Biodiversity and social aspects of the Sawo-Lahewa Marine Protected Area, North Nias: a social-ecological mapping

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Abstract. Sawo-Lahewa sea waters, North Nias District, North Sumatra Province was determined to become one of the marine conservation areas on December 22, 2017 through the Decree of the Minister of Marine Affairs and Fisheries Republic of Indonesia Number 54/Kepmen-KP/2017. This stipulation aims to protect, preserve, and utilize the potential of fisheries and important habitats (coral reefs, mangroves, and seagrass) and important species (turtles, dolphins, manta rays, napoleons, lola, dugongs, whale sharks, sea bamboo Isis puridis, Black Coral Anthipatharia, etc.) to support tourism development. This paper aims to map the condition of biodiversity and social aspects in the Sawo-Lahewa Marine Conservation Area by using the social-ecological framework. Using the data on ecological and social conditions were collected during 2014-2015 and updated with 2019-2020 data. The mapping of ecological aspects have involved the condition of coastal-marine ecosystems, including coral reefs, reef fish abundance, reef megabentos abundance, mangroves, and seagrasses) and also oceanographic conditions, meanwhile, the mapping of social aspects including socio-demography and socio-economics aspects. To enrich the analysis, this paper was also equipped with a discussion of zoning arrangements. Important findings from this study that the sustainability of biodiversity is influenced by the sustainability of local social activities; vice versa.

1. Introduction
Sawo-Lahewa Marine Protected Area (MPA), North Nias District, North Sumatra Province was determined to become one of the marine protected areas in Indonesia on December 22, 2017 through the Decree of the Minister of Marine Affairs and Fisheries Republic of Indonesia Number 54/Kepmen-KP/2017. This stipulation aims to protect, preserve, and utilize the potential of fisheries and important habitats (biodiversity/ecological aspects) and important species as well as to support tourism
development (social aspects). This designation is a commitment of the Indonesian government to reserve 20 million hectare conservation area in 2020 and 30 million hectares in 2030 [1,2,3].

Coastal areas and small islands have a lot of potential biological resources, especially from ecosystem services for the welfare of the community. On the other hand, limited space and high rates of population growth and land development along the coast and small islands put constant pressure on the sustainability of their natural resources. Global climate change is predicted to have a direct impact and poses a serious threat that can eliminate the functions and services of various coastal ecosystems and small islands. The action of reserves area followed by effective management and conservation interventions expected to provide for the sustainability of resources and improving community welfare [4,5].

Approach to the reserve and determination of zoning area are based on biophysical studies of coastal resources and small islands as well as social, economic, cultural aspects of society [6,7]. Concepts and approaches talked-about provide a guarantee of the sustainability of coastal ecosystem resources and small islands and improve the welfare of the community from the ecosystem services provided. In fact, the availability of social and ecological data in the area to be reserved and managed is still limited and sometimes not available at all, so that an ecologically based management approach cannot be carried out. Our study is based on basic data on the potential and support of biological resources at the level of ecosystems, population and species and the environmental conditions of waters that support these resources as well as exploring the social aspects of the community in managing natural resources.

Figure 1. A conceptual framework for the analysis of linked social-ecological systems.

The importance of linkages between ecological and social aspects in planning and implementing natural resource management, including in the Marine Protected Area, refers to the social-ecological system framework that was built by Folke and Berkes in 1998 (see Figure) [8]. Social-ecological systems are defined as systems including social and ecological aspects; nested; multi-level systems; and provide essential services to society such as a supply of food fibre, energy, and drinking water. Ecological knowledge and understanding is a critical link between complex and dynamic ecosystems, adaptive management practices, and institutions. From the descriptions above, this paper aims to map the conditions of ecological (biodiversity) and social aspects of the Sawo-Lahewa Marine Protected Area (MPA), especially in each zone.

2. Methodology
2.1. Time and location
The data used are on ecological and social conditions that were collected in 2014-2015 and updated with 2019-2020 secondary data for social aspects. The research location of ecological aspect consists
of eight research stations was located in the northern waters of North Nias Regency which is including in the Marine Protection Area. The distribution of research stations is along the north-west coast and small islands in Sawo-Lahewa MPA (see Figure 2). For social aspects, research was carried out in villages in Sawo District (Sawo, Sifahandro, Lasara Sawo, Sisarahili, Seriwau, Teluk Bengkuang) and in Lahewa District (Siheneasi, Moawo, Pasar Lahewa, Balefadorutuho).

![Figure 2. Observation sites of ecological aspects](image)

2.2. Data collection & analysis technique

Data collection is conducted by several methods depending on the aspects. Ecological aspects included coral cover, the abundance and biomass of reef fishes, the abundance of megabenthos, seagrass, and mangrove coverage. Coral reef cover obtained through underwater observation using the SCUBA gear using the Underwater Photo Transect (UPT) method [9,10,11]. The photos were further analyzed using the CPCe software program. The value obtained is the percentage of benthic cover categories that fall into 4 groups: very good (75-100%), good (50-74%), fair (25-49.9%), and poor (0-24.9%). Acquisition of coral reef fishes data is using the Underwater Visual Census [12] while megabenthos is using the Benthos Belt Transect which is a development of the belt transect method for megabenthos monitoring [13]. For seagrass and mangrove data obtained through land observation techniques using the quadratic line transect technique plus Hemispherical Photography specifically for mangroves [14].

The collection of social data was carried out using mix-methods (quantitative & qualitative methods in a participatory manner by involving community participation and local stakeholders gradually from the village, sub-district and district levels through a series of surveys (200 household), deep interviews, field observations, focus group discussions. Updating social data is done using data published by the North Nias District Statistics Bureau in 2019-2020.

Ecological data analysis, specifically coral reef data, were analyzed using CPCe software and hemispherical photography for mangroves. Others use calculation analysis on Microsoft Excel. Analysis of social data using quantitative analysis using SPSS for survey data and qualitative analysis for data from field observations, focus group discussions. Furthermore, the ecological and social data are analyzed with a social-ecological system approach [8,15,16] following the criteria set by MoMAF Decree No Kep. 44/KP3K /2012 (see Figure 3).
3. Result and discussion

3.1. Zoning system

The zoning system of the Sawo and Lahewa MPA is divided into four zones including the Core Zone, the Sustainable Fishing Zone, the Utilization Zone, and the Other Zones which designated as the Rehabilitation Zone. The zoning system arrangement follows MoMAF Rule Nomor Per.30/Men/2010:

1. Core Zones: spawning, nurturing and migration paths of fish; habitat of certain priority and unique or endemic aquatic biota, rare or charismatic, diversity of types of biota; characteristics of natural ecosystems and representing certain biota which is still original, having original waters condition which is not disturbed by humans; has sufficient area to guarantee the continuity of effective fisheries management; has characteristics as germplasm, at least 2% of the MPA area.

2. Sustainable Fisheries Zones: has conservation value; has environmental characteristics that support sustainable fisheries; has a diversity of aquatic biota types; has good water conditions; has sufficient area; has potential characteristics of aquatic biota with economic value.

3. Utilization Zone: has tourist attraction; has sufficient area for tourism; has the character of educational and research objects; has good water conditions.

4. Other Zones: in the form of protection zones and rehabilitation zones as well as other zones that support protection and conservation efforts; are outside the core zone, sustainable fishing zones and utilization zones.

The specific coordinates of the Sawo-Lahewa MPA are presented in Table 1. The zoning map of the Sawo and Lahewa MPA areas divided into five areas is presented in 1: 25,000 scale map as shown in Figure 4.

3.1.1. Core zone

The core zone is part of the conservation area that has natural conditions, both biota or physical. The core zone is usually pristine and either has not been disturbed by humans, which are protected and represent the original and its unique biodiversity. The core zone of Sawo-Lahewa MPA has a total area of 609.26 ha. It is exceeded the minimum for the core zone area which is 584.61 ha. Following the result of the potential surveys, the criteria to determine as the Core Zone are:

- The live coral coverage is in stable condition (good category) and shows the recovery process after 2005 earthquakes
- The unique physical and geological conditions of the coast and small islands
- Habitat for some rare and protected biota such as sea turtles, clams, conch Lola and sea bamboo
- A complete coastal ecosystem (coral reefs, seagrass beds, and mangroves) as a place for spawning and nursing of various marine biota
• The location is sacred and as a site for establishing some traditional activities.
• The existence of the Core Zone is expected to reduce pressure from various human activities and be able to maintain and accelerate the process of resource recovery after the 2005 earthquakes and tsunami.

Table 1. Specific Coordinate of the Marine Protected Areas of Sawo and Lahewa

| Area | ID   | Coordinates [East Longitude, North Latitude] | Area (hectare) | Location                  |
|------|------|---------------------------------------------|----------------|---------------------------|
| Area 1 | 1    | 097 25 20,91000E 01 43 22,21320N | 2,485.34       | Sarangbaung Island       |
|      | 2    | 097 28 10,40520E 01 43 23,35800N            |                |                           |
|      | 3    | 097 28 10,40520E 01 40 40,07640N            |                |                           |
|      | 4    | 097 25 20,91000E 01 40 38,01360N            |                |                           |
| Area 2 | 5    | 097 25 59,30760E 01 29 26,97000N            | 2,863.12       | Subdistrict of Sawo      |
|      | 6    | 097 27 08,60040E 01 30 26,40600N            |                |                           |
|      | 7    | 097 27 08,60040E 01 33 04,32000N            |                |                           |
|      | 8    | 097 24 04,43880E 01 33 04,32000N            |                |                           |
|      | 9    | 097 24 04,43880E 01 29 56,81760N            |                |                           |
| Area 3 | 10   | 097 22 37,51680E 01 31 21,36000N            | 3,948.80       | Subdistrict of Sawo      |
|      | 11   | 097 22 37,51680E 01 33 54,59760N            |                |                           |
|      | 12   | 097 18 40,37400E 01 33 54,59760N            |                |                           |
|      | 13   | 097 18 40,37400E 01 30 19,55880N            |                |                           |
|      | 14   | 097 20 52,00800E 01 29 09,45960N            |                |                           |
| Area 4 | 15   | 097 16 40,05120E 01 25 14,33640N            | 7,371.09       | Subdistrict of East Lahewa and Lahewa |
|      | 16   | 097 16 40,05120E 01 29 06,74520N            |                |                           |
|      | 17   | 097 11 32,25480E 01 29 06,74520N            |                |                           |
|      | 18   | 097 11 32,25480E 01 25 09,53400N            |                |                           |
| Area 5 | 19   | 097 09 49,21560E 01 24 47,23560N            | 12,562.50      | Subdistrict of Lahewa    |
|      | 20   | 097 10 38,48880E 01 25 31,62000N            |                |                           |
|      | 21   | 097 10 38,48880E 01 26 29,76000N            |                |                           |
|      | 22   | 097 09 02,82960E 01 27 43,40880N            |                |                           |
|      | 23   | 097 03 59,01840E 01 27 43,40880N            |                |                           |
|      | 24   | 097 02 16,54800E 01 26 29,76000N            |                |                           |
|      | 25   | 097 02 16,54800E 01 22 27,36840N            |                |                           |
|      | 26   | 097 05 58,57440E 01 19 57,27000N            |                |                           |
|      | 27   | 097 08 04,70040E 01 19 57,27000N            |                |                           |
|      | 28   | 097 08 04,70040E 01 22 50,18160N            |                |                           |
3.1.2. **Sustainable fisheries zone**

Sustainable Fishing Zones are all areas in the Sawo-Lahewa MPA that are not included in the Core Zone, Use Zone, and Rehabilitation Zone with an area of 27,870.71 ha. The Sustainable Fisheries Zone is part of the Sawo-Lahewa MPA dedicated to protecting habitat and fish populations, friendly fishing and aquaculture, tourism and recreation, research and development, and education. Potential sustainable fishing zones within the Sawo-Lahewa MPA include:

- High economic value fish habitat
- Large and small pelagic, demersal and coral reef fish areas
- Location of catching for local and outer fishermen
- Areas which is suitable for coastal and brackish aquaculture.

3.1.3. **Utilization zone**

The Utilization Zone is part of the Sawo-Lahewa MPA whose functions include tourism, education, and research. The utilization zones are distributed in several sites with a total area of 821.01 ha. In general, the function of Sawo-Lahewa MPA is as marine tourism with activities such as swimming, snorkelling, diving, fishing, surfing, and other water sports such as jetski, banana boat, and bottom glass boat as well as additional activities including hiking and camping. The development of marine tourism started with building networks and promoting marine tourism destinations both at national and international levels. Another thing that needs attention is the availability of facilities and infrastructure for marine tourism activities. The other function is for research and education with in-situ learning objects. It is also able to be geological geothermal parks for studying earthquake and tsunami, as well as a natural laboratory for the coastal and small islands. Conservation projects are also carried out including rehabilitation and restoration of brackish swamp habitat, mangroves, seagrass beds, and coral reefs. Rehabilitation of endangered biota is highly recommended by replanting mangroves, coral and seagrass transplantation, hatcheries and breeding for sea turtles.

3.1.4. **Other zone (Rehabilitation zone)**
Other Zones following the Minister of Maritime Affairs and Fisheries Regulation 30/2010 are water areas outside the Core Zone, Sustainable Fishing Zones, and Utilization Zones. Other Zones are usually designated for certain needs like specific protection or rehabilitation. After the earthquake and tsunami events of 2004 and 2005, the Other Zones in Sawo-Lahewa MPA are designated as locations for habitat and ecosystem rehabilitation. Activities in the Rehabilitation Zone are determined and adjusted according to the resources within them. The activities are to protect, preserve, repair, restore, and sustainably use of water resources. It is arranged and determined by the area manager together with the community. The Rehabilitation Zone has become an important area since it is useful as a buffer zone and an accelerator for the recovery process after the 2004 and 2005 earthquakes and tsunami.

3.2. Biodiversity condition

3.2.1. Coral reefs

Coral reef ecosystems have high ecological and economic value. In addition to protecting the coast from abrasion, this ecosystem provides a source of livelihood for the surrounding community, especially from the fisheries sector [17]. Coral reefs in the Sawo-Lahewa MPA are distributed along the west, north and east coast and small islands of Sawo-Lahewa MPA. Coral reef waters on the west coast are relatively open and face the open waters of the Indian Ocean, while the north coast and small islands are in the bay and are more protected. On the other hand, the waters on the east coast are somewhat open with some more protected parts in a small bay with a fairly large river mouth. The health condition of coral reefs along the north-west coast and small islands tends to be better compared to coral reefs along the north-east coast. The live coral cover is higher in the west coast location and small islands, while in the north and east coast it is relatively lower and is dominated by dead coral and macroalgae cover. The results of coral reef cover from 15 points are presented in Figure 5.

![Graph of coral cover at each coral research station location.](image)

**Figure 5.** Graph of coral cover at each coral research station location. From the above data, it can be seen that in 15 locations scattered in the waters of North Nias are quite varied in conditions. The value of coral cover is very diverse, from the lowest value of 2.07\% to the highest value of 64.93\%. The average value of all stations is 27.14\%, i.e. coral cover is in a quite good category.

Figure 5 shows the range of live coral cover between stations as well as other benthic components. The observation site at station NIAL05 (Lafau Island) has the highest percentage of coral cover and
diversity. This location has a high loss which is inhabited by many coral biota associations. Habitat complexity supports the abundance and diversity of a community [18]. Therefore, this is the reason why this location is used as a protection zone.

The results of an inventory of coral species richness in the waters of North Nias in 2015 found 184 species of reef-building corals, with 47 genus representing 15 families [19]. Globally the distribution of coral species in the waters of North Nias is included in the distribution of coral species in western Sumatra with a number of species ranging from 351 to 400 species [20].

The diversity at each station shows the various amount. The station around Lafau Island, Lahewa waters has the highest coral species richness, with 87 species from 32 genera representing 12 families. The difference in the number of types between stations is caused by different environmental conditions. In general, the distribution of coral species on the west coast of Sumatra is caused by geographical factors and the influence of activities on land [21]. Common coral groups at each station are the Acroporidae family, including Acropora loripes and Acropora gemmifera, Agaricidae family such as Pavona varians and the Poritidae family, Porites lobata.

3.2.2. Reef fish
Reef fish that are the object of observation for the health of coral reefs include coralivor fish from the family Chaetodontidae, herbivor fish from the family Siganidae, Acanthidae and Acanthuridae, target fish of the family Serranidae, Lutjanidae, Lethrinidae and Hemulidae, as well as rare, threatened and protected fish species. The condition of the indicator fish in North Nias was generally quite good. In fact, in one of the research sites, namely in Lafau Island, Lahewa Waters (NIAL05) is one of the spawning aggregation locations or mating or spawning locations. This location should be included in the protected area to ensure it is a source of larvae and protect from vulnerability [22]. The high abundance of herbivorous fish at station NIAL05 provides a good indication for the growth of coral cover. Data of coral fish abundance at each station presented in Figure 6.

![Figure 6. The abundance of indicator fish at each observation station.](image)

3.2.3. Megabenthos
From the eight megabenthos biota studied throughout 2015, the presence of six types of biota groups was found. The six types of megabenthos biota include Linckia laevigata (blue sea star), sea urchins, Tridacna sp. (giant clams), Drupella spp., Holothurian (sea cucumbers), and Trochus sp. (lola). For the two types of biota groups that are not found at all are Acanthaster planci (crown of
thorns starfish) and lobsters. The observations are presented in Figure 7. The megabenthos presence pattern in all observation stations shows that the most commonly found megabenthos group is the sea urchin group by 47% (6,613 individuals) followed by *Drupella* spp. and clamshells each by 31% (4,402 individuals) and 10% (1,420 individuals).

![Figure 7. Percentage of megabenthos biota groups present in North Nias waters during 2015 observations](image)

The existence of each species or group of megabenthos species is inseparable from the health conditions of coral reefs and the diversity of coral species as habitats of various types of megabenthos fauna at each of these stations. Different percentages of live coral cover between observation sites affect the presence of megabentos in the area. Likewise, the rugosity factor of the bottom of water also has a role in the presence and composition of species or groups of megabenthos species. Some species prefer habitats with rough bottom rugosity where there are many boulder corals. Some other species actually prefer the rugosity (contour) of a flatwater base.

### 3.2.4. Mangrove

On the small islands to the north of the mainland, mangroves are not found in the form of large expanses. Mangrove vegetation is only found in the form of individual spots of trees which are mangrove stubs. Mangroves with a vast expanse of land can also be found in Lahewa, namely in the formation of bays in the Port of Lahewa. Mangroves with large expanse can only be found in the eastern part of the observation area, namely the bay of Sawo.

The Nias earthquake in 2005 caused significant changes in coastal ecosystems. Mangrove forests that were once fertile suddenly destroyed by the earthquake were replaced with a stretch of coral that was lifted as much as one to two meters from the seabed which became the mainland. At present, the mangrove forests in North Nias are mostly pioneers. This is very clearly seen on Tureloto Beach, Balefadoro Tuho Village. There, the mangrove in the form of a small stub that had just grown on a stretch of raised rock. From the observations, it was found that the average mangrove cover value was 61.83%. Based on the criteria of the Minister of the Environment Decree No. 201 of 2004 and the guidebook for monitoring the status of mangrove conditions [14] included the condition of mangroves in North Nias in good condition. Percentage of cover at each observation location is presented in the Figure 8.
3.2.5. Seagrass

Seagrass beds are found to be quite extensive in shallow basins of reefs. From the observations obtained an average value of 61.03% (Table 5). Based on KepMenLH No. 200 of 2004 concerning Damage Standard Criteria and Guidelines for Determination of Seagrass Status included seagrass cover conditions in North Nias in a healthy and solid condition. Seagrass cover in the waters of North Nias in 2015 is presented in Table 2.

Table 2. Seagrass cover in North Nias waters in 2015

| Location                  | Average cover (%) |
|---------------------------|-------------------|
| Lahewa                    | 60.19             |
| Baohi Island              | 75.42             |
| Teluk Bengkuang           | 69.79             |
| Furodowi                  | 58.21             |
| Sarang Baung Island       | 55.68             |
| Siheneasi                 | 46.88             |
| Average                   | 61.03             |

3.3. Oceanography condition

The aquatic environment is an important part and determinant of the potential, condition and sustainability of biological natural resources. Specific characteristics and waters in each location give a measure and become a factor to be considered in efforts to manage and conserve biological resources. Sawo-Lahewa Local Marine Park consists of coastal areas and some of the small islands with varied and complete geophysical conditions consisting of the gulf, headland, strait, shallow and deep waters that will affect the physical and chemical conditions of the waters.

Measurement of chemical conditions consists of nutrients and chlorophyll-a content, while physical conditions include temperature, salinity and conductivity of waters. In general marine nutrients shown normal conditions, which they were at environmental quality standard conditions that support marine life and marine tourism needs. In the condition of local nutrients consisting of phosphates and nitrates tend to be higher along the coast close to the mainland, but to be lower in the waters of small islands far from the mainland. The distribution patterns of the two nutrients have shown differences, which were relatively higher Phosphate concentrations in the east coast (Sawo coast), while Nitrates was shown higher concentrations in the west coast (Lahewa coast). The ammonia was shown normal...
conditions and below the quality standard the marine environment and show relatively the same distribution pattern at all locations.

The high concentration of nutrients along the coastline of the Sawo-Lahewa Local Marine Park and surrounding areas were caused by high freshwater and sediment input [23,24] from the mainland and the end in along the Sawo-Lahewa coast, North Nias [19]. Another chemical condition was chlorophyll-a which was shown relatively low concentrations and appears to be higher in concentrations in the coast of Sawo compared to Lahewa. The Value of chlorophyll-a in Sawo waters was 0.4 mg/m³ and Lahewa waters were 0.25 mg/m³, but it was in the normal range [25] with low eutrophication rates [26].

The basic contours of the waters were quite complete and varied within the Sawo-Lahewa Local Marine Park and around the area, North Nias. In general, the contours of relatively sloping waters, especially in coastal areas and steep in the waters of Sarangbanung Island that was far from the mainland. The depth of the waters in the coastal areas and the bay were relatively shallow with a maximum depth of up to 70 meters, while in open waters around Sarangbaung Island there were basins on both sides with depths reaching up to 700 meters. Coastal with a cape shape also has a rather steep slope with deeper waters. Sea contour conditions affect the pattern of surface currents, especially the direction and strength. The current pattern along the side of Sarangbauing Island moves more strongly from the southwest to the north than the east side which moves from the northeast to the south. Along the coast, the current comes from the west and east sides of Nias Island and it was influenced by tidal and tidal currents.

Measurement of the physical condition of waters consisting of currents, temperature, salinity and conductivity have resulted in the normal range. Variations in the physical condition of the waters look somewhat different in the coastal waters and small islands and the west and north sides of the sea with open waters compared than protected east. Differences in physical conditions are caused by differences in depth, tides and freshwater input [19].

3.4. Social condition

The population is one of the important resources in the social aspect of a socio-ecological system, including in the Sawo-Lahewa MPA. Demographic conditions in an area determine the planning and process of various development programs, including the management of the MPA. The rate of population growth greatly influences the policy choices that must be taken by the government and also the community, especially regarding the provision of public infrastructure [27]. In the context of MPA management, a smaller and looser population is believed to put lower pressure on the ecological system (biodiversity) compared to a larger and denser population.

Table 3. Population, gender ratio, and percentage per sub-district in North Nias District 2013 and 2019 [28,29]

| Sub-District   | Population 2013 | Population 2019 | Gender Ratio 2013 | Gender Ratio 2019 | Percentage 2013 | Percentage 2019 |
|---------------|-----------------|-----------------|-------------------|-------------------|-----------------|-----------------|
| Tugala Oyo    | 6.181           | 6.250           | 98.24             | 98.35             | 4.8             | 4.53            |
| Alasa         | 19.208          | 22.625          | 97.33             | 97.44             | 14.9            | 16.40           |
| Alasa Talumuzoi | 6.587          | 7.002           | 99.36             | 99.49             | 5.1             | 5.08            |
| Namohalu Esiwa | 12.331         | 12.699          | 96.95             | 97.07             | 9.6             | 9.20            |
| Sitolu Ori    | 11.571          | 12.271          | 99.88             | 99.95             | 9.0             | 8.89            |
| Tuhemberua    | 10.525          | 11.070          | 97.54             | 97.64             | 8.2             | 8.02            |
| Lotu          | 11.297          | 11.486          | 98.26             | 98.34             | 8.8             | 8.33            |
| Afulu         | 10.641          | 11.722          | 97.06             | 97.17             | 8.2             | 8.50            |
| Sawo          | 9.741           | 9.985           | 97.15             | 97.29             | 7.5             | 7.24            |
| Lahewa        | 20.968          | 22.118          | 98.13             | 98.23             | 16.2            | 16.03           |
| East Lahewa   | 10.003          | 10.739          | 98.79             | 98.87             | 7.8             | 7.78            |
| North Nias District | 129.053     | 137.967        | 97.97             | 98.07             | 100             | 100             |
Table 4. GRDP North Nias District Based on 2010 Constant Prices by Business Field in 2010-2019 (Million Rupiahs) [30]

| Category | Description | 2010       | 2013       | 2016       | 2019       |
|----------|-------------|------------|------------|------------|------------|
| A        | Agriculture, Forestry, and Fisheries | 807,266.12 | 982,486.89 | 1,132,606.20 | 1,272,450.00 |
| B        | Mining and excavation | 83,472.71 | 96,710.97 | 118,873.17 | 138,820.00 |
| C        | Processing industry | 3,581.19 | 4,057.77 | 4,771.35 | 5,320.00 |
| D        | Electricity and Gas Procurement | 1,856.20 | 2,341.63 | 2,967.71 | 3,410.00 |
| E        | Water Supply, Waste Management, Waste and Recycling | 836.17 | 906.69 | 1,061.81 | 1,150.00 |
| F        | Construction | 139,503.13 | 169,831.73 | 191,662.75 | 221,260.00 |
| G        | Wholesale and retail trade; Car and Motorcycle Repair | 135,579.13 | 157,726.02 | 189,195.00 | 228.55 |
| H        | Transportation and Warehousing | 24,039.51 | 27,420.03 | 33,963.88 | 38,910.00 |
| I        | Provision of Accommodation and Food and Drink | 39,037.61 | 43,675.70 | 52,791.62 | 62,310.00 |
| J        | Information and Communication | 5,507.17 | 6,506.20 | 8,045.46 | 9,710.00 |
| K        | Financial Services and Insurance | 18,496.64 | 28,392.39 | 35,738.35 | 41,260.00 |
| L        | Real Estate | 48,708.00 | 57,819.06 | 69,749.25 | 78,480.00 |
| M,N      | Company Services | 961.50 | 1,135.93 | 1,400.79 | 1,550.00 |
| O        | Government Administration, Defense and Mandatory Social Services | 100,022.34 | 118,286.27 | 137,672.45 | 154,400.00 |
| P        | Educational Services | 28,621.79 | 34,077.06 | 40,378.87 | 47,920.00 |
| Q        | Health Services and Social Activities | 10,013.80 | 14,234.81 | 17,413.42 | 20,590.00 |
| R,S,T,U  | Other services | 4,170.77 | 4,637.14 | 5,620.86 | 6,360.00 |
|          | Gross Regional Domestic Product | 1,451,673.78 | 1,750,246.29 | 2,043,912.94 | 2,332,440.00 |

Table 3 shows that the percentage of the population in Sawo and Lahewa Districts in 2019 was lower than in 2013; before establishing Sawo-Lahewa waters as MPA. This condition could provide opportunities for better MPA management, especially reducing pressure on the ecological system.

On the economic side, there has been a fairly good development. This can at least be seen from the significant increase in the amount of GDRP between 2013 and 2019. Table 4 shows an increase that occurred at Rp. 582,193.71 million or one third. In 2019, Agriculture, Forestry, and Fisheries are still the highest contributing jobs, namely 51.34 percent [30]. North Nias BPS also reported Economic growth of 4.65 percent; higher than 2018 (4.42 percent). The growth came from the fields of Agriculture, Forestry, and Fisheries, which amounted to 2.07 percent. The GRDP of the provision of accommodation and food and drink business fields in which there is a tourism sector also experienced a significant increase: from Rp 43,675.70 million to Rp 62,310.00 million [30].

The economic development of the two business fields is in accordance with one of the objectives of establishing the MPA, namely improving the local economy through marine tourism. Various lists of
tourist destination beaches in North Nias, namely: Walo Beach, Afulu, Lasambo, Red Sand, Sihago, Toyoloto, Lasambo, White Sand, Wunga, Tureloto, Makora, Lafa, Sinali, Pasir Berbisik, Tanayae, Asi Walo, Lakha, Seriwa; and Makora and Lafa Islands. Tourism activities that can be done are snorkeling, diving, free diving, fishing.

4. Conclusion
The Sawo-Lahewa MPA is a complex and integral social-ecological system. The two aspects (ecological and social) determine each other and cannot be separated. Biodiversity sustainability (ecology system) will affect the sustainability of social systems, including the local economy; vice versa. Important findings in this study are also the same as the results of social-ecological mapping at other MPA locations, which emphasize the involvement of social and ecological aspects [31,32,33,34,35]. However, to get better results, the authors suggest the importance of the latest holistic and comprehensive field research.

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