only 70.87 ha (13.95%) remaining in 2022. The increase in population is one of the triggers for land use change in Sisarahili Teluk Siabang Village and Larasa Sawo, North Nias Regency. This is in accordance with the opinion of (Gedefaw et al., 2020), which states that increased population growth is the main driver in land change dynamics. Increasing population growth causes higher demand for land.

https://jurnal.unimed.ac.id/2012/index.php/tgeo/article/view/52747
https://doi.org/10.24114/tgeo.v13i1.52747 (Vol. 13 No. 1 – 2024)
e-ISSN: 2622-9528 p-ISSN: 2301-606X

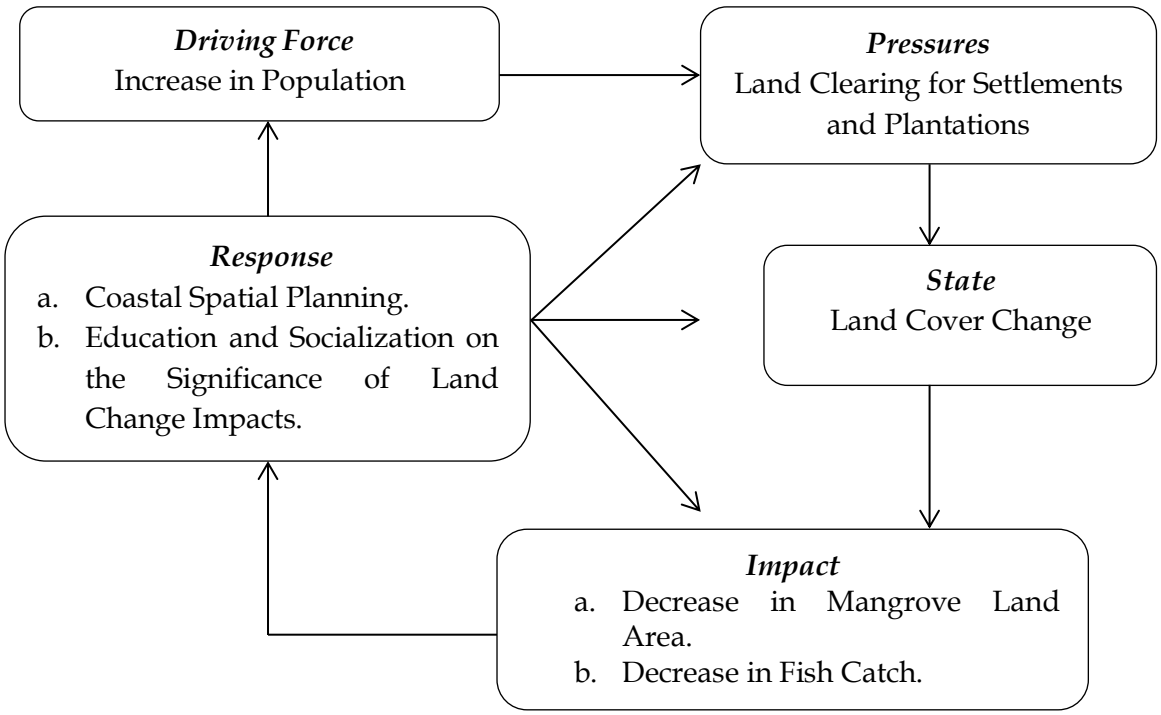

Figure 5. DPSIR Analysis Diagram Related to Mangrove Cover Change in Sisarahili Teluk Siabang and Larasa Sawo Villages.

Impact

Analysis obtained from the land cover map for the last 16 years shows that Sisarahili Teluk Siabang and Larasa Sawo villages in North Nias Regency continue to experience changes. According to Rahmawaty et al. (2022), mangrove land change can increase land degradation, disrupt the function of mangrove forests, and result in the loss of flora and fauna in the mangrove ecosystem. Perez-Vega et al. (2012) stated that a decrease in biodiversity can occur due to the reduction of forest areas, which are a source of biodiversity.

The decreasing vegetation area in mangroves is an important problem in land resource management because mangroves have many benefits, such as economic, ecological, and social benefits. Mangrove forest areas in Sisarahili Teluk Siabang Village and Larasa Sawo have been converted into coconut plantations. The local community believes mangroves have no economic value, so they cut them down and replaced them with coconut plantations. This has led to the continuous degradation of mangrove land.

Response

The efforts made by the central government, local government, community, academics, and stakeholders in preventing the impact of land cover change that occurs in Sisarahili Teluk Siabang Village and Larasa Sawo are by making rules regarding land use through spatial planning of coastal ecosystems and small islands by the provincial marine and fisheries office, as well as socialization and counseling on the impact of land change, mangrove forest degradation, and illegal logging. These programs have been carried out and worked together by the government, academics, NGOs, and local communities.

CONCLUSION

Mangrove land cover continues to experience a reduction in the area; in 2006, it was 139.78 ha and continued to decline until 70.87 ha remained in 2022. This is due to the increasing population growth that

causes mangrove forest degradation and land conversion into agricultural land, plantations, and infrastructure. Population increase is a driving factor, land clearing for settlements and plantations is a pressure factor, land use change is a State factor, reduced mangrove land area is part of Impact and coastal spatial planning, counseling to reforestation response.

REFERENCES

Akram, A. M dan Hasnidar. 2022. Identifikasi Kerusakan Ekosistem Mangrove di Kelurahan Bira Kota Makassar. Journal of Indonesian Tropical fisheris. 5 (1) : 1-11. ISSN : 2655-4461.

Buwono, Y. R. 2017. Identifikasi dan Kerapatan Ekosistem Mangrove di KawasanTeluk Pangpang Kabupaten Banyuwangi. Jurnal Ilmu Perikanan. 8 (1). ISSN :2503-2283.

Dahuri R. 2003. Keanekaragaman Hayati Laut Asset Pembangunan Berkelanjutan Indonesia. Jakarta (ID) : Gramedia Pustaka Utama.

Dasman, S., Adibah Y., Andrianto P. N., Nasrun B. 2024. Pelestarian dan Pemanfaatan Mangrove. Jurnal Pelita. 2 (1). ISSN : 2985-4601.

Duryat dan Rodiani. 2023. Rehabilitasi Mangrove untuk Kesehatan Lingkungan dan Kesejahteraan Masyarakat. Jurnal Pengabdian Fakulatas Pertanian Lampung. 2 (2): 133-145. ISSN : 1829-2235.

Gedewaf, A. A., Clement A., Thomas B., Sayeh K. A. R. M. 2020. Analysis of Land Cover Change Detection in Gozamin Districk, Ethiopia : From Remote Sensing and DPSIR Perspective. Journal Sustainability (12):1-25.

Idrus, A. A., Muhammad L. I., Gito H., dan Gde M. 2018. Sosialisasi Peran dan Fungsi Mangrove pada Masyarakat di Kawasan Gili Sulat Lombok Timur. Jurnal Pengabdian Magister Pendidikan IPA. 1 (1) :52-59. ISSN : 2655-5263.

Ilmiha, J. 2023. Analisis Potensi Beberapa Sektor Ekonomi Kabupaten Nias Utara 2022. Jurnal Simki Economic. 6 (1) :124-133.

Julaikha, S dan L. Sumiyati. 2017. Nilai Ekologis Hutan Mangrove. Jurnal Biologi Tropis. 17 (1). ISSN: 2549-7863.

Kamran, Junaid A. K., Umer K., Abdul W., and Muhammad F. K. 2023. Exploring the nexus between land use land cover (LULC) changes and population growth in a planned city of Islamabad abd unplanned city of Rawalpindi, Pakistan. Juornal Heliyon. 9 :13297. 1-17.

Kamusoko C, Aniya M, Adi B, Manjoro M. 2009. Rural sustainability under threat in Zim-babwe – Simulation of future land use/cover changes in the Bindura district based on the Markov-cellular automata model. Journal Applied Geography. 29: 435-447.

Koda, S. H. A. 2021. Analisis Ekologis Mangrove dan Dampak Perilaku Masyarakat terhadap Ekosistem Mangrove di Pesisir Pantai Kokar, Kabupaten Alor Nusa Tenggara Timur. Jurnal Penelitian Sains. 23 (1). ISSN : 2597-7059.

Liu, Y., Shaker, U. D., and Yue J. 2021. Urban growth sustainability of Islamabad, Pakistan, over the last 3 decades : a perspective beased on object-based backdating change detection. GeoJuornal. 86 :2035-2055.

Lisna., Adam M., Bau T. 2017. Potensi Vegetasi Hutan Mangrove di Wilayah Pesisir Pantai Desa Khatulistiwa Kecamatan Tinombo Selatan Kabupaten Parigi Moutong. Jurnal warta Rimba. 5(1) : 63-70. ISSN : 2579-6267.

Majid, I., Mimien H. I. A. ., Fachur R., dan Istamar, S. 2016. Konservasi Hutan Mangrove di Pesisir Pantai Kota Ternate Terintegrasi dengan Kurikulum Sekolah. Jurnal Bioedukasi. 4(2). ISSN : 2301-4678.

Nurhidayah, M., Taufik M., dan Febri L. 2023. Identifikasi Ekosistem Mangrove

dan Pemanfaatannya oleh Masyarakat Kawasan Taman Wisata Alam Teluk Youtefa. Jurnal Review Pendidikan dan Pengajaran. 6(2). ISSN : 2655-6022.

Medrofa, Septinus. 2017. Potensi dan Strategi Pengelolaan Mangrove di Kecamatan Sawo Kabupaten Nias Utara Provinsi Sumatera Utara. [Tesis]. Institut Pertanian Bogor.

Munibah, K. 2008. Model Spasial Perubahan Penggunaan Lahan dan Arahan Penggunaan Lahan Berwawasan Lingkungan (Studi Kasus DAS Cidan, Provinsi Banten). [Disertasi]. Bogor (ID) : Institut Pertanian Bogor.

Muslimah dan Megawati. 2008. Analisis Damapak Alih Fungsi Lahan Perkebunan Terhadap Pendapatan Petani di Kecamatan Seruway Kabupaten Aceh Tamiang. Jurnal Agrisamudra. 2 (5) :9-10.

Pattimahu D. V. 2010. Kebijakan Pengelolaan Hutan Mangrove Berkelanjutan di Kebupaten Seram Bagian Barat, Maluku. [Disertasi]. Bogor (ID) : Institut Pertanian Bogor.

Perez-Vega A, Mas J, Ligmann-Zielinska A. 2012. Comparing Two Approaches to Land Use/Cover Change Modeling and their Implications for The Assessment of Biodiversity Loss in A Deciduous Tropical Forest. Environ Model Software 29 (1): 11-23.

Putra, A., Dafiuddin S., Frans T., dan Irvan F. 2022. Analisis Vegetasi Mangrove di Desa Mekarsari Kabupaten Tanah Laut (Studi Kasus PT. Arutmin Indonesia Tambang Mekarsari. Environmental Pollution Journal. 2(1): 311-316.ISSN : 2776-5296.

Ragusta R., Armen M., dan Rozaina N. 2011. Analisis Ekonomi Perkebunan Kelapa dalam Terhadap Perekonomian Wilayah Kabupaten Tanjung Jabur Timur. Jurnal Sosial Ekonomila Bisnis. 25-26.

Rahmad, Y., Elfrida., Mawardi., dan Albian M. 2020. Keanekaragaman Tumbuhan Mangrove di Desa Alur Dua Tahun 2019. Jurnal Jempa. 7(1).

Rahmawaty, Harahap M.M., Kurniawan H., Mandasari D. 2020. DPSIR Model Approach to Address Land Use Changes in Deli Serdang District, North Sumatera Province. IOP Conference Series Earth Environmental Sci. 724 (1) :012028.

Rahmawaty, Harahap M.M., Kurniawan H., Rauf A. 2021b. Land Use Changes Monitoring Over a Period of Ten Years In Panjang Island, Pangkalan Susu, Langkat North Sumatera. IOP Conference Series Earth Environmental Sci. 782 (8):032008.

Rahmawaty, Harahap M.M, Kurniawan H, Rauf A. 2022. Land Cover Change Impact Analysis : An Integration of Remote Sensing, GIS and DPSIR Framework to Deal with Degraded Land in Lepan Watershed, North Sumatera, Indonesia. Biodiversitas. 6 (23) : 3000-3011.

Ramena, G. O., Cynthia E. V., dan Frits O. P. S. 2020. Pengaruh Aktivitas Masyarakat Terhadap Ekosistem Mangrove di Kecamatan Mananggu. Jurnal Spasial. 7 (3). ISSN : 2442-3262.

Rasool, R., Abida F., Miftah ul S., Harmeet S., and Pervez A. 2021. Land use land cover change in Kashmir Himalaya : Linking remote sensing with an indicator based DPSIR approach. Journal Ecological Indicators. 125 : 107-447.

Saidah, S., La H., Sitti K., dan Surdin. 2024. Deskripsi Kerusakan Ekosistem Hutan Mangrove. Jurnal Penelitian Pendidikan Geografi. 9 (1). ISSN : 2502-2776.

Shinta., Mega L. S., Yuli A., dan Subiyanto. 2022. Identifikasi Jenis Mangrove pada Kawasan Ekosistem Mangove di Kabupaten Pangandaran. Jurnal Akuatek. 3(1) :9-18.

Utomo, B., Sri B., dan Chatarina M. 2017. Strategi Pengelolaan Hutan Mangrove di Desa Tanggul Tlare Kecamatan Kedung Kabupaten Jepara. Jurnal

Ilmu Lingkungan. 15 (2) :117-123. ISSN:1829-8907.

Wardhani, M. K. 2011. Kawasan Konservasi Mangrove : Suatu Potensi Ekowisata. Jurnal Kelautan. 4 (1). ISSN : 1907-9931.

Widiatmaka, Ambarwulan W., Purwanto M. Y. J., Setiawan Y., Effendi H. 2015. Daya Dukung Lingkungan Berbasis Kemampuan Lahan di Tuban, Jawa Timur. Jurnal Manusia Dan Lingkungan. 22 (1) :247-259.

Yulius, T.A., Tanto, Ramdhan, M., Putra,A. dan Salim, H.L. 2014. Perubahan Tutupan Lahan di Pesisir Bungus Teluk Kabung, Sumatera Barat Tahun 2003-2013 Menggunakan Sistem Informasi Geografis. Jurnal Ilmu dan Teknologi KelautanTropis, 6 (2): 311-318.

Zaitunah, A., Samsusri, Ahmad A.G., Safitri R.A. 2018. Normalized Difference Vegetation Index (NDVI) Analysis for Land Cover Types Using Landsat 8 OLI in Besitang Watershed, Indonesia. IOP Conference Series : Eath and Environmental Science 126 : 012112.