ESTABLISHMENT OF MARINE PROTECTED AREA (MPA) IN TATOARENG SUBDISTRICT, KEPULAUAN SANGIHE DISTRICT, NORTH SULAWESI PROVINCE-INDONESIA

BIOPHYSICAL AND SOCIODEMOGRAPHIC PROFILE OF THE PROPOSED MPA SITE

Coral and Marine Resources Management
in the Coral Triangle - Southeast Asia

CORAL TRIANGLE INITIATIVE
ON CORAL REEFS, FISHERIES AND FOOD SECURITY

ESTABLISHMENT OF MARINE PROTECTED AREA (MPA) IN TATOARENG SUBDISTRICT, KEPULAUAN SANGIHE DISTRICT, NORTH SULAWESI PROVINCE-INDONESIA

BIOPHYSICAL AND SOCIODEMOGRAPHIC PROFILE OF THE PROPOSED MPA SITE

FINAL REPORT : JULY 2016

Coral and Marine Resources Management
in the Coral Triangle - Southeast Asia

CORAL TRIANGLE INITIATIVE
ON CORAL REEFS, FISHERIES AND FOOD SECURITY

Table of Contents

List of Appendices

List of Tables

List of Figures

Executive Summary

Indonesia is located within the Coral Triangle. This country has diverse aquatic resources and is considered a high priority in biodiversity conservation. The Regional Technical Assistance on Coastal and Marine Resources Management in the Coral Triangle-Southeast Asia (RETA 7813 or CTI-SEA) of the Asian Development Bank initiated the conservation program that involves the Coral Triangle. One of the activities is the establishment of Marine Protected Areas (MPAs). One of CTI-SEA's aims is to increase the resilience of marine ecosystems and improve the socioeconomic condition of Indonesia, Malaysia, and the Philippines. This effort will create networks of MPAs in the CT3 particularly in the Sulu-Sulawesi Marine Ecoregion and will help achieve an effective biodiversity management of 20 million hectares by 2020.

The objective of the study is to determine the status of the biophysical and socioeconomic conditions of the communities involved for the establishment of marine protected areas. The coral reef condition in the Tatoareng Subdistrict was classified as poor to fair, while reef fish condition was high in terms of species richness and abundance relative to the other sites studied.

The coral reefs in the different islands were damaged primarily by dynamite fishing and stone net fishing. These illegal fishing methods reduced the fish population in the coastal areas and it may have an influence on the fishing communities that depend on fishing as their source of daily living. The scarcity of fish catch and minimal work opportunities in the different villages/islands resulted in persistent poverty. The lack of alternative livelihood opportunities forced the fishermen to engage in illegal fishing activities in order to provide fish/food for their families.

Marine protection is one of the most popular coastal resources management options because it has multiple objectives to address the problems of managing coastal resources and communities. It is an effective management strategy to restore degraded coastal habitats, protect the commercially important fish species, and conserve the fisheries resources for present and future generations. Based on the data analysis, the six potential sites identified as parts of the MPA include Kahakitang, Kalama, Mahengetang, Para, Salingkere, Siha, and Nitu Islands. The MPAs will be established to protect the ecosystem of coral reefs, mangroves, and seagrass beds as well as endemic biotas. MPA sites which are protected should have fair to good coral condition and they must also have considerable and robust stands of branching coral reefs. The success of this endeavor needs the full support of the national government, national agencies, nongovernment organizations (NGOs), and the engagement of the villages/communities.

I. Introduction

Indonesia is rich in aquatic resources, such as coral reefs, mangrove, seagrass, and associated fishes. The region is considered as high priority for world biodiversity conservation because of its strategic site within the Coral Triangle Initiative (CTI) area. In an effort to protect and conserve the rich biodiversity, CTI-SEA initiated the program to support Indonesia, Malaysia, and the Philippines in managing and protecting their coastal and marine resources. One of the activities is the establishment of MPA within the territorial waters of Tatoareng Subdistrict, Kepulauan Sangihe District (KSD).

The area is composed of four major islands (i.e., Para, Kahakitang, Kalama, and Mahengetang) and some adjacent small islands. Based on local knowledge, the area is considered a potential site for MPA if the local communities and the government support the establishment of a management protection area. The area is easy to manage and accessible from Manado by sea or air transportation. Manado is the capital city of North Sulawesi Province and is located in the main land of North Sulawesi. The MPA site is located in Tatoareng Subdistrict, Kepulauan Sangihe District- North Sulawesi Province. This conservation effort will be integrated into the management plan with the participation of the communities.

The establishment of MPAs is the most popular coastal resources management (CRM) option because it involves multiple objectives to address both the needs of the resources and the communities. It is an effective management strategy to protect and conserve fisheries resources. Zoning of MPAs can be done within the area from strict protection and preservation zones to utilization and multiple use zones (e.g., allowing industrial and tourism activities adjacent to an MPA) (Aliño and Uychiaoco 1999). MPAs are managed in several forms including closed areas, preservation and no-take zones, multi-benefits and marine reserves, or other various management strategies, such as designation of marine park, marine sanctuary, marine protected area, and wildlife areas (Charles 2001; Act No. 27/2007).

The establishment of MPAs through CTI-SEA could increase the resiliency of marine ecosystems, alleviate poverty conditions, and improve coastal management strategies for the conservation and protection of marine resources. This effort will create networks of MPAs (NMPA) in the CTI particularly in the Sulu-Sulawesi Marine Ecoregion (SSME).

CTI-Indonesia had been established and it is currently developing MPAs to achieve the target of 20 million hectares (ha) of protected area by 2020. The CTI-SEA encourages the establishment of new MPAs to increase managed areas for the protection of fish stocks and easier recovery of the degraded coastal resources. An MPA network is an organized collection of individual sites, designed to link individual areas and comprehensively represent the region's spectrum of marine life characteristics. A network can help to ensure a functional marine ecosystem by encompassing the temporal and spatial scales at which ecological systems operate, help resolve and manage conflicts in the use of natural resources and ensure reasonable uses to minimize conflict among the fishing communities, facilitate the efficient use of resources by preventing duplication of effort (such as when small, individual areas attempt to maintain their own management resources), and reduce the degradation of coastal and marine habitats, mitigate the loss of endangered marine species, and restore depleted fisheries.

Several studies suggested that natural disturbances combined with intensive anthropogenic activities have impending effects on the marine ecosystem due to the low adaptive capacity of the ecosystems to the changes in the physical environment caused by a variable climate. The synergistic and long-term effects of these disturbances affect the resilience of the ecosystems, thus the latter become more degraded.

The establishment of MPAs has been proven as an effective solution for the management of marine resources which includes the protection, conservation, and restoration of coastal and fisheries resources. MPA is an alternative strategy to cope with the failures of previous management body despite criticisms against this form of coastal resource management. It is also a globally acceptable intervention to overcome natural and anthropogenic threats to the marine ecosystems (Agardy 2000; Sale et al., 2005).

However, if this endeavor is not the priority of the Ministry of Marine Affairs and Fisheries there will be a problem in its implementation (Jentoft et al., 2007; Christie & White 2007; Duxbury & Dickinson, 2007).

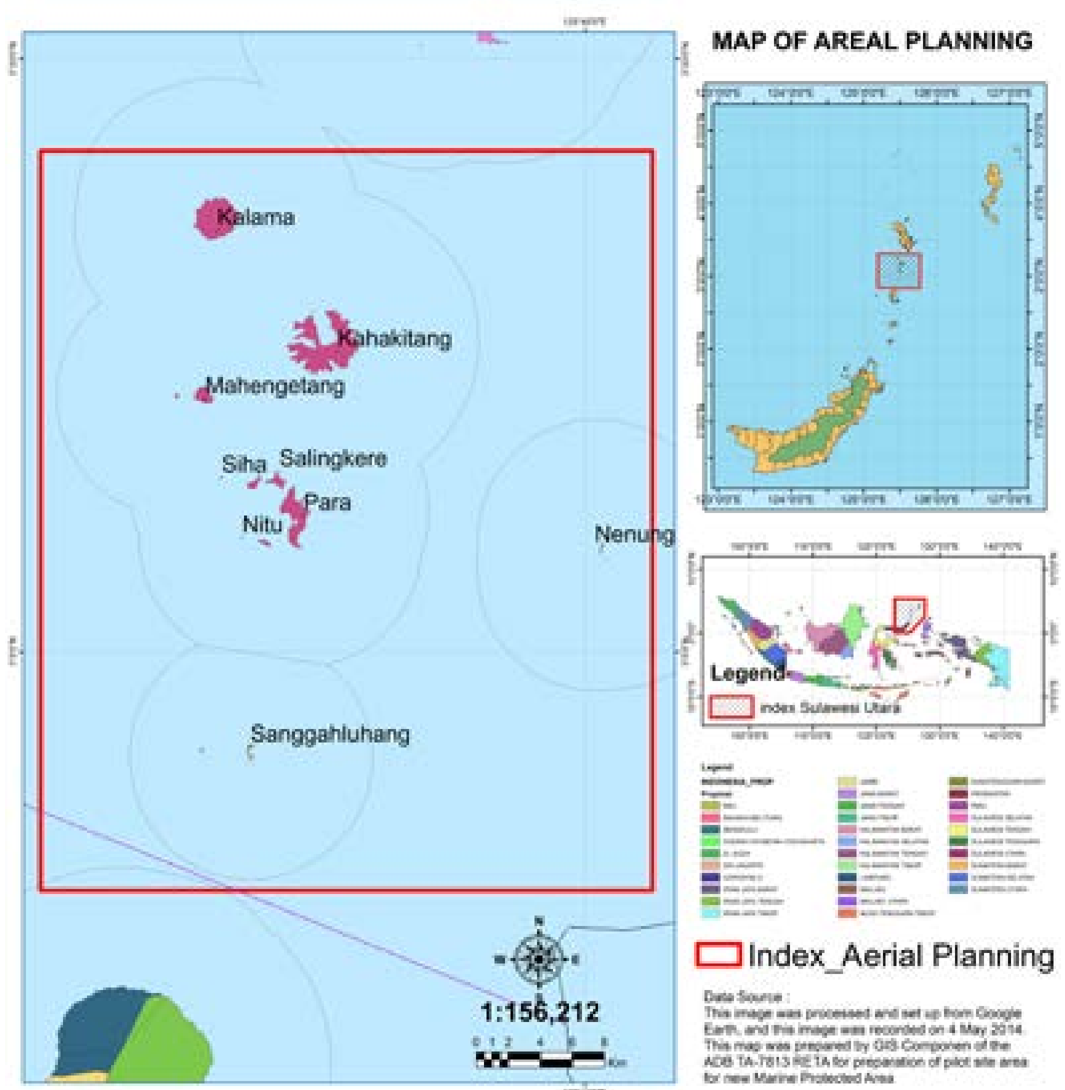
II. Objective

The main objective of the study is to determine the status of the biophysical and socio-demographic profile of the community. The result of the study will be used for the selection and identification of MPAs.

III. Scope of the Study

The activity focuses on the biophysical (i.e., coral reefs, mangroves, and seagrass) and sociodemographic profile of the community. The study covers the four major islands (i.e., Para, Kahakitang, Kalama, and Mahengetang) and some adjacent small islands in Tatoareng Subdistrict, Kepulauan Sangihe District (Fig. 1).

Figure 1. Map of the proposed conservation area in Tatoareng Subdistrict



IV. Methodology

A. Coral Reefs

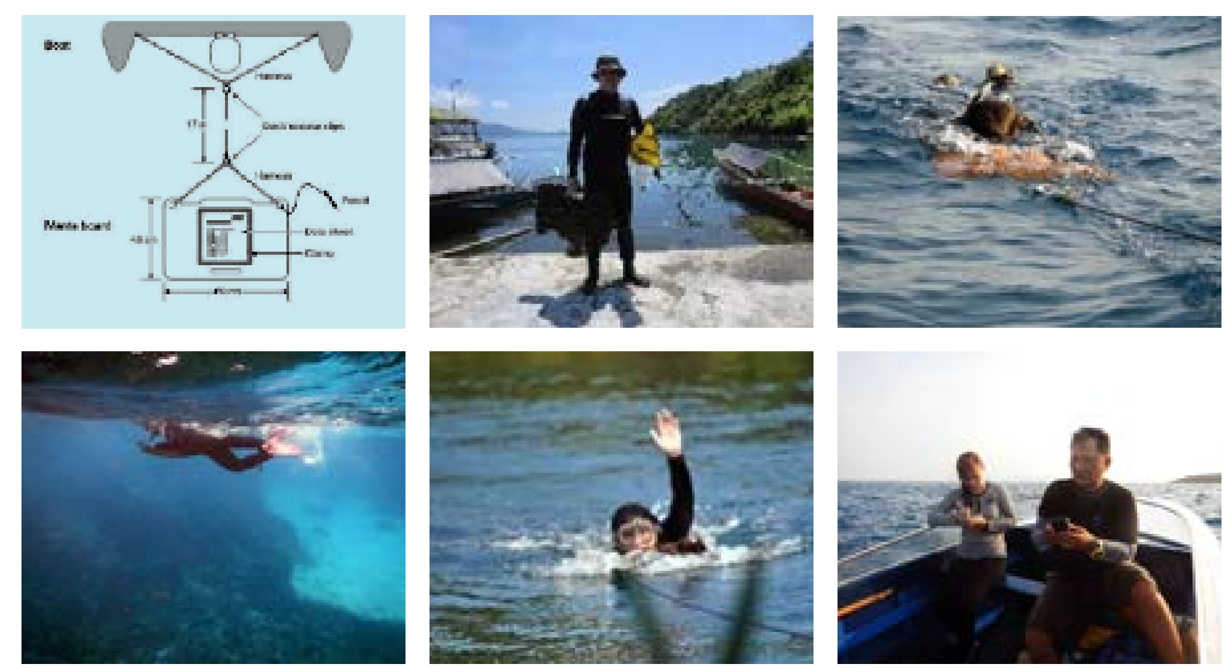
1. Manta Tow Methods

The manta tow surveys methods were carried out for four days from 24-28 September 2015. Rapid broad-scale coral reef surveys were conducted in four major islands (i.e., Para, Kahakitang, Kalama, and Mahengetang) and in one small island (Nitu) using a modified manta tow technique (English et al., 1994).

The method validated the location and extent of coral reef areas and provided broad area classification of the general bottom features around the island under the jurisdiction of the aforementioned areas. In the modified manta tow technique, the observer was towed by a boat with a speed of approximately 5 km/hour or equal to walking speed. The survey was completed faster and covered a larger area (Fig. 2).

In the survey, percentage cover of the live hard corals, soft corals, dead corals, invertebrates, abiotic components, and distinct reef features were recorded in a data sheet. The starting and end points for each tow were marked by an on-board observer using a hand-held Global Positioning System (GPS) and additional waypoints were recorded. From the results of the rapid and broad area surveys, sites with the highest live coral cover were identified.

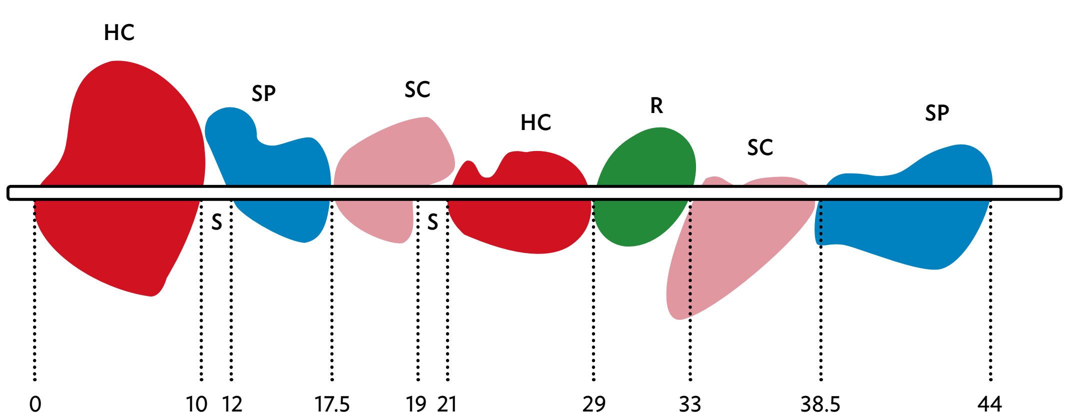
Figure 2. Conducting the manta tow method



2. Line Intercept Transect (LIT)

From 19 September to 10 October 2015, benthic survey was done using the line intercept transect (LIT) technique (UNEP, 1993). The method recorded the percentage cover of different benthic attributes, such as coral life form, dead coral, soft coral, algae, and other abiotic components (i.e., sand, rubble, and silt). All benthic organisms intercepted along the transect were recorded in situ using the benthic life forms category with taxon (Fig. 3). The 50 meters transect lines were laid on shallow (3 m) and deep (10 m) parts of the reef bottom parallel to the coast. Using the manta tow information, the selected coordinates were relocated using the GPS for the detailed benthic survey. Reef health was assessed using the quartile index established by Yap and Gomez (1984) wherein the proportion of living hard corals were compared relative to other benthic components (e.g., dead coral, soft coral, algae, rubble, etc.). There were 50 sites that were distributed around the small island waters in Tatoareng Subdistrict. Coral reefs having 0-24.9% life hard coral cover were classified as poor, 25-49.9% cover as fair, 50-74.9% as good cover, and 75-100% cover as excellent.

Figure 3. Line intercept transect (LIT) measurement in 50 m depth



B. Reef Fish

1. Fish Visual Census (FVC) technique

Fish Visual Census (FVC) technique (English et al. 1994) was used to determine the species diversity and abundance of reef fish. FVC was conducted on the same transect lines surveyed for benthic community. The fish observers waited for about 5-10 minutes after the line has been laid before the actual census was performed to allow for the disturbed fish community to return to its normal activity.

Starting at one end of the transect line, all fish within a 5 x 5 meters imaginary quadrat were identified up to species level and the numbers and estimated sizes were recorded. Observer swam along the transect line and stopped at every 5 meters until the end of the transect (Fig. 4). Each transect covered an area of 250 m^2 (50 m long x 5 m width). All fish were grouped into target, coral indicator, and major species. Target species are the commercially important fish, coral indicator species are coral-associated, and major species are those that belong to noncommercially important species.

Figure 4. Fish visual census technique (English et al. 1994)

C. Mangroves

The assessment of mangrove was done from 6-20 July 2015 in Kahakitang, Kalama, Mahengetang, and Para Islands using the spot check method (English et al., 1994; Bengen, 2003). A line transect measuring 100 meters was laid perpendicular to the coastline. The 10 x 10 meters quadrat was used for tree category (> 4 cm diameter) while 5 x 5 meters quadrat for sapling category (< 4 cm diameter and height > 1 m), and 2 x 2 meters quadrat for seedling category (< 1 m high). All trunk diameters and height of mangrove trees within the quadrat were identified, counted, and measured. The bottom substrate was also noted and classified. The book of Lovelock (1964), Tomlinson (1986), and Calumpong and Meñez (1997) were used for species identification.

The mangrove parameters were calculated using the following formula:

Density (D (I) nd/ha)

$D \sum = \textit{individuals of species/Total area}$

Relative Density (RD) (%) per species

$RD =$ (D of each species/D of whole species) x 100

Frequency (F) $= \sum \textit{Sub – quadrat per species}$

$F \sum = \textit{total quadrats in sampling area}$

Relative Frequency (RF) (%) per species

$F =$ (F of species/F total species) x 100

Based on the standard criteria and Guidelines for Mangrove Destruction Determination (Ministry of Environmental Decree No. 201, 2004), a density of more than 1,500 trees/ hectare is categorized as good while a density of 1,000-1,500 trees/hectare is fair and a density of less than 1,000 trees/hectare is poor. Barbour in Onrizal (2008) stated that H' ranged from 0 to 7, with the following criteria: (a) 0-2 is low; (b) 2-3 is moderate; and (c) 3-7 is high.

D. Seagrass and Algae

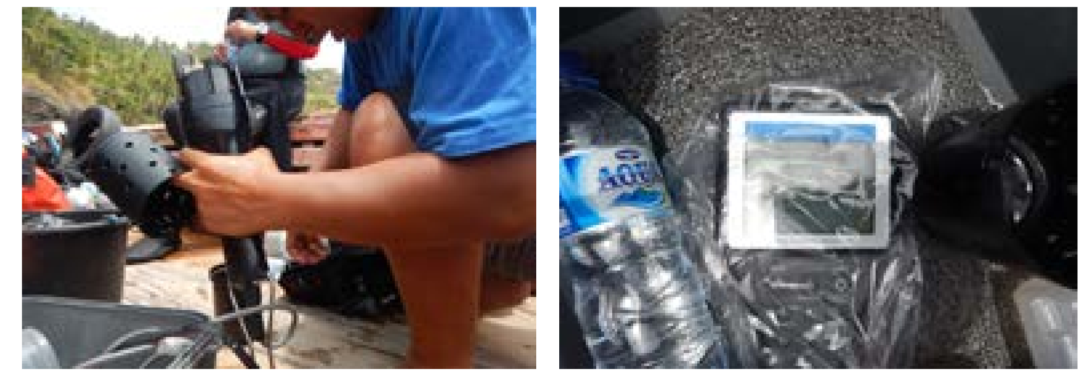
The survey of seagrass and algae was done from 6-25 July 2015, using the transect-quadrat method (Krebs 1999). Transect was laid perpendicular to the coastline with an interval of 50 meters. Seagrass was observed using 1 x 1 meter quadrat and randomly distributed in 100 meters line transect. Seagrass species, density, cover, and substrate type were recorded. Algae (seaweed) were surveyed using the transect-quadrat method. A fifty-meter line transect was laid perpendicular to the shoreline. Ten quadrats were distributed along the 50 meter transect in every 5 meters. The 50 x 50 cm quadrat divided into sub-quadrats (10 x 10 cm) was used to estimate the species cover (English et al. 1994).

Based on the Environmental Minister's Decree Numbered 2002004, seagrass status can be categorized as: in good condition (rich/healthy) if it has > 60% cover, fair if from 30 to 59.9% cover, and poor if it has less than 29.9%.

E. Water Quality

Water quality data were collected through in situ measurements in 34 stations (Fig. 5). Water samples were collected for a period of twenty days from 19-29 August 2015 and 29 September -10 October 2015. The water quality, which included surface water temperature, salinity, turbidity, conductivity, visibility, and dissolved oxygen, was measured using the Horiba U-10.

Figure 5. Water quality measurement with Horiba water quality checker



F. Satellite Images

Figure 6 shows satellite images covering four major islands (i.e., Para, Kahakitang, Kalama, and Mahengetang) and some adjacent small islands in Tatoareng Subdistrict, Kepulauan Sangihe District (KSD).

Figure 6. Satellite images of Tatoareng Subdistrict, Kepulauan Sangihe District, North Sulawesi Province

G. Demographic Profile

The socioeconomic survey was conducted from 6 to 25 July 2015 in Kahakitang, Dalako Bembanehe, Taleko, Batusaiki, Kalama, Mahengetang, Para, and Para 1. Primary data were collected through a one-on-one interview of 300 respondents using a semistructured questionnaire. The questionnaire covers the respondents' sociocultural activities, public perception, readiness, desire, and participation. Secondary data, such as accessibility, health, environmental safety, infrastructure, community response, and sociocultural conditions were also gathered. Focus Group Discussion (FGD) was also held in each village of about 30 people from government officials to community leaders, fishermen, and women. The fishermen exchange rate (FER) was computed to determine the total income of the fishermen. FER is the ratio of total revenue and total expenditure of the fishermen's households during a certain period. In this case, the specified income is gross income or the profit of the fishing households. FER can be formulated as follows:

$FER = Yt/Et$; $Yt = YFt + YNFt$; $Et = EFt + EKt$

Where:

YFt = Total fishermen income from fishing (IDR)

YNFt = Total fishermen income from nonfishing (IDR)

EFt = Total fishermen expenditure for fishing (IDR)

EKt = Total fishermen expenditure for family consumption (IDR)

t = time period (month, year, etc)

Data collected described the socioeconomic profile in relation with aspects of demographics, education, public health and facilities, community support, public institutions, social conflict, community participation, compliance, resource status, livelihood opportunities, and resource utilization.

V. Results and Discussion

A. Coral Reefs

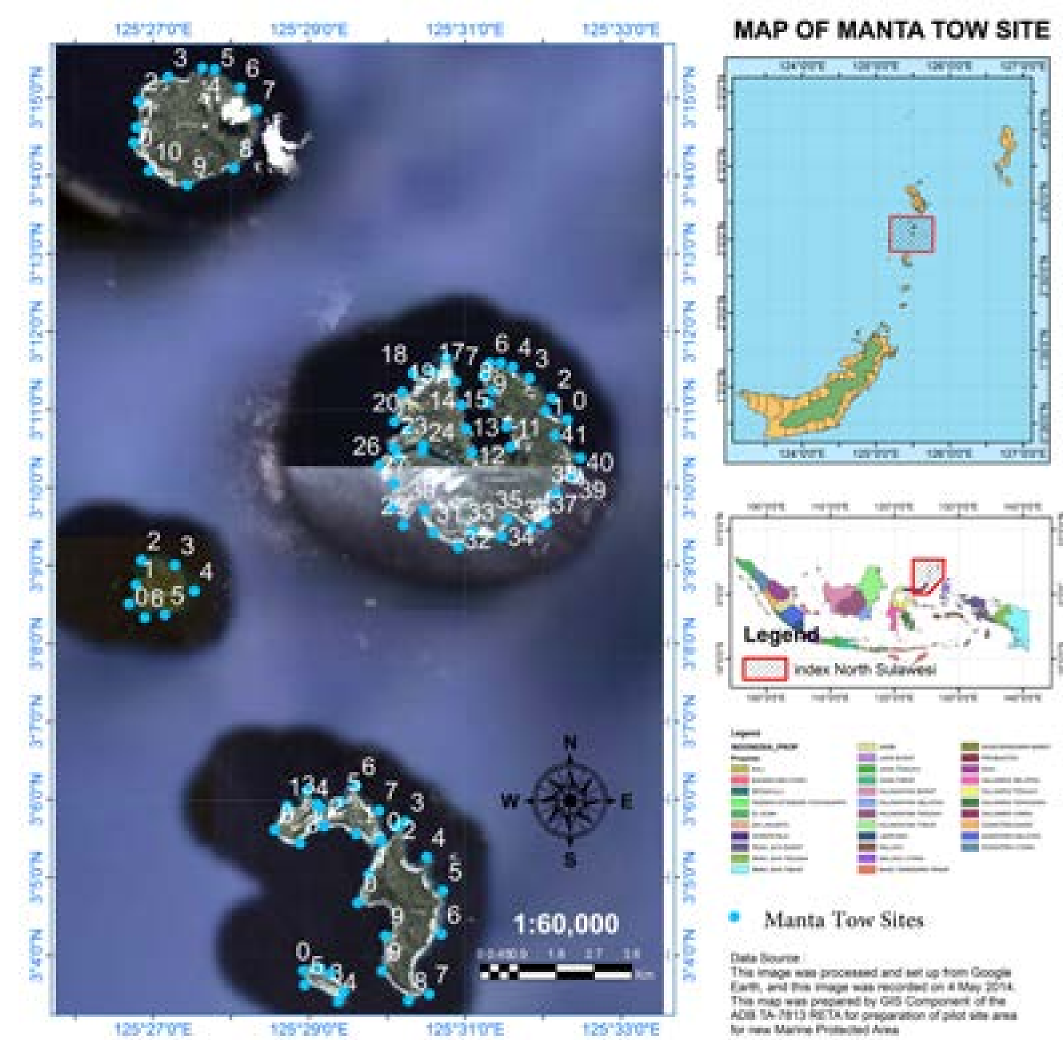
1. Manta Tow Method

Manta tow survey was done in four major islands (i.e., Para, Kahakitang, Kalama, and Mahengetang) and three small islands. Table 1, Figure 7 and Appendix 1 summarize the results. Based on the manta tow survey, the general condition of coral reefs ranges from poor to fair but mostly are of poor coral condition. Only two observations with good coral condition were recorded in Kalama and Mahengetang. These areas are potential sites for MPA establishment. Broad-scale assessment delineated potential areas for protection (i.e., areas with high live coral aggregations).

Table 1. Coral reef condition in the seven islands based on the manta tow survey

Site	No. of Tows	Range of cover percentage	Classification (no. of observations)			
			Poor	Fair	Good	Excellent
Kalama	10	10-55	7	2	1	0
Kahakitang	41	5-40	22	19	0	0
Mahengetang	6	20-60	1	4	1	0
North Siha & Salingkere	7	10-25	6	1	0	0
South Siha & Salingkere	3	10-40	1	2	0	0
Para	10	10-30	3	7	0	0
Nitu	5	5-25	4	1	0	0
Total	82	5-60	44	36	2	0

Figure 7. Map of manta tow survey sites



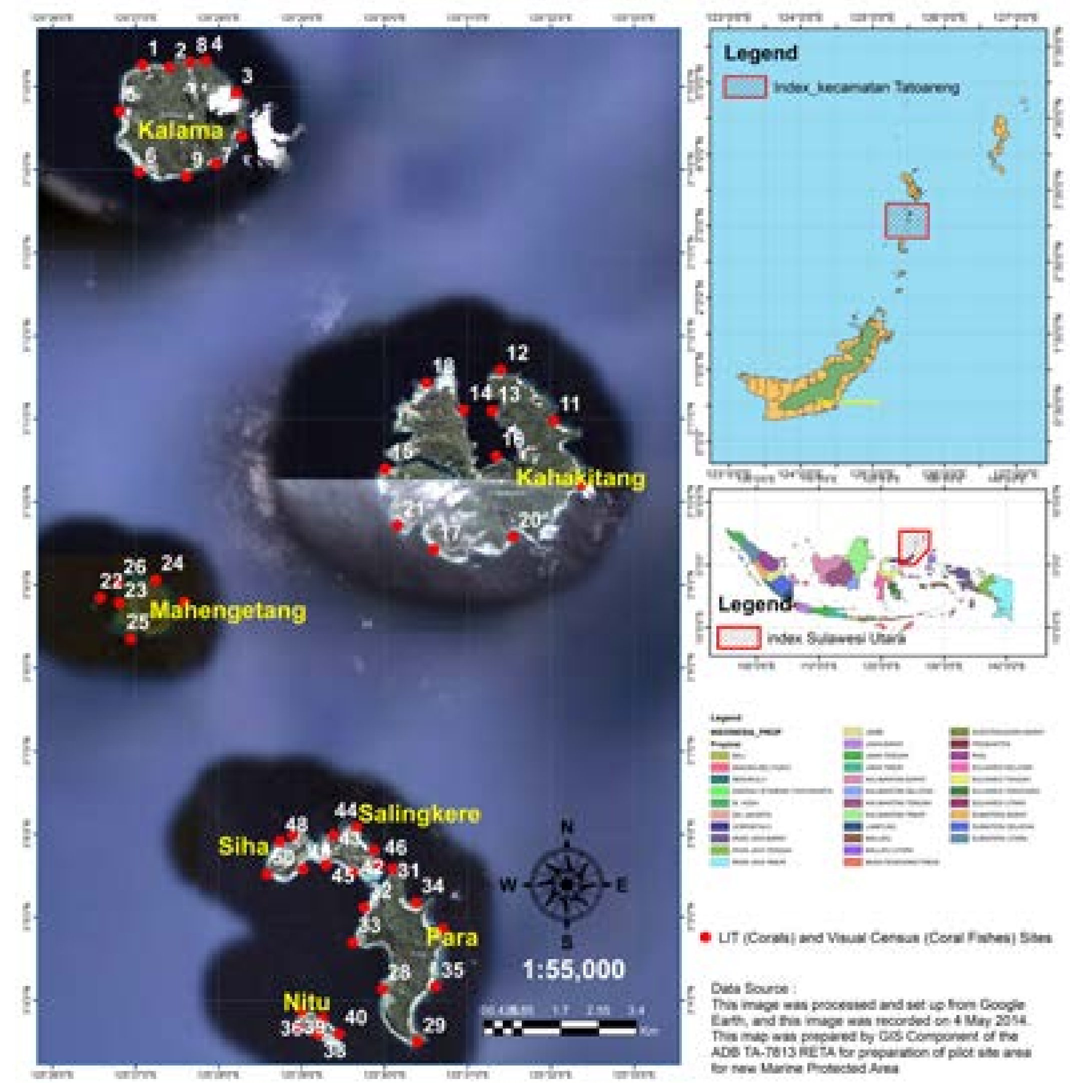
The method validated the location and extent of coral reef areas and provided broad area classification of the general bottom features around the island under the jurisdiction of the areas of study. In the modified manta tow technique, the observer was towed by a boat with an approximate speed of 5 km/hour or equal to walking speed and the survey was completed faster and covered a larger area (Fig. 7).

In the survey, percentage cover of the live hard corals, soft corals, dead corals, invertebrates, abiotic components, and distinct reef features were recorded. The starting and end points for each tow were recorded by an on-board observer using a hand-held GPS and additional waypoints were marked. From the results of the rapid and broad area surveys, sites with the highest percentage live coral cover were identified.

2. Line Intercept Transect (LIT)

Fifty sites of coral reefs were surveyed in Tatoareng Subdistrict. Ten of these were in Kalama Island, eleven in Kahakitang, six in Mahengetang, eight in Para, five in Nitu, six in Salingkere, and four in Siha (Fig. 8 & appendix 2).

Figure 8. Map of sampling sites in the small islands in Tatoareng Subdistrict, Kepulauan Sangihe District, North Sulawesi Province



a. *Kalama Island*

Figure 9 shows the satellite images of coastal resources and ten stations in Kalama Island. Based on the LIT method, the coral reef condition in Kalama Island varied for each site and depth (Fig. 10). Sites 5 at 10 meters deep recorded the highest coral cover, followed by site 6 in 3 meters deep; while stations 3 and 7 had the lowest coral cover. These stations could be considered as parts of the no-take zones. The community index analysis indicated that the diversity of hard corals in the area, particularly in sites 2 and 3, had a relative index value of <1.0 and this was supported by the evenness index of less than 0.4 (Appendix 3). The area is under stress due to anthropogenic factors.

Figure 9. Imagery interpretation and distribution of coastal resources in Kalama Island

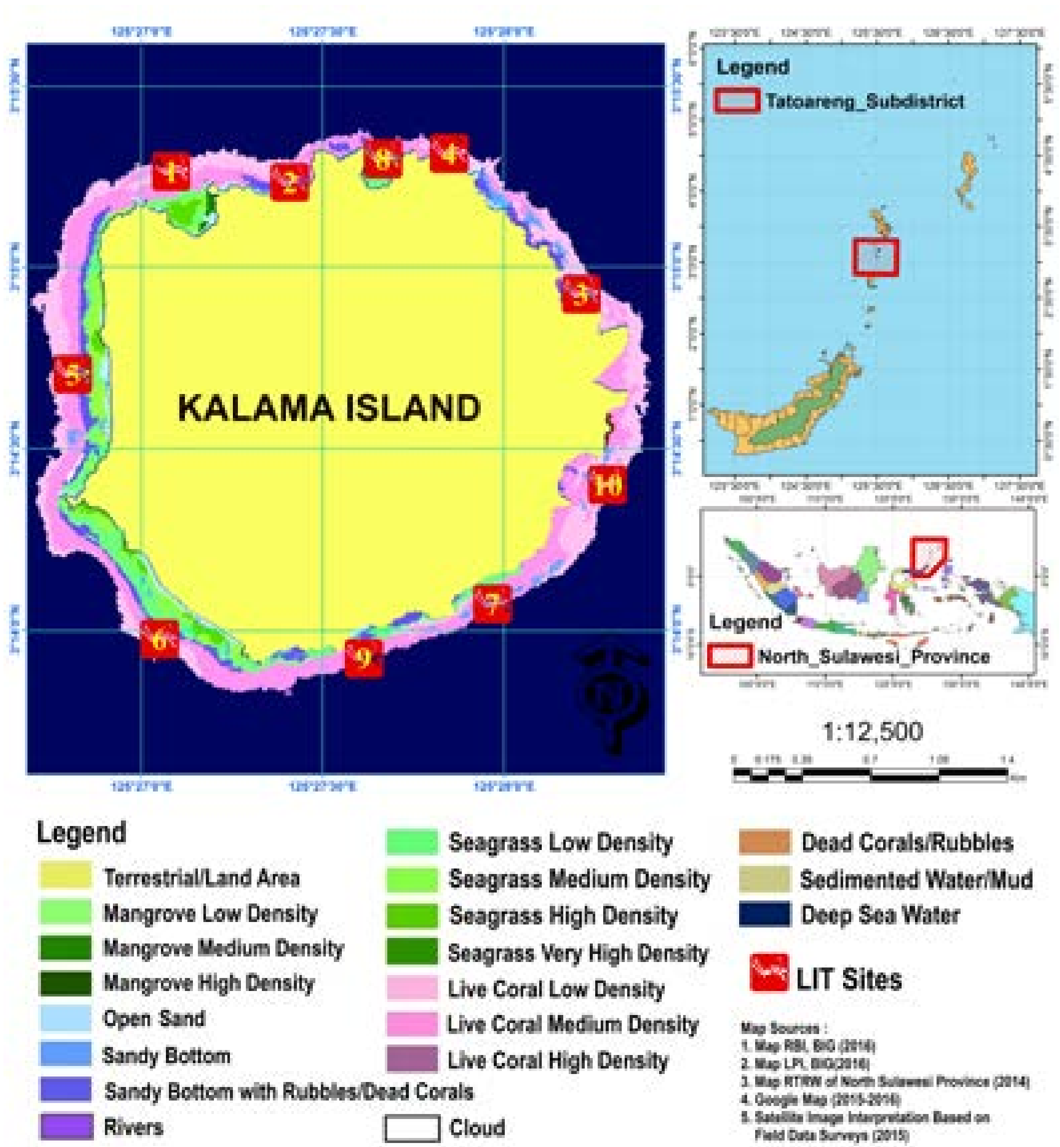
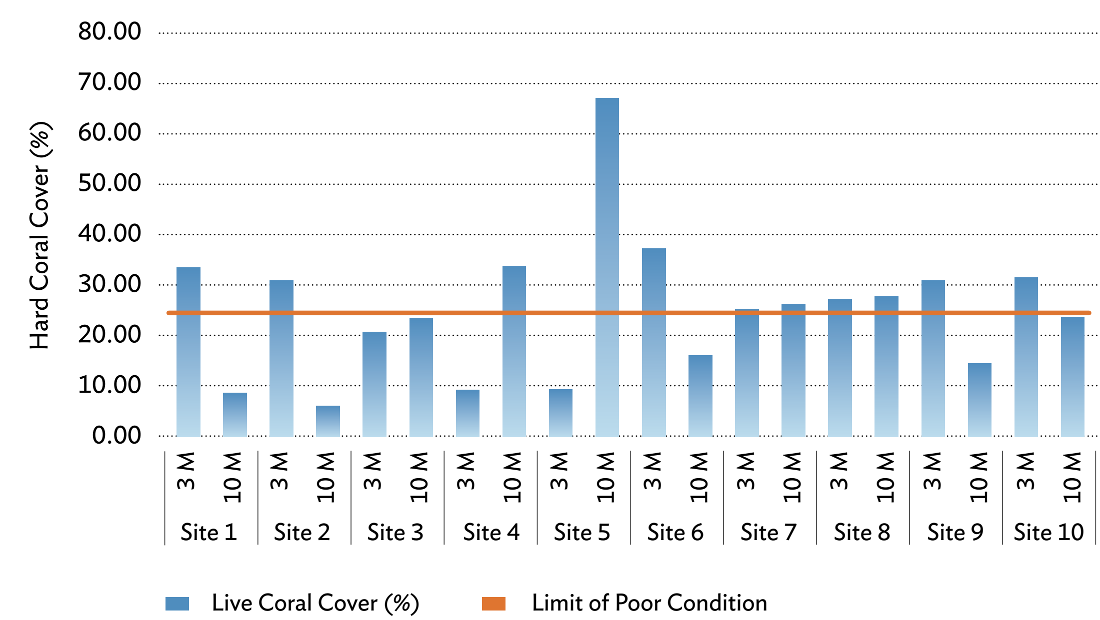


Figure 10. Coral cover in Kalama Island



b. Kahakitang Island

Figure 11 shows the satellite images and distribution of coastal resources in Kahakitang Island. Eleven sites were investigated to determine the status of coral reefs and reef fish in the island target. The coral condition in Kahakitang Island also varied for each site and depth (Fig. 12). Taleko Peninsula (site 15) recorded good hard coral cover of more than 50% at 3 and 10 meters deep while eight sites with fair coral cover condition and two sites (16 and 20) with poor condition. Despite the fair coral reef condition of Kahakitang Island, the community analysis indicated that the hard corals had relatively low diversity. Ten study sites in the island had species diversity index below 1.0 with evenness index lower than 0.4 (Appendix 4). Based on the result of the study, Taleko Paninsula was recommended to be the core zone of the Marine Protected Area in Kahakitang island.

Figure 11. Imagery interpretation and distribution of coastal resources in Kahakitang Island

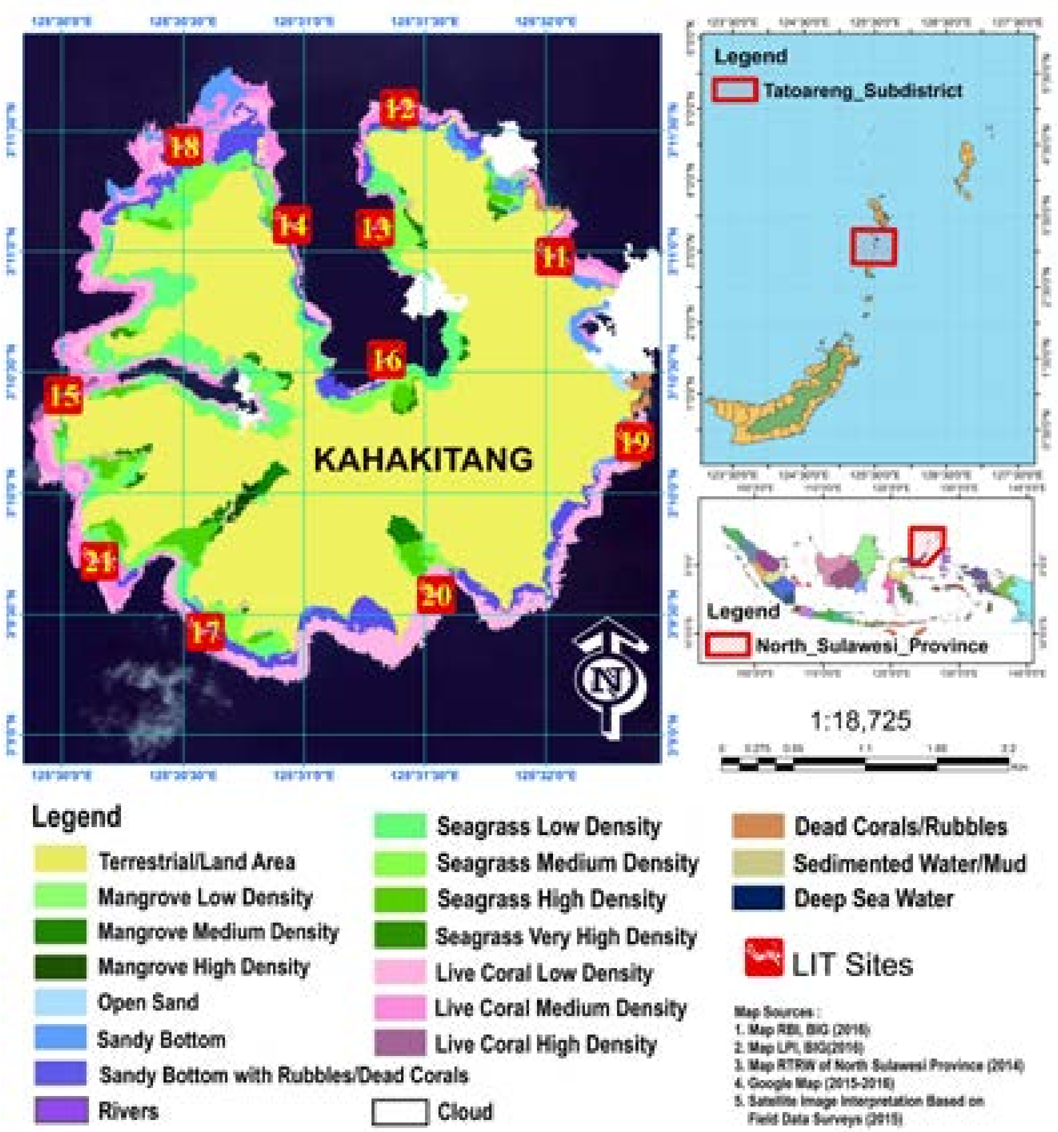
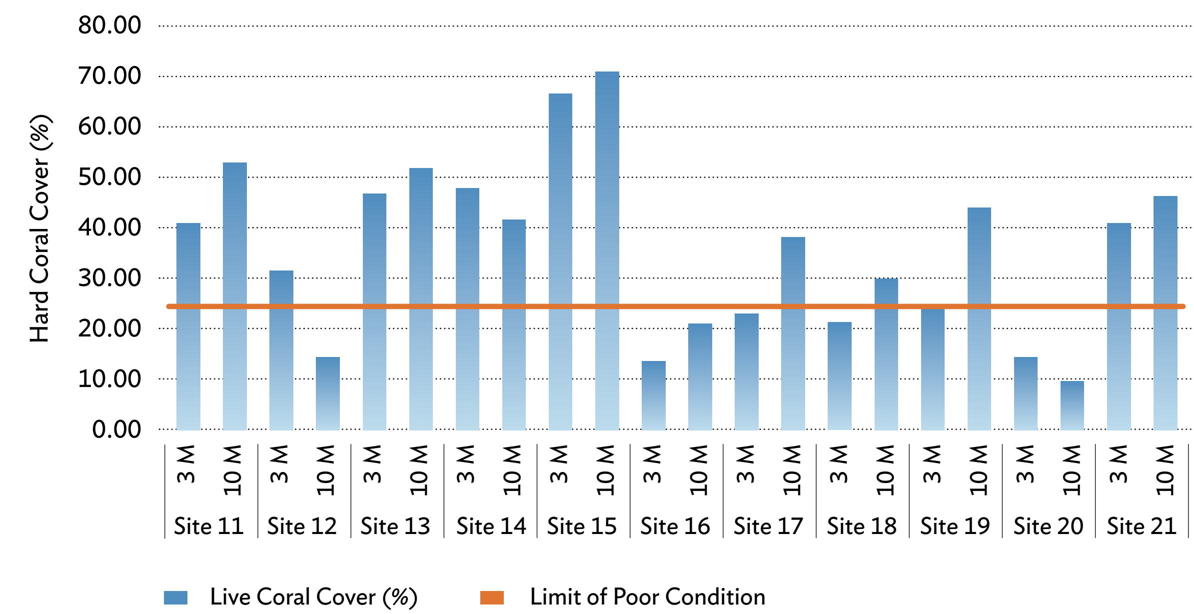


Figure 12. Coral cover in Kahakitang Island



c. *Mahengetang Island*

Figure 13 shows the six investigated sites in Mahengetang Island. The number of sites was lower as compared to Kahakitang Island (11). Mahengetang Island had two sites with good coral condition (sites 23 and 26), four sites with fair coral condition, and one with poor coral condition (Fig. 14). The status of coral in Mahengetang Island was better than in Kahakitang and Kalama Islands. Only four sites out of twenty observation sites exhibited species diversity index of < 1.0. This condition is also supported by a similarity index value (E) which is generally above 0.5 (Appendix 5). The result showed a stable coral reef community in Mahengetang Island.

Figure 13. Imagery interpretation and distribution of coastal resources in Mahengetang Island

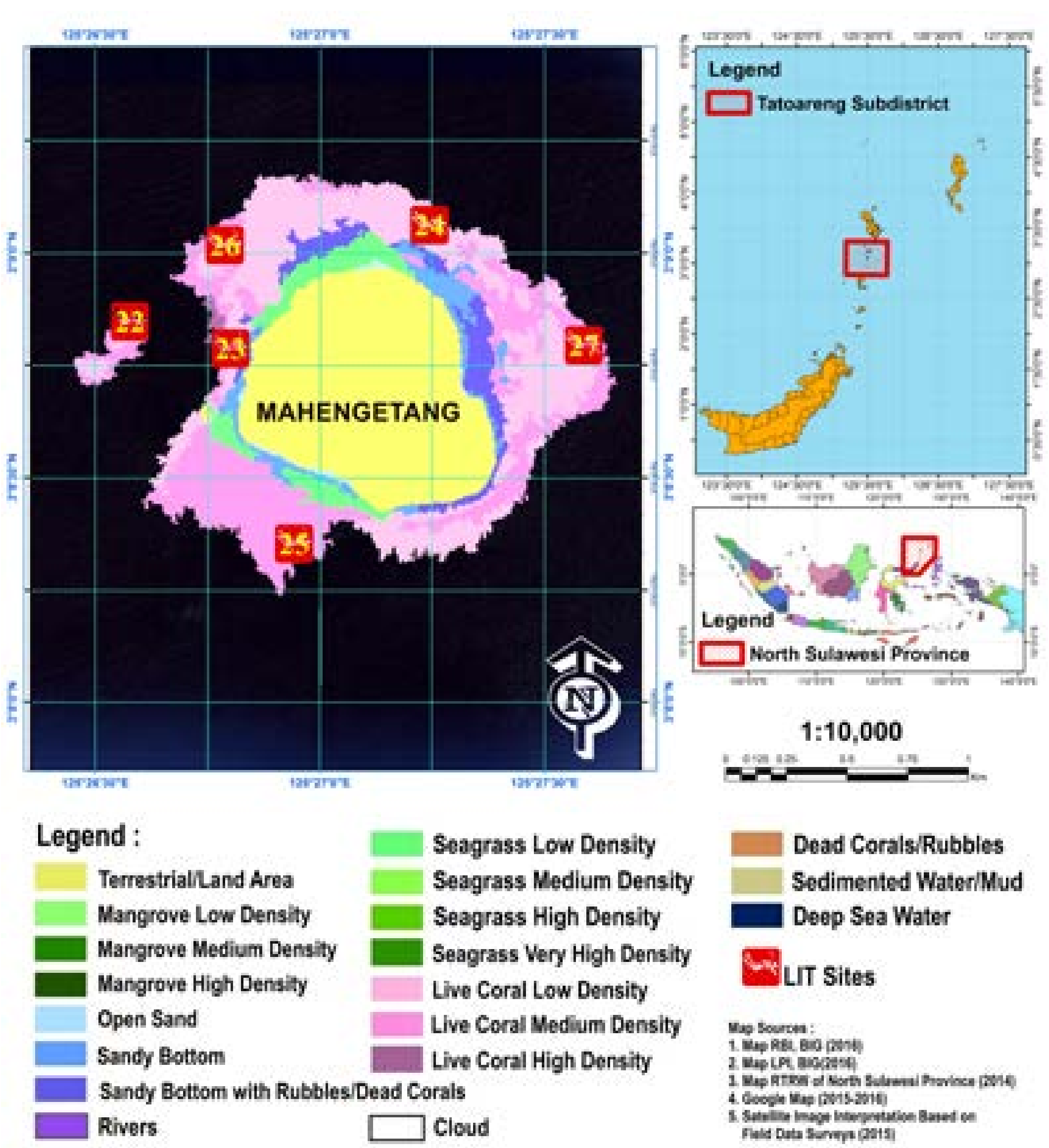
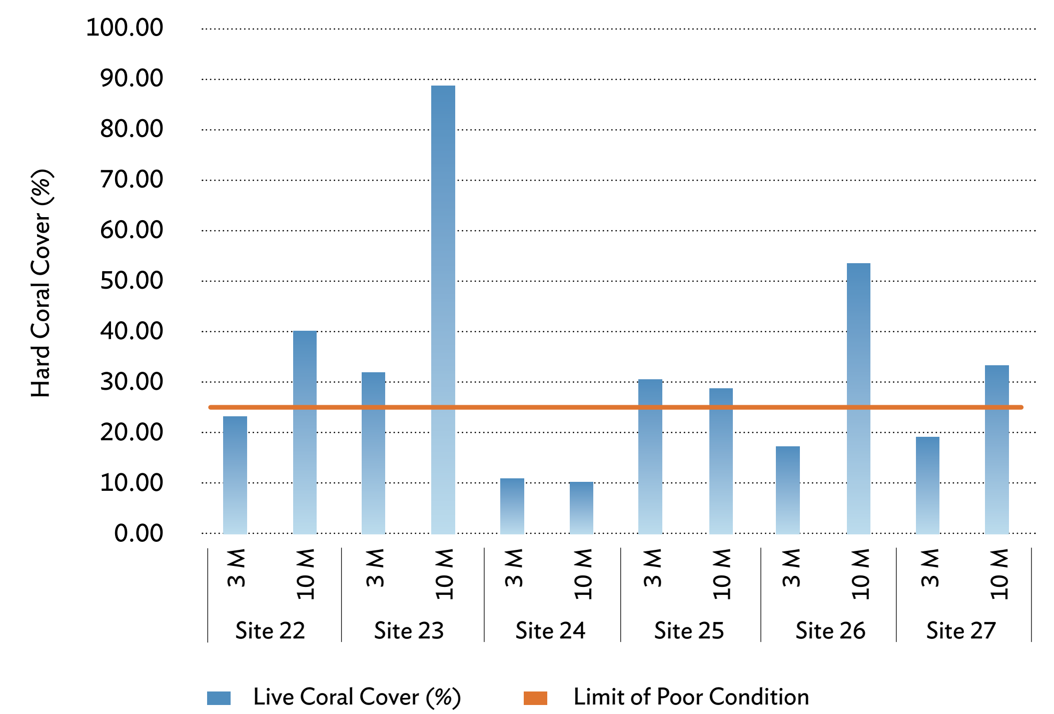


Figure 14. Coral cover in Mahengetang Island



d. Para Island

Figure 15 shows the satellite images of the coastal ecosystem in eight investigated sites in Para Island. Good coral condition in Para Island was found in two sites (sites 29 and 31) (Fig. 16). Six other sites had fair coral condition and another six sites also had poor coral condition. Coral reefs near the inhabited areas (in front of Para village and North of Para 1 village) had poor coral condition. Similar to Kahakitang and Kalama Islands, the community structure condition of the coral reefs is relatively poor, except in sites 29 and 31. The sites recorded a species diversity index of < 1.0 and a similarity index value (E) below 0.5 (Appendix 6). These indicate that the community stability of the coral reefs of the island is still quite alarming.

Figure 15. Imagery interpretation and distribution of coastal resources in Para Island

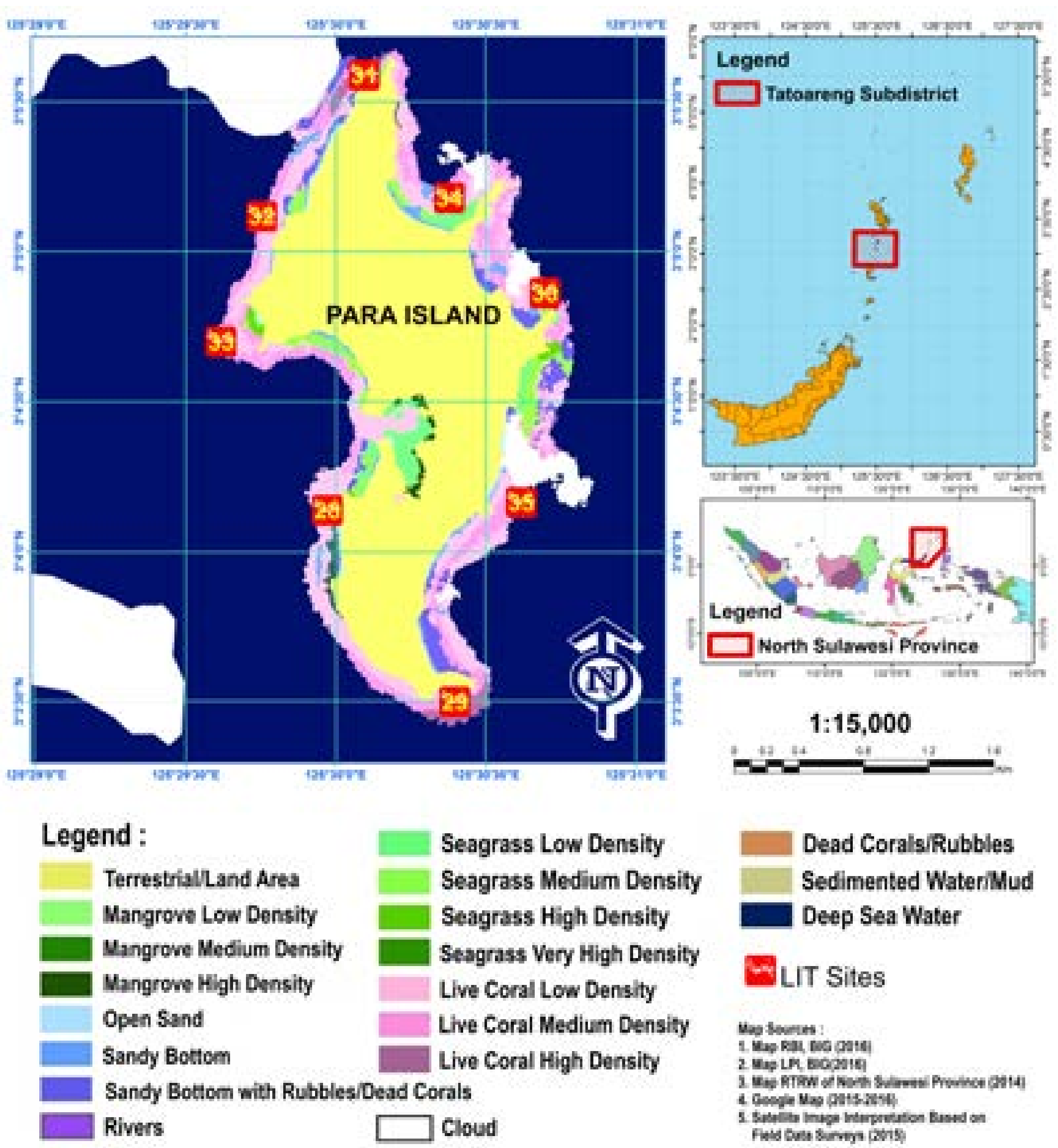
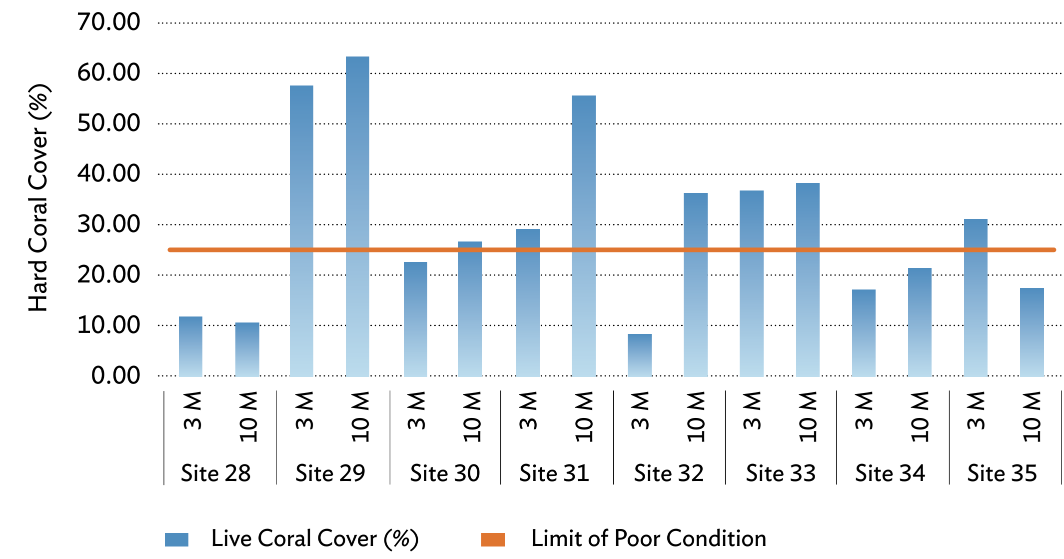


Figure 16. Coral cover in Para Island



e. Nitu Island

Figure 17 shows the coastal resources distribution in Nitu Island. The island had five study sites and fair coral cover were recorded in sites 36 and 39 (Fig. 18). The other sites recorded a poor coral cover due to destruction of coral reefs. Regarding those sites in Nitu Island, it could be said that the species diversity index of < 1.0 with a similarity index value (E) below 0.5, reflect that the stability of the coral reef community is relatively low (Appendix 7).

Figure 17. Imagery interpretation and distribution of coastal resources in Nitu Island

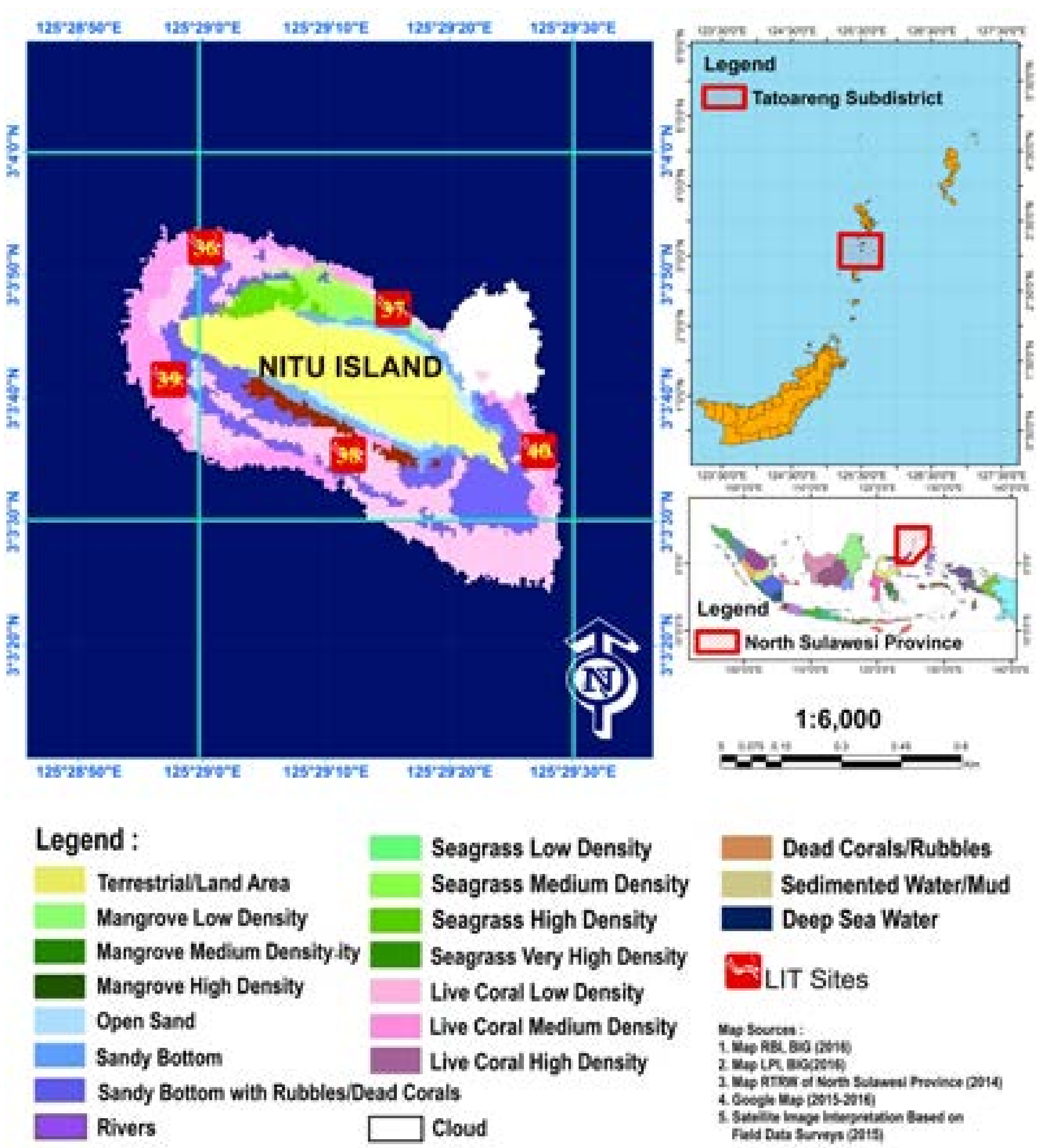
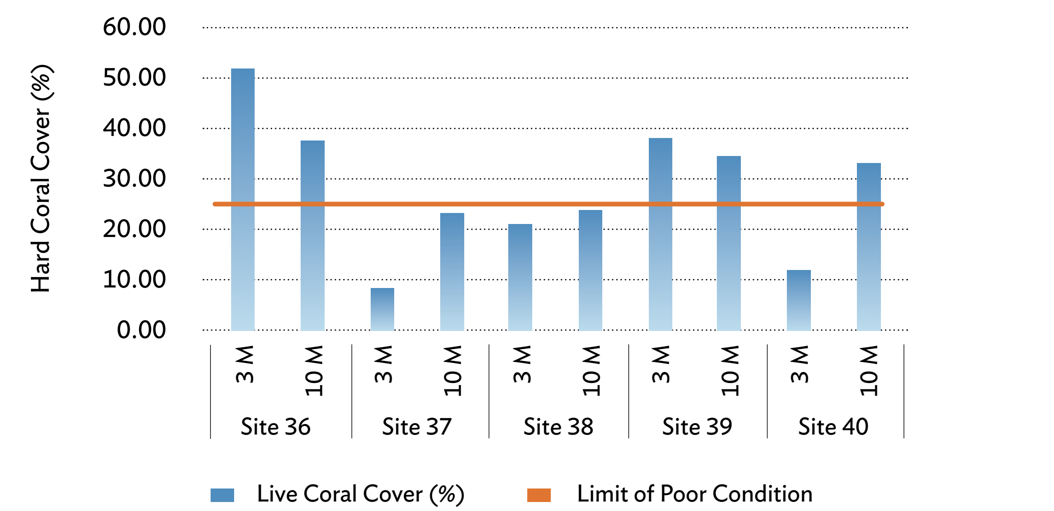


Figure 18. Coral cover in Nitu Island



f. Salingkere Island

Figure 19 presents the coastal resources in Salingkere Island. The island had no good coral cover recorded but it had six sites with fair to poor coral cover condition (Fig. 20). The island had a species diversity index of less than 1.0 with similarity index (E) below 0.5 (Appendix 8). These suggest that the stability of the coral community is generally poor.

Figure 19. Imagery Interpretation and distribution of coastal resources in Salingkere Island

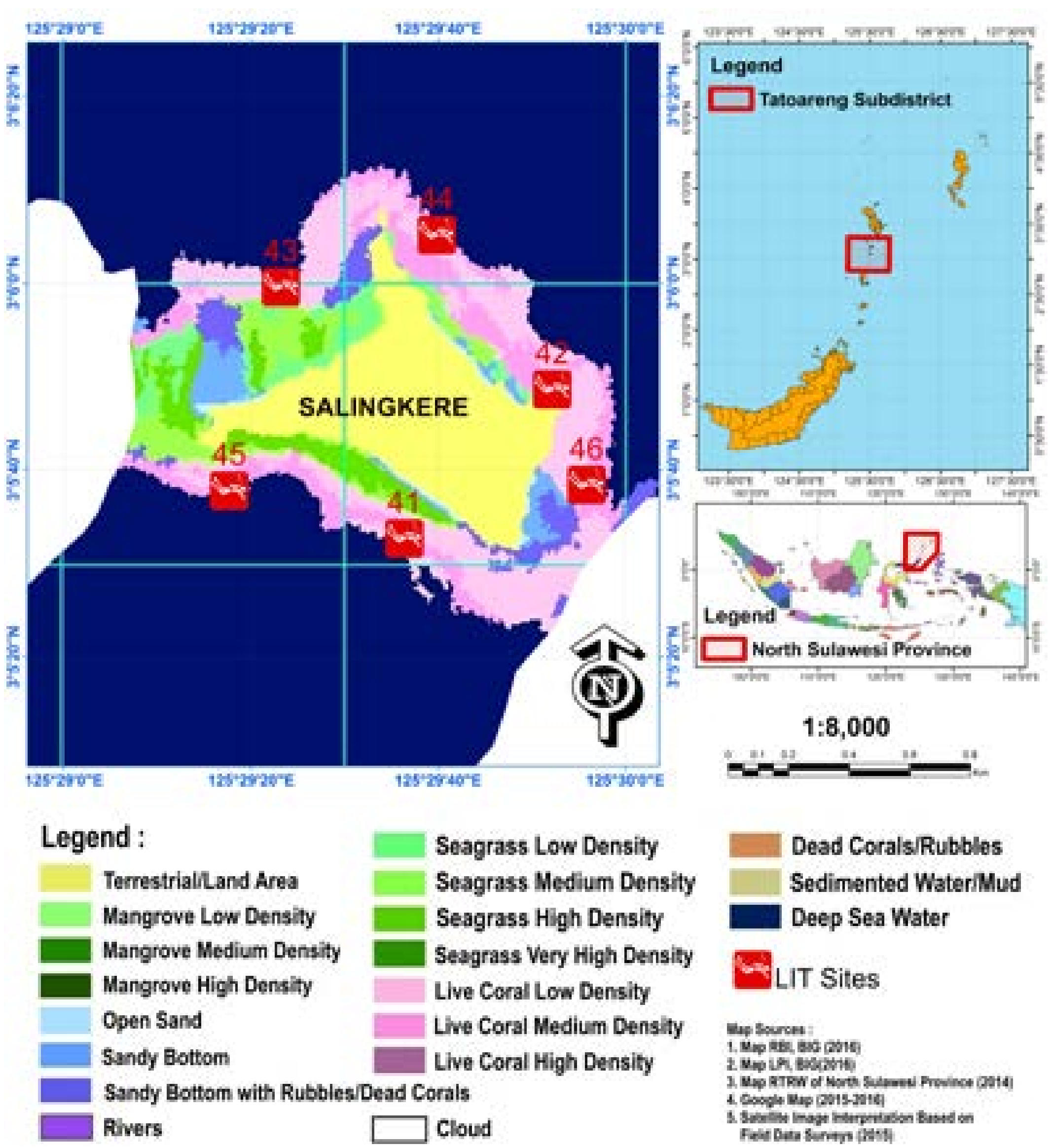
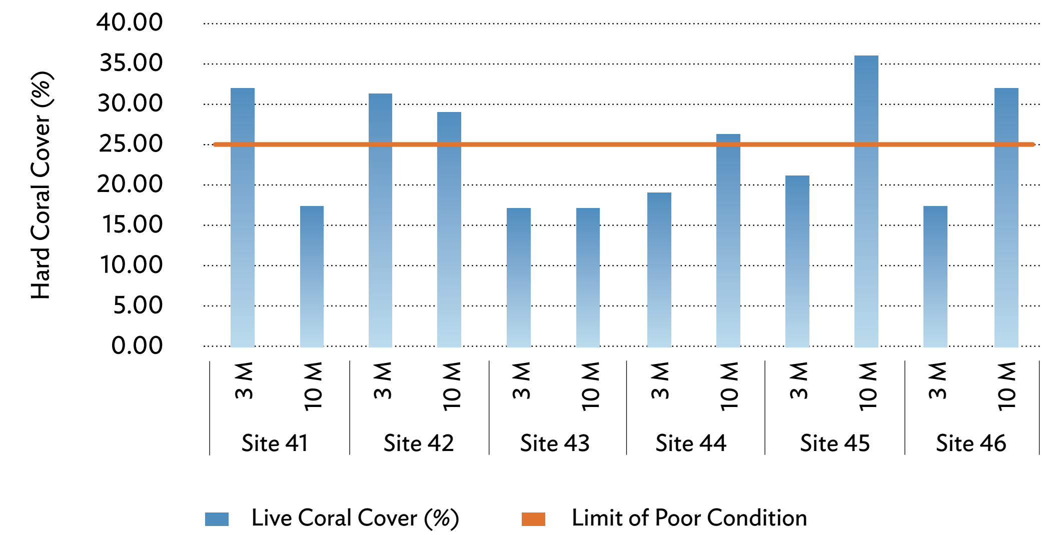


Figure 20. Coral cover in Salingkere Island



g. *Siha Island*

Figure 21 presents the coastal resources in Siha Island. Four sites were studied to define the status of coral reefs in this island. It was found that coral reefs had a fair to poor coral cover (Figure 22) with less than 1.0 diversity index and a similarity index (E) below 0.5 (Appendix 9). These conditions indicate that the stability of the coral reef community of the island is critical.

Figure 21. Imagery interpretation and distribution of coastal resources in Siha Island

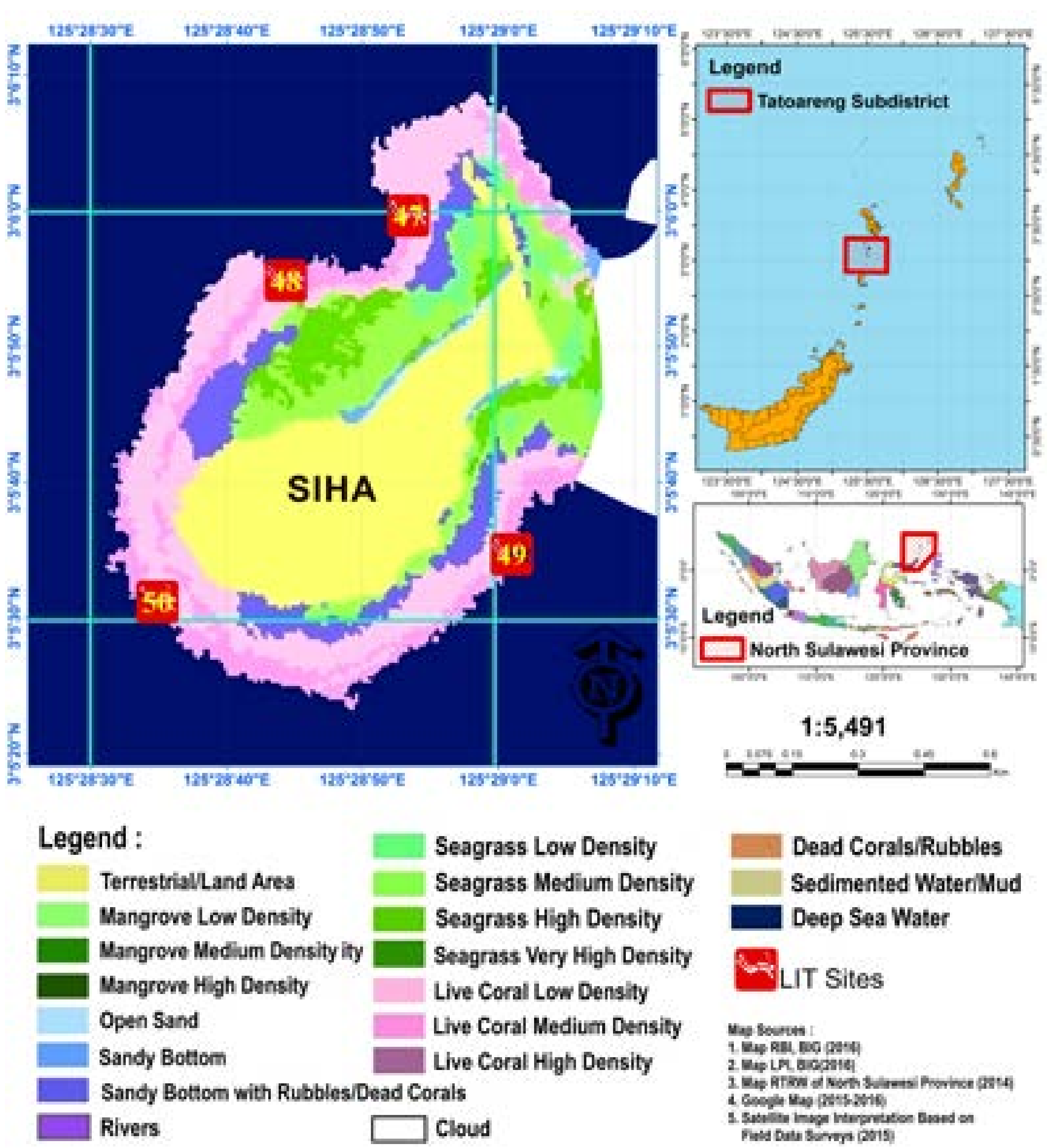
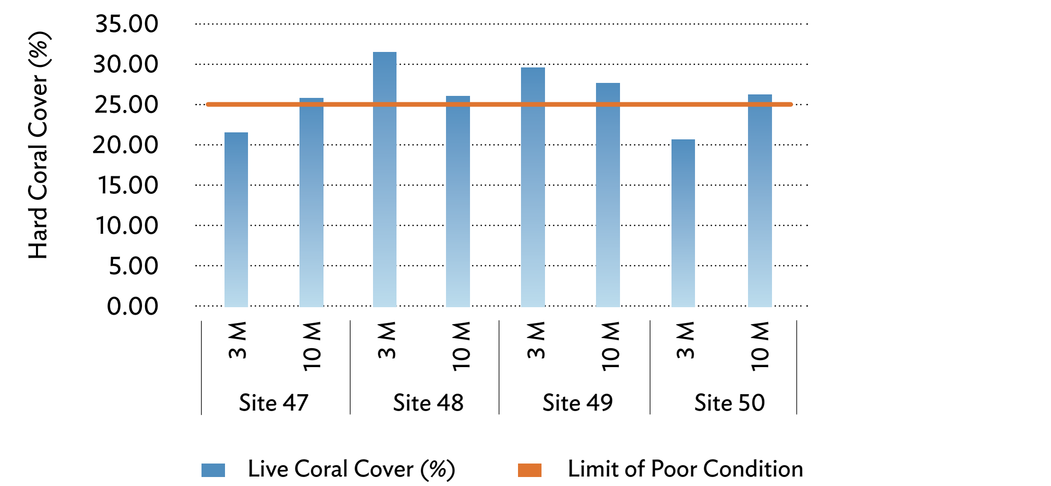


Figure 22. Coral cover in Siha Island



The coral reefs of Tatoareng Subdistrict recorded fair to poor coral cover. The coral reefs suffered a widespread damage due to human activities, such as destructive fishing practices (the use of compressors, cyanide, and stone net). The damaged coral reefs may make way for opportunistic species of algae to grow and develop in the damaged reef areas. However, the reef areas can slowly recover with proper management intervention.

B. Reef Fish

Species richness and abundance of reef fish were grouped into three categories: coral indicator species, target species, and major species. The reef fish condition varied for each site according to species richness, abundance, and dominant species.

A total of 250 species from 100 genera and 34 families were recorded in Tatoareng Subdistrict. The reef fish diversity was relatively high. However, most of the species belong to major species or noncommercially important species. Only few large dominant fish were target or commercially important species. These groups belong to the *Acanthuridae* (*Naso* sp.), *Siganidae* (*Siganus* spp.), *Serranidae (Gracila albomarginata, Cephalopolis argus)*, *Carangidae* (*Caranx* spp.), *Haemulidae* (*Plectorhynchus* spp.), *Lutjanidae* (*Macolor* spp.), and *Scaridae* (*Chlorurus* spp., *Scarus* spp.) families.

Large species such as *Bolbometopon muricatum (Scaridae)* were recorded in Siha, Salingkere, and Para Islands. *Napoleon Wrasse, Cheillinus undulatus (Labridae)* on the other hand, were observed in all sites surveyed. The species are under restricted protection status by the Minister of Marine Affairs and Fisheries (Decree: No. 37/Kepmen-KP/2013).

The highest species richness was recorded in sites 3, 4, and 5 (10 m deep). Low species richness was recorded in shallow reef waters (3 m deep) due to poor or damaged reefs. The highest fish abundance was found in site 5 (i.e., 10 m deep, 1,278 individuals). Low fish abundance (i.e., 297 individuals) was recorded in site 7 (3 m deep). The highest species richness was recorded in site 11 (Kahakitang Island) in the Eastern coast/near the tower with 124 species, and site 18 (North Coast) with 123 species. The lowest species richness was recorded in site 13 (in front of Bembenahe Village) and 69 species in site 12 (white sand of North Peninsula). The high species richness in sites 11 and 18 correlated with high fish abundance.

Highest fish species was recorded in Mahengetang Island (125 species) while highest fish abundance (1,187 individuals) was recorded in site 23 (Ngihade Coast). Fish abundance was dominated by *Hemitaurichthys polylepis* (coral indicator species), *Pterocaesio tile* (target species), and *Chromis ternatensis* (major species).

The poor coral condition in Para village influenced fish species richness and abundance. From eight sites surveyed, only 57 species and 392 fish individuals were recorded. The highest species richness (142 species) and abundance (1,491 individuals) were recorded in site 31 (the Strait between Para and Salingkere Islands). The species richness and fish abundance in Nitu Island were relatively low. The highest species richness (112 species) and abundance (981 individuals) were recorded in the eastern side of Nitu Island (site 40).

The highest fish species richness and abundance in Salingkere Island were found in site 3 (in front of Para 1) with 112 species and 962 individuals, respectively. The lowest species was recorded in site 46 (East) with 83 species and 112 individuals.

Siha is generally a beautiful island with white sandy beaches spread around the island. However, species richness and abundance of reef fish were low (Table 2). The species richness and abundance of reef fish were related to the reef status of the island (poor coral cover). Species richness was relatively similar but the highest was found in site 50 (western part) with 103 species while the highest fish abundance was recorded in the northern part of the island (824 individuals).

Table 2. Species richness and mean abundance of reef fish in the seven sites

Site	Species richness		Mean abundance	
	3m	10m	3m	10m
Kalama	23	28	90	142
Kahakitang	21	24	81	133
Mahengetang	25	27	196	180
Para	21	27	82	120
Nitu	19	23	71	124
Salingkere	18	21	62	71
Siha	18	21	72	94

Based on the reef fish community structure, the species diversity (H') in the seven islands surveyed differed between sites. All the survey sites had relatively high species diversity index (3-4) except in Mahengetang (Site 22) and Para (Site 32) with a diversity index of less than 3. The diversity index (H') generally conforms to the similarity index (E > 0.8) and only four sites had a value less than 0.8 (Appendix 10-16). Ecologically, two indexes suggest that the seven islands of Tatoareng Subdistrict are potential sites for MPA establishment.

Strict protection of the remaining coral reefs in the different villages should be imposed for faster recovery of the damaged reef areas. The coral reefs need to be managed and conserved in order to increase fisheries productivity for the benefit of the fishing communities that derive their sustenance from fishing in the area.

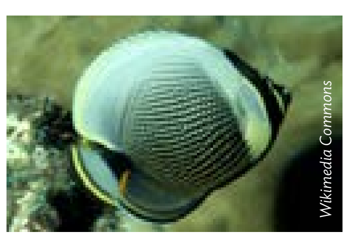
Establishment of MPA is the best management strategy to protect the coral reefs and in turn improve the reef fish community structure in order to sustain the fishery activities of the local communities. Illegal fishing methods must be stopped and alternative livelihood development must be introduced in the different villages to increase the income of the fishing communities.

Table 3. Reef fish community structure in Para Island and the surrounding waters

Island	Range of Value	NS	NI	H'	E	D
Kalama	Minimum	71	297	3.792	0.825	0.023
	Maximum	141	1278	4.184	0.918	0.046
Kahakitang	Minimum	69	397	3.646	0.803	0.019
	Maximum	124	985	4.187	0.915	0.053
Mahengetang	Minimum	71	521	2.820	0.661	0.026
	Maximum	125	1187	4.067	0.885	0.146
Para	Minimum	57	392	2.992	0.737	0.024
	Maximum	142	1491	4.086	0.893	0.134
Siha	Minimum	84	461	3.607	0.794	0.025
	Maximum	103	824	4.047	0.911	0.080
Salingkere	Minimum	83	472	3.714	0.803	0.024
	Maximum	112	962	4.082	0.908	0.073
Nitu	Minimum	66	256	3.460	0.782	0.025
	Maximum	112	981	4.151	0.912	0.066

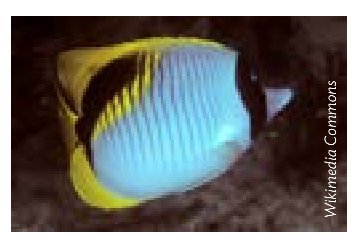
Coral indicator species were mostly from the family *Chaetodontidae* (Fig. 23). Field surveys recorded 30 species belonging to four genera (*Chaetodon, Forcipiger, Heniochus,* and *Hemithaurichthys*). The highest species richness (25 species) was found in Mahengetang Island followed by Kalama Island (28 species). Highest abundance was recorded in Mahengetang Island (Table 4).

Figure 23. Indicator species in the different study sites

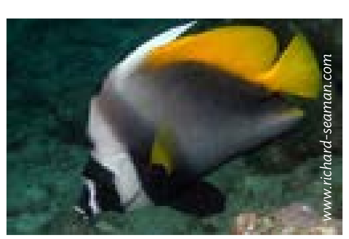


Chaetodon reticulatus

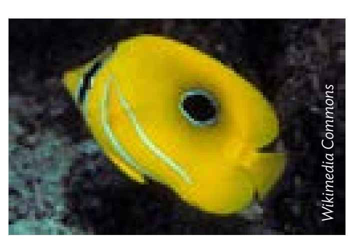
Chaetodon speculum



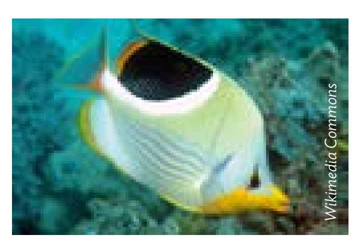
Chaetodon lineolatus



Heniochus singularius



Chaetodon bennetti



Chaetodon ephippium

Table 4. Number of fish indicator species in the different islands

Station	Depth	Total Species	Mean Number of Individuals
Kalama	3m	23	89.791
	10m	28	141.685
Kahakitang	3m	21	81.385
	10m	24	133.159
Mahengetang	3m	25	195.567
	10m	27	179.933
Para	3m	21	81.655
	10m	27	119.858
Nitu	3m	19	70.617
	10m	23	124.133
Salingkere	3m	18	62.300
	10m	21	71.283
Siha	3m	18	71.500
	10m	21	94.333

Chaetodon kleinii and *C. Lunulatus* were common species observed in all survey sites. *Hemitaurichthys polylepis* was the most dominant among the coral indicator species (Fig. 24). This species was generally found in large schools in the deeper waters especially in slop areas of coral reefs. Improving the coral reef condition through protection and conservation will increase the biological fish species in the area.

Figure 24. Dominant coral indicator species in the different study sites

A total of 115 target species were recorded from 43 genera and 20 families. Highest species richness was recorded in Kalama Island while mean abundance was recorded in Nitu Island followed by Kalama Island (Table 5). The dominant target species recorded in all survey sites were *Acanthurus pyroferus, A. thompsoni,* and *Chlorurus bleekeri. Pterocaesio tile* species had the highest abundance among the target species.

Table 5. Species richness and mean abundance of target species in the seven islands

Island	Depth	Total Species	Mean number of Individuals
Kalama	3m	82	422.438
	10m	89	490.663
Kahakitang	3m	81	413.955
	10m	87	542.970
Mahengetang	3m	63	327.883
	10m	84	534.383
Para	3m	69	368.150
	10m	89	579.006
Nitu	3m	60	301.133
	10m	73	618.950
Salingkere	3m	66	303.333
	10m	82	476.183
Siha	3m	69	401.167
	10m	78	544.750

A total of 105 species from 48 genera and 16 families of major species were recorded in the seven islands. Kahakitang and Para Islands had the highest species richness while Para and Kahakitang Islands had the highest mean fish abundance (Table 6). *Amblyglyhidodon curacao* was the most common species recorded in all sites while *Chromis ternatensis* was the most dominant among the species and these were found in branching corals (*Acropora* and non-*Acropora* branching).

Table 6. Species richness and mean abundance of major species in the seven islands

Sites	Depth	Number of Species	Mean Number of Individuals
Kalama	3m	82	496.710
	10m	83	523.319
Kahakitang	3m	83	536.395
	10m	81	472.704
Mahengetang	3m	64	432.183
	10m	79	503.633
Para	3m	69	392.927
	10m	88	636.568
Nitu	3m	58	401.050
	10m	64	385.033
Salingkere	3m	55	310.783
	10m	65	350.250
Siha	3m	60	349.500
	10m	63	332.333

C. Mangroves

The assessment sites of mangrove forests were in Kahakitang, Kalama, and Para Islands (Fig. 25). Absence of mangrove vegetation was observed in some islands in Tatoareng Subdistrict. Four mangrove species were recorded of which *Nypa fruticans* and *Rhizophora apiculata* were dominant mangrove species in all sampling stations. The substrate consisted of a mixture of sand, mud, pebbles, and rubbles. The mangrove forest was patch-growing with low density and the trees reached up to 10 meters in height (Appendix 17).

Figure 25. Map of mangrove transect stations

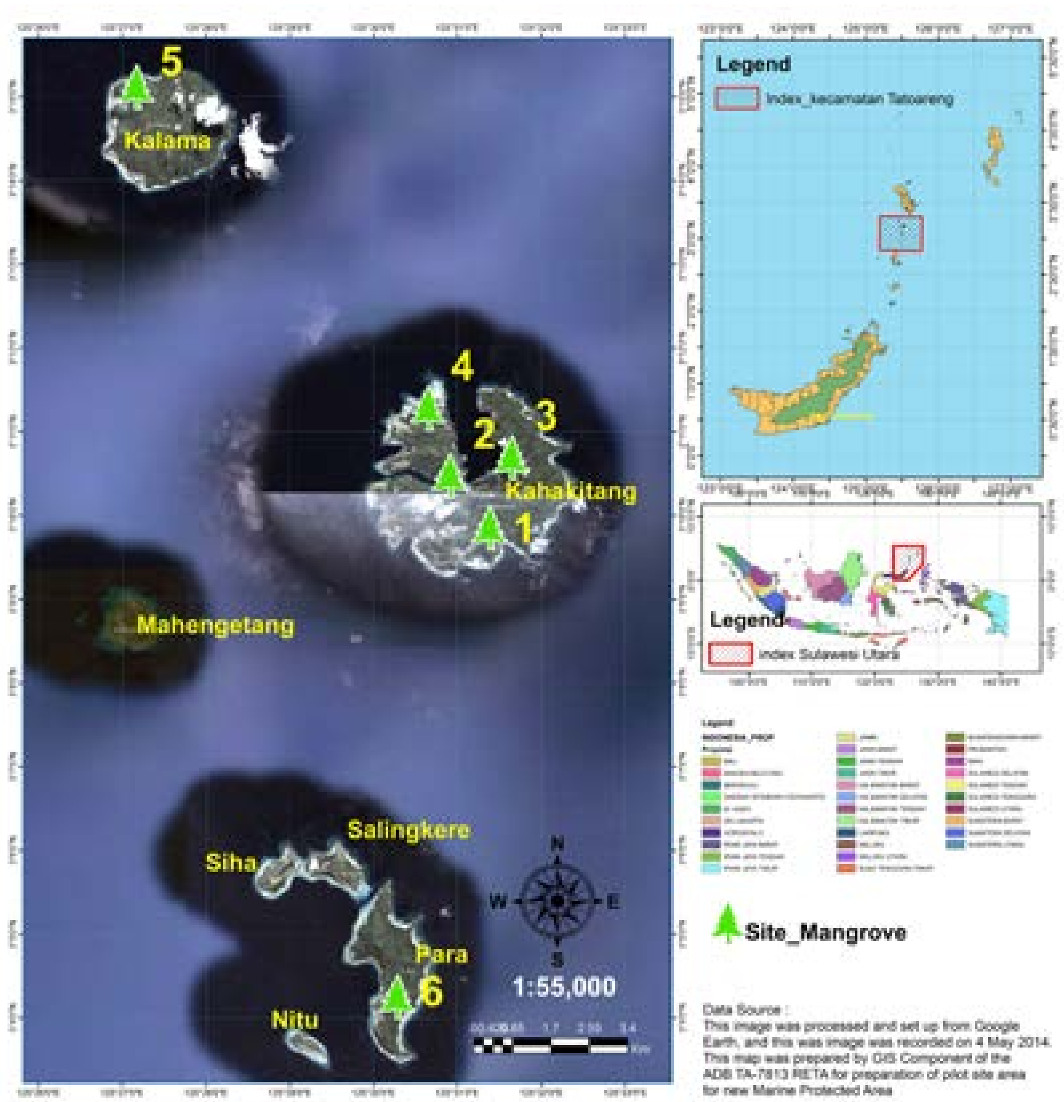


Table 7 shows the highest importance value index (IVI) in Kahakitang Island station. *Bruguiera gymnorhiza* was the highest in Sowang; meanwhile *Avicennia marina* was high in Taleko Batusaiki and Behongang, and *Sonneratia alba* was the highest in Dalako. The result shows that these species have strong adaptability to human and natural disturbances.

Table 7. Status of the mangrove ecosystem in Kahakitang Island

Location	Species	Relative Density	Relative Frequency	Diversity Index	IVI
Sowang Village	*B. gymnorhiza* *S. alba* *R. apiculata* *A. marina*	42.11 31.58 26.32 26.32	45.45 18.18 36.36 26.32	1.430	156.13 61.67 74.58 52.12
Taleko Batusaiki Village	*A. marina* *S. alba* *B. gymnorhiza* *R. apiculata*	42.86 20.00 22.86 14.29	13.13 33.33 20.00 33.33	1.3005	86.38 74.30 79.29 61.04
Behongang Village	*A. marina* *R. apiculata*	42.86 57.14	60.00 40.00	0.682	167.43 132.57
Dalako Village	*R. apiculata* *S. alba* *B. gymnorhiza*	35.29 47.06 17.65	20.00 30.00 50.00	1.028	76.09 115.52 108.40

In Kalama Island, patchy growth of mangrove vegetation was found in Liwua with mangrove height of about 30 meters. *Sonneratia alba* and *Avicennia marina* were recorded with low density and average height of 10 meters. *Sonneratia alba* had the highest importance value index (Table 8). Three mangrove species (*Rhizophora apiculata, Bruguiera gymnorhiza,* and *Sonneratia alba*) were recorded in Para Island. The mangrove area was composed of thick sandy-muddy substrate. *B. gymnorhiza* species had the highest IVI among the three species (Table 8).

Table 8. Status of the mangrove ecosystems in Kalama and Para Islands

Location	Species	Relative Density	Relative Frequency	Diversity Index	IVI
Liwua	*S. alba* *A. marina*	70.59 29.41	60.00 40.00	0.605	189.60 110.40
Para Induk	*R. apiculata* *B. gymnorhiza* *S. alba*	41.18 29.41 29.41	30.77 38.46 30.77	1.085	91.27 107.20 101.54

In terms of mangrove density, Sowang site recorded the highest density with 3,800 trees/ha followed by Behongang with 1,400 trees/ha; Dalako, Liwua, and Para with 3,400 trees/ha. However, the lowest mangrove density was recorded in Taleko Batusaiki with 7,000 trees/ha. Fair mangrove condition in Behongang was observed while the other stations were of poor condition. The associated biota observed were small crabs and a few small fish such as mudskippers.

The diversity index was relatively low, from 0.605 to 1.430. The low diversity index indicates that the mangrove area is affected by human and natural disturbances. The highest IVI was recorded in *Sonneratia alba* (189.60) in Liwua and Kalama Islands. The local people in Tatoareng Subdistrict protect the mangrove forest even if no regulation has been implemented. Illegal cutting of mangrove trees happened ten years ago in Tatoareng Subdistrict.

Rhizophora apiculata was the most common species in all sampling locations. Mangrove diversity was low and the density was good. Establishment of mangrove protected area will be needed to protect and conserve the mangrove ecosystem so that the ecological (spawning, nursery, and feeding ground) and physical functions (trapping sedimentation and seagrass protection) will be sustained.

D. Seagrass and Algae

Figure 26 presents the sampling stations for seagrass and algae. Eight seagrass species were recorded in the different sampling stations (Table 9). The highest seagrass cover (60-95%) was recorded in Kahakitang, Para, and Salingkere, while less than 50% seagrass cover were recorded in Mahengetang and Kalama Islands. Seagrass bed was dominated by *Syringodium isoetifolium, Enhalus acoroides, Cymodocea rotundata,* and *Cymodocea serrulata* (Appendix 18).

Figure 26. Map of seagrass and algae sampling stations

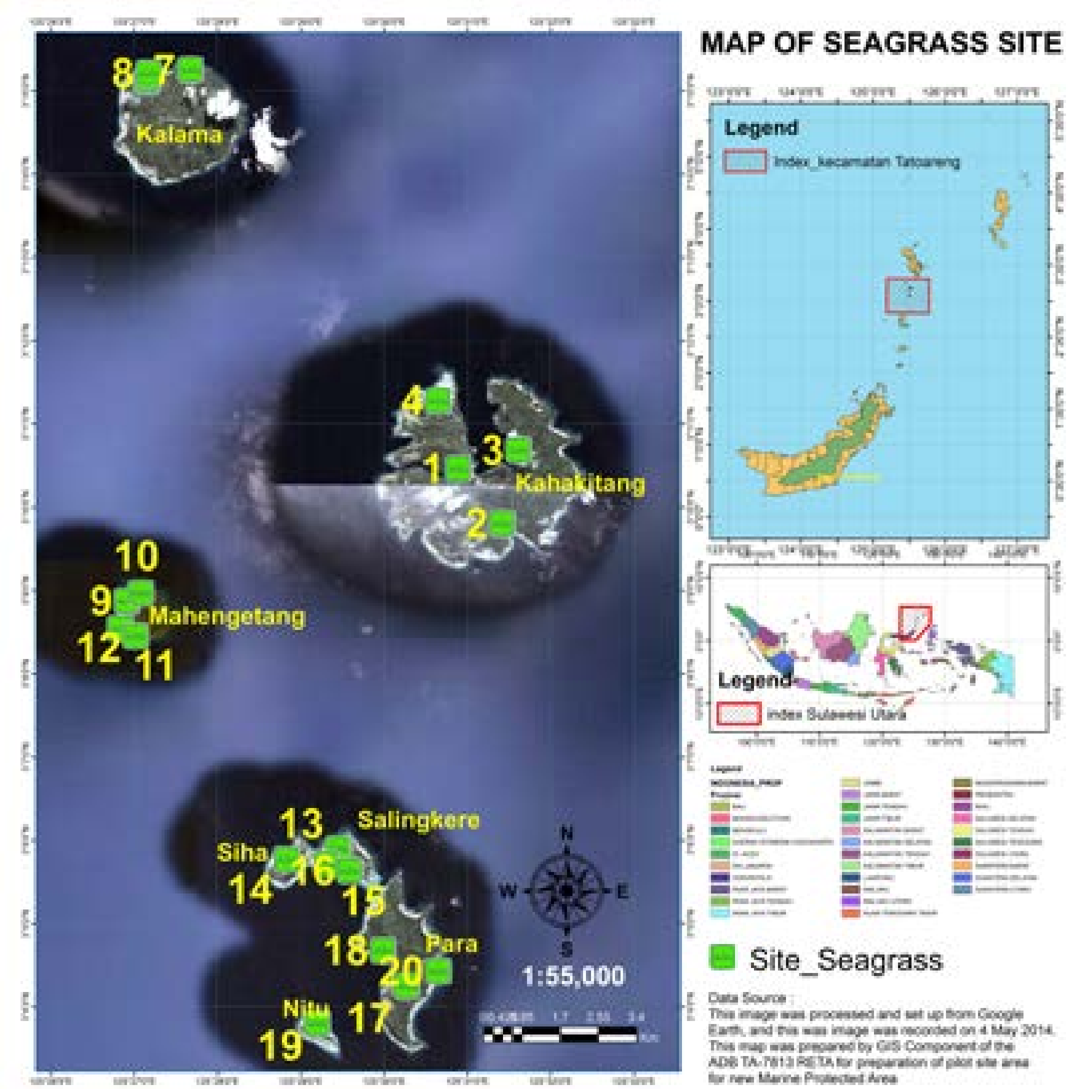


Table 9. Species of seagrass in Tatoareng Subdistrict

Species	Kahakitang				Kalama				Mahengetang				Para Satu				Para Induk			
	Station				Station				Station				Station				Station			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Si	++	++	++	+	+	+	+	+	+	+	+	+	++	++	+	+	+	++	+	++
Th	+	++	-	-	-	-	+	-	-	-	-	-	+	++	+	-	+	-	+	+
Ea	++	++	+	+	-	+	+	+	+	+	-	-	++	+	+	+	+	+	+	+
Hu	++	+	+	+	-	+	+	-	+	-	+	-	+	+	+	+	+	-	+	+
Ho	+	+	-	-	-	-	-	-	-	-	-	-	+	-	+	-	+	+	+	+
Hm	-	+	-	-	-	-	-	-	-	-	-	-	+	+	-	-	+	+	-	+
Cr	++	+	+	++	+	+	+	+	+	+	-	-	++	+	+	+	+	+	+	+
Cs	++	+	+	++	+	+	+	+	+	+	-	-	++	+	+	+	+	+	+	+

Notes: Si = *Syringodium isoetifolium;* Th = *Thalassia hemprichii;* Ea = *Enhalus acoroides;* Hu = *Halodule uninervis;* Ho = *Halophila ovalis;* Hm = *Halophila minor;* Cr = *Cymodocea rotundata;* Cs = *Cymodocea serrulata;* ++ = plenty; + = less; - = not found

The results of this study showed that species diversity and abundance of macrobenthic algae were higher in the waters of Kahakitang Island, Para, and Salingkere than in Mahengetang and Kalama Islands. Five species of marcrobenthic algae were recorded in all study stations (Appendix 19). There were three species of green algae (*Halimeda opuntia macroloba, Halimeda,* and *Udotea orientalis*), one species of brown algae (*Sargassum polycystum*), and one species of red algae (*Gracilaria edulis*) (Table 10). *Syringodium isoetifolium* (Si) was the most dominant species of seagrass and was present in all sampling sites. *Halophila ovalis* and *Halophila minor* were absent in Kalama and Mahengetang Islands while *Thalassia hemprichii* was also absent in Mahengetang Island. Associated biota includes sea urchins, which was recorded at 1 to 4 individuals per square meter.

The percent cover of macrobenthic algae in Kahakitang and Para Islands ranged from 20% to 30%, while Kalama and Mahengetang Islands had less than 20%. The occurrence and absence of macro benthic algae in the different sampling stations depended on the site specificity of the species.

Table 10. Species of macrobenthic algae in Tatoareng Subdistrict

Species	Kahakitang				Kalama				Mahengetang				Para I				Para Induk			
	Station				Station				Station				Station				Station			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
H. macroloba	+	++	++	+	++	+	+	+	+	-	-	+	++	++	+	+	++	+	+	++
H. opuntia	+	++	++	+	+	-	+	-	-	+	-	+	+	++	+	+	++	++	+	+
U. orientalis	+	++	+	+	+	+	-	+	+	+	-	-	++	+	++	+	++	+	+	+
S. polycystum	+	+	+	+	+	+	+	-	+	-	+	-	+	+	+	+	+	+	+	+
G. edulis	+	+	+	+	+	-	+	-	-	+	-	-	+	+	+	+	+	+	+	+

Notes: Hm = *Halimeda macroloba;* Ho = *Halimeda opuntia;* Uo = *Udotea orientalis;* Sp = *Sargassum polycystum;* Ge = *Gracilaria edulis;* ++ = plenty; + = less; = not found

Table 11. Physicochemical parameters in Tatoareng Subdistrict's waters

No.	Value	Tempe-rature (°C)	Water pH	mS/cm	Ntu	mg/L DO	g/L TDS	Salinity (ppt)	Bright-ness
1	Minimum	27.80	8.14	50.6	1	8.23	30.2	33.1	20
2	Maximum	29.31	8.54	51.6	1	9.32	31.1	34	25
3	Interval	1.51	0.4	1	0	1.09	0.9	0.9	5

Appendix 20-26 show the distribution of mangrove, seagrass, and algae, including terrestrial vegetation and villages, in the different study stations. The distribution of these resources varied depending on the geographical location of the islands. Generally, the different islands were surrounded with coral reefs, seagrass, and algae while mangrove forests in patchy growth were scattered in the coastal areas. Villages were also observed in the different islands under this study.

E. Demographic Profile

1. Demography

Tatoareng Subdistrict is geographically located at 3°4‘0” - 3°14‘2”N and 125°20‘16“ - 125° 30‘52” E and the district capital is Kahakitang Village. Tatoareng is one of the subdistricts in the Kepulauan Sangihe District (KSD) of North Sulawesi. It has the following administrative boundaries: South Manganitu Subdistrict in the North borders, Mollucas Sea in the East, the West Siau in the South District of Sitaro, and Celebes Sea in the West.

The distance from Kahakitang (the subdistrict capital) to Manado (provincial capital) is 132 nautical miles (244.46 km), while the distance from Kahakitang Village to Tahuna is 39 nautical miles (72.23 km). Tatoareng Subdistrict consists of seven villages, where the farthest to the district capital are Para and Kalama Village, ± 5 nautical miles. Kalama is the largest village (Table 12).

Table 12. Villages in Tatoareng Subdistrict

District Town	Village	Distance (nm)	Distance (km)	Area (km2)
Kahakitang	Para	5.00	9.26	4.45
	Para 1	4.50	8.33	1.22
	Mahengetang	4.00	7.41	1.10
	Kahakitang	0	0	0.90
	Kalama	5.00	9.26	67
	Dalako Bembanehe	1.62	3.00	0.82
	Taleko Batusaiki	2.16	4.00	0.82

Sources: Village office: 2015

Based on the administrative territory of the local government in 2002, Tatoareng Subdistrict was divided into four villages and fifteen lindongan/subvillages. In 2004, number of villages in the subdistrict increased to seven villages and twenty-four lindongan/subvillages. The subdistrict is led by a subdistrict head (*Camat*), the village level is led by a *kapitalaung* (village chief) and lindongan (subvillage) is led by a lindongan chief.

Four villages are located in a separate island, while Kahakitang, Dalako Bembanehe, and Taleko Batusaiki Villages are located in Kahakitang Island. Kahakitang Village is the center of subdistrict government, and it is the largest island of the subdistrict where three villages are located. Kahakitang Island, especially Kahakitang Village, is suggested to be the center of the aquatic management and conservation area (Table 13).

Table 13. Village, type, state, and number of subvillages

Village	Type	State	Subvillage
Para	Village	Self-support	2
Para 1	Village	Self-support	2
Mahengetang	Village	Self-support	3
Kahakitang	Village	Self-support	4
Kalama	Village	Self-support	5
Dalako Bembanehe	Village	Self-support	4
Taleko Batusaiki	Village	Self-support	4

2. Population and Employment

In 2015, population in Tatoareng Subdistrict was 5,493 with 1,587 households and a density of 305.55 ind/km2. The highest population was found in Kalama, with 1,112 people and a density of 128.22 ind/km2; the lowest was found in Taleko Batusaiki, with 512 people and a density of 624.39 ind/km2, while the highest density was found in Dalako Bembanehe, with 915.85 ind/km2 (Table 14).

Table 14. Population composition of each village in Tatoareng Subdistrict

Village	Population	Household	Male	Female
Para	1,071	300	545	526
Para 1	552	160	301	251
Mahengetang	773	227	395	378
Kahakitang	722	201	368	354
Kalama	1,112	319	517	595
Dalako Bembanehe	751	206	387	364
Taleko Batusaiki	512	174	261	251
Total	**5,493**	**1,587**	**2,774**	**2,719**

Source: Villages Office 2015

Fishing is the primarily source of income of the coastal communities in Tatoareng Subdistrict and farming is the secondary source of income (Table 15). Most of the fishermen are traditional fishers using small outrigger boats with outboard engines and using traditional methods of fishing such as handlines and nets. Other fishermen work as laborers in purse seiners catching pelagic fish. Fishermen who work as laborers in purse seiners do not have their own fishing gears and boats. The rest of the villagers who are not fishermen are engaged in farming.

Table 15. Income source of coastal communities in Tatoareng Subdistrict

Village	Farmer	Fisher	Trader	PNS	Other	Total
Para	27	117	11	14	25	194
Para 1	39	155	15	8	19	236
Mahengetang	27	91	8	11	35	172
Kahakitang	69	98	10	31	35	243
Kalama	67	86	9	16	36	214
Dalako Bembanehe	78	210	10	8	20	326
Taleko Batusaiki	81	15	13	11	31	151

3. Economic Condition

The status of the marine and coastal resources directly affects the income of the fishermen. The economy of the communities in these islands are directly dependent on the productivity of marine resources/organisms. The fishermen exchange rate (FER) was used to determine the living condition of the fishermen.

The FER is a parameter to measure the living condition of the fishing communities. FER is the ratio of total revenue and total expenditure of the fishermen's households during a certain period of time. FER is also referred to as subsistence exchange rate and is also used to measure the household's ability to meet the needs of fishermen's families.

The income from fishing is not enough to meet the needs of the family. Farming, construction labors, and salesmanship provide additional income that can range from IDR 200,000 to 1,500,000 per month. The fishermen need IDR 75,000 per fishing operation and IDR 1,000,000 to 2,000,000 per month for their household needs. Products like vegetables and other fruits are expensive because these products are all imported from outside the village (Tahuma and Manado).

To upgrade the economic condition of the fishing communities, coastal communities should be improved and women should be empowered in such a way as to increase their earning capacity. The survey revealed that there was a big gap between the boat owners' and the fishermen's income in Tatoareng Subdistrict. The boat owners' earnings could reach tens of millions per month, while the fishermen could generally earn only about IDR 500,000-3,000,000/month, with an average of IDR. 1,500,000. Only two boat owners (one in Mahengetang and one in Para 1) responded to the questionnaire.

The average FER in Tatoareng Subdistrict was 0.94. It can be lower, equal or higher than one. FER < 1 means that the fishing families have lower financial capability to meet the family needs. FER = 1 means that the fishermen's families can only meet their basic needs. FER > 1 means that the fishermen's families have enough means to meet their needs, potential to help the needs of others, and have the capability to save in the form of investments. Based on these criteria, fishermen's families in Tatoareng Subdistrict have low purchasing capacity and they can only meet some of their daily needs, such as food, health, and the education of their children up to the secondary school or high school level (Table 16).

Table 16. Fishermen Exchange Rate (FER) in Tatoareng Subdistrict

Village	FER
Para	0.97
Para 1	0.94
Mahengetang	0.97
Kahakitang	0.90
Kalama	0.95
Dalako Bembanehe	0.89
Taleko Batusaiki	0.93
Mean	0.94

4. Infrastructure

Infrastructure like roads were found only on Kahakitang Island where three villages are located. Presently, there is a road connecting Kahakitang Village to Taleko Batusaiki, but Dalako Bembanehe Village is not connected. For Kalama, Mahengetang, and Para Islands only concrete village roads are available. The subvillages isolated from the main villages can be reached through village roads or by boat.

One of the most important resources needed by the community is electricity. At present, Tatoareng Subdistrict has no electricity. There is a solar power plant in Mahengetang Island but it is intended for seawater desalinization facilities to produce fresh water for drinking. Some families have small generator for their own electricity consumption.

Another problem in the villages is the source of fresh water supply for the households' needs. Most houses have concrete water containers to hold/catch rainwater during the rainy season. Deep wells are located in the villages but the water contains a certain amount of salt and it is only intended for washing and bathing.

Kahakitang and Para Villages have ports for fast boats from the village to Manado and vice versa. The fast boat Express from Manado to Tahuna stops in Kahakitang Village on Mondays and Majestic stops in Para Village. Every Thursday, the boat Express, on its way from Tahuna to Manado, stops in Kahakitang Village. In other days, the people use the local boat transport to Tahuna and they take a ship to Manado.

5. Community/Social Condition

Tatoareng Subdistrict residents are dominated by the Sangerese ethnic group. Majority of the people are Protestant Christians (5,131) and the rest are Catholics (362). Kalama and Para have the largest population with 1,112 and 1,071, respectively; followed by Mahengetang (773), Dalako Bembanehe (751), Kahakitang (722), and Para 1 (552); while Taleko Batusaiki has the lowest population (512) (Table 17).

Table 17. Population of the villages based on religion

Village	Protestant	Catholic	Total
Para	1,071		1,071
Para 1	552		552
Mahengetang	773		773
Kahakitang	722		722
Kalama	1,112		1,112
Dalako Bembanehe	389	362	751
Taleko Batusaiki	512		512
Total	5,131	362	5,493

Source: Villages Offices 2015

There are only two health centers in Kahakitang and Kalama Islands with one doctor, eight paramedics, and seven non-paramedics (Table 18). The number of health personnel is very limited considering the population in the different islands. All respondents said that patients would be taken to the public health center in Kahakitang and Kalama village for medical examination and if the illness got worse, the patient would be referred to the hospital in Tahuna or Manado.

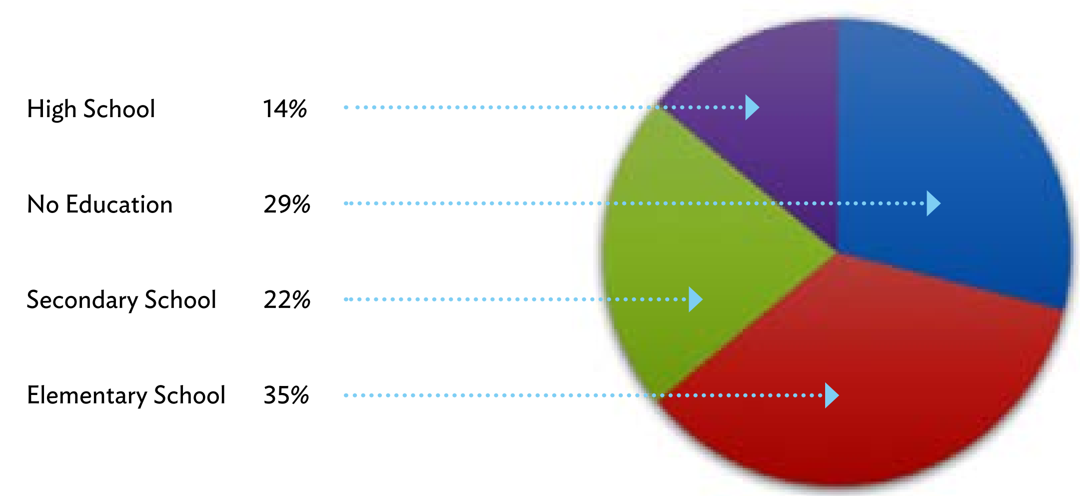
Table 18. Health infrastructure in Tatoareng Subdistrict

Village	Health Center			Doctor	Paramedic	Non-paramedic
	U	P	K			
Para						1
Para 1					2	2
Mahengetang						1
Kahakitang	1		1	1	5	2
Kalama		1			1	1

6. Education

Based on the present data, the educational level of the fishing communities is classified as low. Majority of the respondents (35%) finished elementary school, 29% did not finish elementary school/no education, 22% finished secondary school, and 14% finished high school (Fig. 27). The economic condition of the community dictates the level of education of the children. Families with better source of livelihood can afford to send their children to high school up to college.

Figure 27. Pie chart of respondents' education level



Elementary and secondary schools are the only educational institutions available in the different islands. Secondary schools exist only in Para, Kahakitang, and Kalama villages (Table 19). Students from Mahengetang Island and Para 1 Village are quite far from the secondary school and their parents have difficulty providing transportation allowance for their children. Most parents choose to send their children to study in Tahuna or Manado for better school infrastructure and higher level of education. The children who cannot continue their education help their parents earn income for their daily living.

Low level of people's education affect their involvement, awareness, and participation in resource management. As such, infrastructure development, capacity building through training, orientation, and counseling could increase the knowledge of the community in the conservation and protection of marine and coastal resources.

Table 19. Number of schools in the different villages

Village	KG	KG Teacher	ES		ES Teacher		SS		SS Teacher	
			G	P	G	P	G	P	G	P
Para			1	1	5	4	1		5	
Para 1				2		6				
Mahengetang				1		5				
Kahakitang			1	1	6	6	1		7	
Kalama	1	1	1	1	5	5	1		4	
Dalako Bembanehe				1		5				
Taleko Batusaiki			1		5					
Total			4	7	21	31	3		16	

Note: G: Government; P: Private, KG= Kinder Garten, ES= Elementary School, SS= Secondary School.

(Source: Villages Office 2015)

F. Fisheries Resources Condition and the Dilemma of Common Property

Fishery production in Tatoareng Subdistrict waters depend on the weather and season. The peak season for fishing activities occurs from March to June when there are no south and west monsoon winds. During the south and west monsoon seasons, fishermen limit their fishing operations as seawater is rough and it is not favorable for fishing.

The competition of fishermen groups in Tatoareng Subdistrict is very strong. Both the communities and the local authorities do not provide limitations on the exploitation of coastal and marine resources in the region. There are no policies or rules and regulations to protect coastal and marine resources and govern fishing activities, such as the allowable number of fishermen, fishing gear, and boat type to be used for fishing, or specifications of regulated fish species, and maximum total catch. The community perceives that available resources are for everybody or the fishing ground is public property and it is free, and what they get and receive is a gift or heritage from the resources.

The issues on fishing ground and illegal fishing methods in Tatoareng Subdistrict, particularly in Para and Mahengetang Villages, arise when there is a school of fish in the contested fishing grounds. The fishermen who have first seen the school of fish have the power or privilege to catch fish but this is not acceptable to other fishermen groups because the school of fish is in the contested fishing ground. However, social control was recently applied to reduce and prevent conflict among the fishermen.

Fish resources generally targeted are scads (*Decapterus* spp.) or locally known as "malalugis." Other fish catch are skipjack tuna *(Katsuwonus pelamis)*, tuna (*Thunnus* sp.), and various reef fish. Overexploitation and increase in the number of fishermen have resulted in the decline of fisheries resources. According to the fishermen these are the main reasons for low fish catch. Local fishermen complain that it is more difficult to catch fish at this time, unlike in the past when fish catch was more plentiful. To remedy this problem, some fishermen have ventured to fishing outside Tatoareng Subdistrict.

Open access gives the impression that no user is responsible for the sustainability of fisheries resources. When the resources of a certain area are damaged, the fishermen can move to other fishing grounds. In addition, the principle of open access consider other users as a competitor on fish resources. This is different from the concept of private ownership or communal ownership, where the community continuously protect and manage the fisheries resources to maintain productivity and sustainability for community benefit. The beliefs and views of the community regarding open access and common property of the resources have a negative impact on resource management.

The centralized management system of the government affects the open access to the resources. Before the implementation of regional autonomy, coastal and marine resources were managed by the fishing community. The government had the authority and power to manage coastal and marine resources. However, according to the subdistrict and village government officials interviewed in the study sites, regional autonomy is only understood by the government officials at the district level and do not reach the lower level of government such as the subdistricts and villages.

G. The Community's Capacity to Comprehend the Idea of Conservation

To understand the comprehension capacity of the coastal communities, it is important to clarify the definition of the concept. The comprehension capacity can be defined as the ability or capacity of a system to modify the characters in order to cope with present or future changes (Adger et al., 2004). In this context, what is being referred to is the comprehension capacity of the communities affected by the conservation management plan in Tatoareng Subdistrict and their corresponding attitude toward the plan.

Conservation is a resource management program that aims to maintain and improve the quality of the resources, either human or natural resources. All respondents in the study agreed with the proposed conservation program in the areas despite the low understanding of the community about the concept. The fishermen initially rejected the conservation program because they did not understand its concept and main purpose. The local government initially established the working group for the establishment of MPAs in certain areas. This working group explained the concept of conservation to the fishing communities. After explaining the main purpose and objectives of conservation, the fishermen finally agreed to support the program.

The fishing practices of the community can affect the conservation and management of its resources. Destructive fishing methods, such as the "stone net" or muro-ami, commonly used by the communities, completely destroy the corals. The stone net operates in shallow waters (7-10 meters depth) using a 200-meter long gear. One solution to this problem is the replacement of the fishing gear "stone net" or muro-ami. Muroami has been in Indonesia for so many years. It was widely used in coral areas for coral fishes. Fish are herded toward the net by hitting the rocks and making sounds. This fishing gear is not environment-friendly, thus it is not recommended and is strictly prohibited. Moreover, the fishing gear is long enough and can reach a depth of more than 200 meters. Other alternative livelihood programs, such as fish culture and seaweed farming, should be introduced in the village to stop the operation of stone nets in the coral areas.

H. Conservation Potential and Issues

Field observation data were analyzed to provide recommendations on the categories and types of aquatic conservation on the small islands. The results will be used in public consultation with the different stakeholders in Tatoareng Subdistrict. The potential areas for conservation cover the seven islands in Tatoareng Subdistrict (i.e., Kalama, Kahakitang, Mahengetang, Salingkere, Para, Siha, and Nitu). The management issues in the study sites were compiled from interviews and compared with field observations. The assessment of the area was based on the technical manual for identification, inventory, and conservation area reserves on marine, coastal, and small islands (Supplement 1 of E-Kawasan Konservasi Perairan Pesisir Pulau Pulau Kecil [E-KKPP3K] or Conservation Area of Marine, Coastal, and Small Island guidelines).

Based on the Coastal Areas and Small Islands (KKP3K) manual, a mandate of Act No. 31/2004, No. 45/2007, No. 27,/2007 and No. 1/2014, Marine Protected Areas consist of the following categories: (1) Aquatic Conservation Areas, (2) Coastal Conservation Areas and Small Islands, (3) Maritime Conservation Areas, then referred to as MPA, and (4) Coastal Borders. In each category of KKP3K, divided into several types of reserved areas, the type will be recommended based on criteria analysis as well as potential analysis.

I. Criteria Analysis

1. Naturalness

The naturalness of the resources is assessed by calculating the percentage of human activities in the area. Human interventions, such as pearl culture, seaweed, floating nets, port development, embankment, and waste disposal, among others, were considered. The human interventions in Tatoareng Subdistrict were: (1) coral reef destruction; (2) port and jetty development on Kahakitang, Kalama, Mahengetang, and Para Islands; (3) embankment of Kalama, Kahakitang, Mahengetang, and Para Islands; and (4) waste disposals in the seven villages.

The natural condition of the coastal resources especially the corals reefs in Tatoareng Subdistrict is very low due to the destruction of coral reefs. Destructive fishing techniques, such as stone net or muroami (Soma Batu) fishing, is legal in the villages while compressor for fishing is widely used in the area.

Stone net fishing practice is the most common fishing method in the area and the main culprit in the destruction of coral reefs. The practice will continue if there is no alternative environment-friendly fishing gear introduced to prevent the mass destruction of the coral reefs. Mangrove, seagrass, and seaweeds in Tatoareng Subdistrict are more pristine than the other resources due to less human activity involving these resources, which are seldom exploited, unlike the coral reef ecosystem.

Based on the distribution and naturalness level, the coastal areas of Tatoareng Subdistrict with high level of ecosystem integrity were only recorded in the Northern part of Kalama Island (Liwua), a part of Sowang area, the village of Taleko Batusaiki, Behongang, Dalako (Kahakitang Island), and Para (Para Island). The ecosystem/habitat naturalness was calculated using the following formula (Yunia, 1996, as cited in Lubis, 2014):

Or = (1-(Am/An)*100%

Where:

Or = naturalness (%)

Am = area of ecosystem influenced by human

An = total area of ecosystem being valued

The naturalness scorings were as follows:

> 75% = highly natural (3)

≤ 50 Pr ≤ 75% = fair (2)

≤ 50% = not natural/poor (1)

Based on the imagery interpretation, the coastal ecosystem of Kalama, Kahakitang, Mahengetang, and Para Islands (i.e., the coral reefs, mangroves, and seagrass) has a total area of 965.8 hectares, and 690.9 hectares of coral reefs, 24.1 hectares of mangrove forests, 250.8 hectares of seagrass, and 50.8 hectares of seaweeds. From the total area of 965.8 hectares, the naturalness covers only 274.9 hectares. Based on Qr analysis, the naturalness level of the coastal ecosystems in this area is 29.463 %, which is low (1).

2. Uniqueness

The uniqueness of the flora and fauna of an aquatic environment is based on the abundance or presence of plants and animals in the area. The rareness and the endemism are determined based on the existence of the flora or fauna in other places.

The category values used for each level are as follow:

Unique = 3, if the plant or animal exists only in one region in Indonesia

Unique enough = 2, if the plant or animal exists in several areas of the same biogeography

Not unique = 1, if the plant or animal exists in many places of Indonesia

Based on the criteria, the level of uniqueness of the flora and fauna in the coastal areas of Tatoareng Subdistrict is 2 (all flora and fauna found also exist in the same biogeographic region). Field observations and community information indicate that there is no endemic marine biota in the group of islands in Tatoareng Subdistrict.

The coastal areas of the Tatoareng Subdistrict have no unique or endemic mangrove and seagrass species. Identification of the mangrove and seagrass revealed that the species found in the area are also found in other areas of Indonesia. No birds, mudskippers, and mollusks were found in the study areas.

The absence of unique and rare biota in the mangrove forest is inversely proportional to the area of mangrove ecosystem. The low number of flora and fauna species in the mangrove and seagrass ecosystems demonstrate that these ecosystems provide low nutrients to the different species of flora and fauna. It has a diversity index of less than 0.3.

Based on field observations, the Tatoareng Subdistrict is ecologically and biologically unique. The most prominent ecologically unique feature of the area is its underwater volcano (seamount) in Mahengetang Island, surrounded with benthic animals, such as hard corals, mollusks, crustaceans, and reef fish. This characteristic makes Mahengetang Island a highly potential area for sustainable tourism activities.

3. Rareness

Field surveys recorded that napoleon wrasse *(Cheilinus undulatus)* exists in the islands with a very minimal population due to overfishing and destructive fishing mehods. This fish is included in Appendix II of CITES and have also been put in the limited protection status under the Indonesian Marine Affairs and Fisheries Minister's Decree. No. 37/Kepmen-KP/2013 concerning the Protection Status of the Napoleon Fish *(Cheilinus undulatus)*.

The analysis of fish population condition in the study area was based on the abundance of each species:

a. *For protected fish assessment:*

There are some (≥ 1) protected fish species in high numbers: 3

There are some (≥ 1) protected fish species in low numbers: 2

There is one protected fish species in low numbers: 1

b. *For assessment of fish necessarily protected:*

There are some (≥ 1) necessarily protected fish species in high numbers: 3

There are some (≥ 1) necessarily protected fish species in low numbers: 2

There is one necessarily protected fish species in low numbers: 1

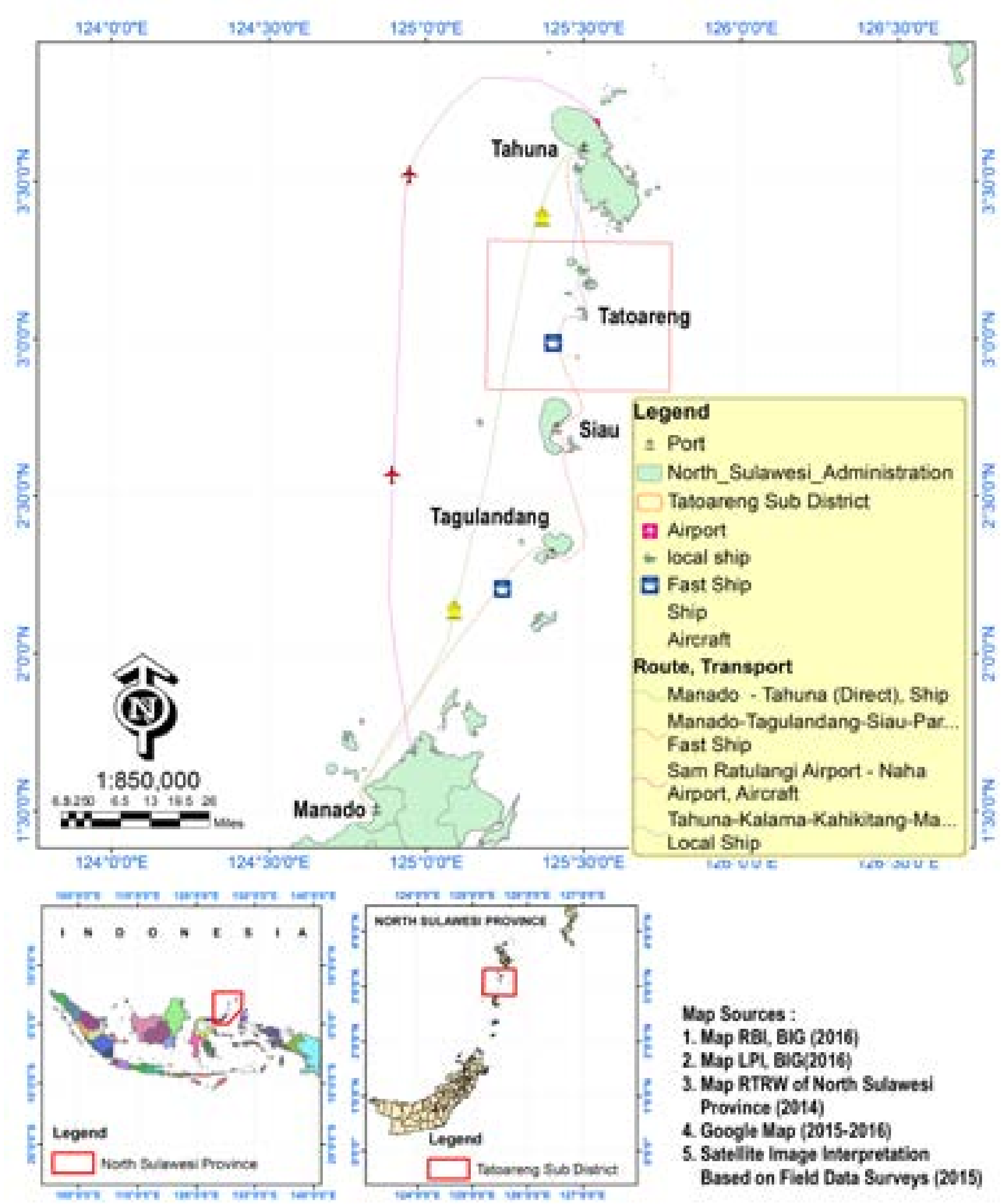
Based on these criteria, the status of the protected fish and necessarily protected fish in Tatoareng Subdistrict belongs to category number 2. However, the small islands in Tatoareng Subdistrict have high potentials for ecotourism due to their white sandy beaches. Residents of the coastal community claimed that turtles migrate in some locations, such as the northern part of Kalama Island and the eastern part of Para Island. Hunting and egg collections are the main threats to the turtle population. In Indonesia, all species of turtles are protected under Act No. 5, 1990 and are also included in Appendix I in CITES.

The maleo bird *(Macrocephalon maleo)* is found in the coastal area of eastern Para Island and it is an endemic species of Sulawesi islands. In the 1850s, Alfred Russell Wallace, an English naturalist, described Sulawesi coast as "black with the maleo" because young maleo birds were distributed everywhere. The population drastically decreased due to habitat destruction and rampant egg collection. The birds had disappeared in some areas in Sulawesi Island. Maleo birds are now listed as "endangered" species by the IUCN (International Union for the Conservation of Nature) and included in Appendix I in CITES. They are also entirely protected by Indonesian law. Hunting, capture, killing, or disturbance of the adults or their eggs may subject the violator to imprisonment up to five years and may be fined up to IDR 200 million (Act No. 5/1990).

4. Recreation and Tourism

The accessibility of Tatoareng Subdistrict is an important factor in promoting the development of tourism industry in the small islands. The transportation to reach the area is either by plane or by boat/ship. The flight from Manado to Tahuna is everyday, with 50 minutes air travel, and the ship schedule is on a daily basis with an overnight trip. The Tahuna express ship takes 4 hours and is scheduled every three days from Manado to Tagulandang via Para and Kahakitang while Para express ship is scheduled every two days from Tahuna to Kalama via Kahakitang (Fig. 28).

Figure 28. Accessibility map of Tatoareng Subdistrict's conservation reserve



The scores to describe the subdistrict's potentials for recreation and tourism are as follows: (1) highly potential (if it covers a minimum of two of point a/b/c)—3; (2) enough potential (if it has one of point a/b/c)—2 and no potential (if it has none of point a/b/c)—1.

Based on the category, the coastal area of Tatoareng has high potentials for recreation and tourism. The tourism industry in KSD has potentials in the coastal areas and small islands. The possible tourist destinations for both local and foreign visitors in Tatoareng Subdistrict are the Ship Wreck Tahuna, Banua Wuhu Island, Bukide rocks and the lost city of Maselihe Kendahe, and the underwater volcano in Mahengetang Island (Fig. 29).

Figure 29. Underwater volcano in Mahengetang Island

5. Diversity

The coastal resources in Tatoareng Subdistrict is classified as low due to overexploitation and illegal activities of the community. The low diversity of coastal resources is inversely proportional to the fishery abundance in the different islands. Coral reefs were damaged by illegal fishing methods, mangrove vegetation was patchy, but the status of seagrass beds was quite good. Lack of management interventions in these resources may result into a decline of fish stocks in the different islands.

6. Beauty/Aesthetics

The coastal areas of Tatoareng Subdistrict showed impressive natural beauty with clean white sandy beaches located in all islands. The broad white sandy beaches with clear seawater is ideal for swimming, snorkeling, and some coral reefs are good enough as dive sites.

7. Representativeness

This parameter was assessed by studying the ideal ecosystems/habitats in the region for conservation and protection. The formula used to assess the feasibility of the ecosystem/habitat for protected and conservation areas in the small islands was:

Pr = (EEc/EEs)*100%

Where:

Pr = representativeness (%)

EEc = number of ecosystem types in the area

EEs = ideal number of ecosystem types in the area (Biogeography)

Scoring for representativeness given are as follow:

Pr ≥ 75% = represented (3)

40 ≤ Pr < 75% = fairly represented (2);

Pr < 40% = not represented (1)

Based on the survey and data analysis, the level of representation of the coastal ecosystem in Tatoareng Subdistrict was fairly represented (2) with an average Pr of 42.86% (Table 20).

Table 20. Representativeness of the coastal ecosystem in Tatoareng Subdistrict

	Area of Tatoareng Subdistrict						
Ecosystem and Habitat	Kalama Is.	Mahenge-tang Is.	Kahaki-tang Is.	Para Is.	Nenung Is.	Sangga-luhang Is.	Total
Coral Reefs	1	1	1	1	1	1	6
Mangroves	1	0	1	1	0	0	3
Seagrass	1	1	1	1	1	1	6
Sandy beach	1	1	1	1	0	1	5
Muddy beach	0	0	1	1	0	0	2
Lagoon	0	0	1	1	0	0	2
Estuary	0	0	0	0	0	0	0
Representativeness 42.857143							

(Source: Villages Office 2015)

8. Community Support

The guidelines for the establishment of Marine Protected Area by the Ministry of Forestry in 1995 were used to determine the support of the community for the establishment of marine protected area and this was supported by proper information on the concept of marine protected areas. Results showed that all respondents in the study agreed to the establishment of conservation areas in Tatoareng Subdistrict (Table 21). The coastal resources will be protected and managed for the benefit of the fishermen and communities living in the different islands.

Table 21. Community support for KKP3K establishment in Tatoareng Subdistrict

Village	Number of Respondents	Agree	Disagree
Para	16	16	0
Para 1	38	38	0
Mahengetang	21	21	0
Kahakitang	28	28	0
Kalama	36	36	0
Dalako Bembanehe	32	32	0
Taleko Batusaiki	31	31	0
Total	202	202	0

9. Location Quotient (LQ)

The fishery commodities in the proposed locations should also have significant contribution to the Gross Regional Revenue of North Sulawesi Province. Location quotient (LQ) analysis was used to measure the role and the type of commodity in the area. It was also used to compare the roles played by the fisheries sector/industry in the district with the other sector/industry in the province. LQ >1 means the sector in the district has a higher role than the same sector in the province. It means that if the fishery production in KSD is higher than in the province, there is a possibility to export in other areas.

An analysis of the role of the fishery subsectors was carried out using the 2014/2015 data of the Statistic Office for North Sulawesi Province and KSD. The Gross Regional Revenue of North Sulawesi Province in 2015 from the fishery subsector using the prevalent price in 2014 was IDR. 4,637,540,000,000 or it contributed about 8.21% to the province while the Gross Regional Revenue of KSD in 2014 from the fishery sector was IDR 198,690,000,000 or about 4.83%. The comparison of the fisheries' role between the province and the district was LQ 1.09 or LQ >1. The result showed that North Sulawesi Province has the capacity to export fish products at the regional level.

10. Potential Conflict of Interest (Stakeholder Analysis)

The potential conflict could be traced from interviews with various respondents in relation with the area, the spatial planning and utilization, political factors, and the regional economic interests.

All respondents as well as residents of Tatoareng Subdistrict stressed that the conflict could be minimized if the community and fishermen would be involved in the management planning and implementation. Zoning plan must also be done to eliminate the conflict on habitat utilization. The Sanggaluhang Islands group has a conflict with the villages in PGI and Mahengetang Island on habitat utilization. Based on the interviews, capacity development and livelihood development will reduce the conflict in Tatoareng Subdistrict.

11. Potential Threat

There are several factors that affect the biodiversity of coastal and marine resources in Tatoareng Subdistrict, these are overexploitation, destructive fishing method, physical habitat degradation, pollution, climate change, and natural disasters. The biggest threat in this subdistrict is habitat degradation, especially in coral reef areas due to destructive pelagic fish fishing methods, climate change, natural disasters, marketing, and low awareness of the community about marine conservation.

The fishermen expected that they would still be allowed to catch pelagic and demersal fish after the establishment of marine protected areas in the small island of Tatoareng Subdistrict. The communities affected also expected that they would still be allowed to fish within the territories of Nenung and Sanggaluhang Islands.

The communities' lack of knowledge about marine conservation and protection pose a threat to the coastal resources. The fishermen's awareness of conservation programs is inadequate and needs to be supplemented by continuous information campaign and dialogues. The unpredictable weather condition also affects the living condition of the coastal communities in Tatoareng Subdistrict.

The impact of climate change to the livelihood activities in the different islands resulted in the loss of capital of farmers and fishermen including the middlemen. The effects of this climate change to fisheries production, livelihood development, health, education, and the economy is evident in the islands. Climate vulnerability assessment should be done to determine the different climate change problems so that the adaptation and strategies can be implemented to mitigate the impact of this phenomenon. Lack of community knowledge on the impact of climate change was observed in the islands. Information campaign should be done to disseminate the effect of climate change to the fisheries resources and to the economic condition of the communities.

12. Cultural Uniqueness

Cultural attractions are potential tourism magnets that need to be explored. There are two strong cultural traditions in Tatoareng Subdistrict, the Tulude and Masamper. Tulude is a ceremony of the indigenous heritage of "Nusa Utara" (Sangihe Islands, Talaud, and Sitaro) in the northern periphery of North Sulawesi Province. This sacred and religious event has been practiced for centuries by ethnical communities showing their colorful custom, traditions, and culture. The Masamper comes from the word "zangvereniging" (Dutch language), which means, the choral society. Some said that masamper came from the word "zang vrij" meaning, freely singing. This tradition is a part of Sangihe-Talaud ethnic's culture and it was introduced by the Zendings European Christian Missionaries. The song was used in the church and was adapted to the old traditions of "Nusa Utara" communities. Metunjuke is a singing activity where people sing while walking around and pointing to the other members.

VI. Delineation for Zoning Plan of the Marine Conservation Area

The fishermen expected that they would still be allowed to catch pelagic and demersal fishes after the establishment of marine protected areas in Kalama and Para Islands. The affected communities also expected that they would still be allowed to fish within the territories of the Nenung Group of Islands and the Sanggaluhang Group of Islands.

VII. The Marine Conservation Area

The government of Indonesia has several types of conservation areas (Table 22). In each region, the type of MPA appropriate for each area will be identified using predetermined methods involving the identification of the highest value obtained in recreation and tourism potentials, area utilization for cultural tourism, and uniqueness.

Table 22. Types of Marine Protected Areas in Indonesia

1.	(TNP)	Taman National Perairan	- Aquatic National Park
2.	(SP)	Suaka Peisir	- Coastal Sanctuary
3.	(SAP)	Suaka Alam Perairan	- Aquatic Nature Sanctuary
4.	(TPK)	Taman Pulau Kecil	- Small Island Park
5.	(TWP)	Taman Wisata Perairan	- Aquatic Tourism Park
6.	(SPK)	Suaka Pulau Kecil	- Small Island Sanctuary
7.	(SP)	Suaka Perikanan	- Fisheries Sanctuary
8.	(TP)	Taman Pesisir	- Coastal Park

Each type has a reference value

The proposed marine conservation area's name is Tatoareng Small Islands Park. The park would have a total area of 167,398 hectares. Following the table of conservation area type/category determination of the Directorate of Area and Fish Species Conservation, the Ministry of Marine Affair and Fisheries, it is apparent that the score obtained 3.09 in the CKKP3P type in Small Island Park (Table 23). The area is feasible for protection and conservation where management strategies will be applied.

Table 23. Parameters used to determine the MPA of Tatoareng Subdistrict

No.	Criteria	Assesment	TNP	TWP	SAP	SP	TP	TPK	SPs	SPK
1	Biodiversity	2	3	2	3	2	2	2	3	3
2	Naturalness	1	3	1	3	2	1	1	3	3
3	Representativeness	2	3	1	3	2	1	1	3	3
4	Uniqueness	2	3	2	3	3	2	2	2	2
5	Migratory path	2	2	2	3	3	2	2	3	3
6	Habitat of typical/ rare and Endemic fish	1	3	2	3	3	2	2	3	3
7	Protected fish	2	3	2	3	3	2	2	3	3
8	Necessarily protected fish	1	2	1	2	3	2	2	2	3
9	Recreation and tourism Potential	3	3	3	2	1	3	3	1	1
10	Facility of access to location	3	3	3	1	1	3	3	1	1
11	Tourism potential	3	2	3	2	1	3	3	3	1
12	Cultural uniqueness	2	3	3	2	2	3	3	2	2
13	Fish spawning ground	2	3	2	3	3	2	2	3	3
14	Nursery ground	2	2	2	3	3	2	2	3	3
15	Fisheries importance value	2	2	2	1	1	3	3	1	1
16	Strategic interest	No	No	No	No	No	No	No	No	No
17	Future areas coverage:									
	a. Terrestrial coastal areas	No	No	No	No	No	Yes	No	Yes	No
	b. Small islands	Yes	No	No	No	No	No	Yes	No	Yes

	Mandate of UU31	Mandate of UU27			
Score			3,128.57		698.43
MPA Recommendation			TPK		SPK

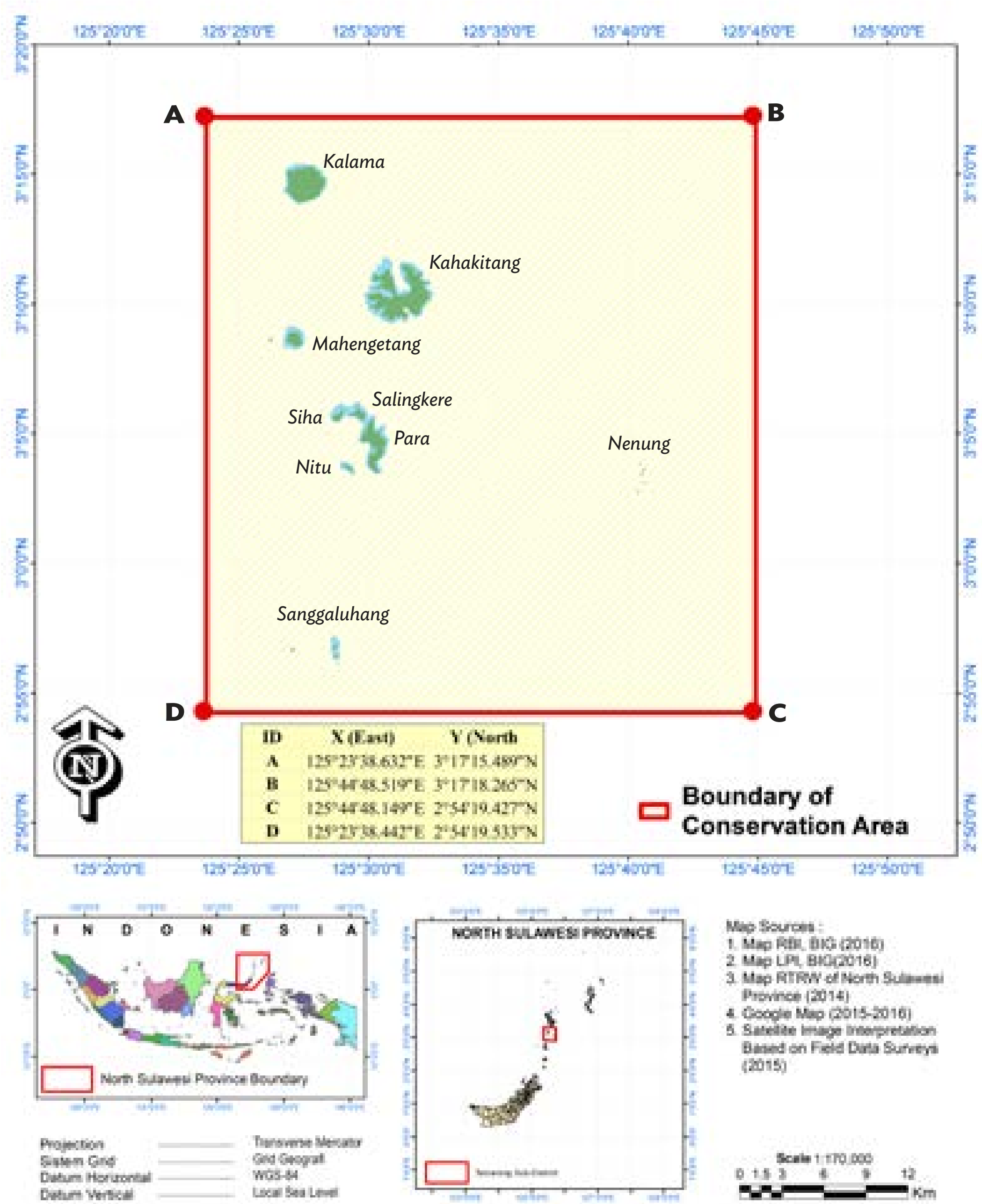
Note: Major Recommendation; Alternative Recommendation

* Only future manager is permitted to fill "assesment" column of black-blocked

VIII. Proposed MPA in Tatoareng Subdistrict

There are six core zones identified in the Aquatic Conservation Area of Tatoareng. Four core zones are located in Kahakitang, which has two, Kalama, and Mahengetang, and two core zones in Para and Nitu Islands (Fig. 30 and Appendix 28 to 33).

Figure 30. Proposed Map for Tatoareng's Small Islands Park



IX. Summary and Recommendations

The fringing reefs in Tatoareng Subdistrict are in a generally poor to fair coral condition. The more recent perturbations have further stressed these reefs. In spite of this, hard corals remain diverse and thriving although the wide-scale impact of destructive fishing has left its mark on the reefs. But the strong commitment of the government of Tatoareng Subdistrict and its coastal communities is a positive step in the conservation and recovery of this resource. Reef fish status in this area on the other hand, is generally high in terms of species richness and abundance relative to the other sites.

The establishment of MPAs and marine reserves, in all its variation, is seen as a cost-effective management strategy in high biodiversity areas through habitat preservation, conservation, and protection of important species (White et al. 2006). The establishment of MPAs, specifically of "No-Take Areas," is also an effective strategy in managing coastal fisheries (Roberts and Polunin 1993 in White et al. 2006).

Based on the field study, criteria analysis, and potential analysis, it is concluded that the small islands park is a suitable type of marine conservation area for Tatoareng Subdistrict with its total area of 167,398 hectares. Based on the data obtained in the seven islands, six potential sites for protection and conservation were identified. These include mangrove-protected and marine-protected areas in Kahakitang, Kalama, and Mahengetang Islands and two MPA in Para Island.

There are several recommendations for the establishment of the Tatoareng Small Islands Park. First, it would be best if the MPAs to be established would encompass not only coral reefs but other coastal marine habitats such as mangroves and seagrass beds. Second, sites to be protected should have fair to good coral condition and have considerable and robust stands of branching corals. Lastly, reef areas close to the buffer zone boundaries of the established marine protected area should be kept open for traditional fishing. It is in these areas where the benefits of protection (i.e., spillover) could be felt by local fishermen.

All the recommendations above should be followed by good will of relevant stakeholders through several actions. One of the best options for faster recovery of both coral and reef fish is to strengthen the participation of local people in partnership with the government, national agencies (e.g., Ministry of Marine Affairs and Fisheries), and non-government organizations to improve enforcement and management of Tatoareng's coastal waters. The conservation effort could be integrated into the management planning with the participation of the community.

The communities in Tatoareng Subdistrict fully supported the establishment of MPAs, but their awareness of coastal resource management and climate change is very minimal and should be augmented by capacity building and information dissemination. The economy of the villages depends mainly on fishing. But fishing activities are not always favorable throughout the year and during lean seasons, some fishermen seek employment as laborers.

The increase in the number of fishermen in the islands resulted in low fish catch. Some fishermen were forced to use illegal fishing methods to increase their catch, but these methods destroyed the coastal resources resulting in scarcity of fishes and other marine products. This can be remedied by identifying other means of livelihood and developing these to provide additional source of income and reduce the fishermen's dependency on marine resources.

Women empowerment is one strategy to uplift the economic condition of the different islands. Women should be trained on other sources of livelihood because they also have a significant role in the development and protection of natural resources.

Appendices

Appendix 1: Location of manta tow survey in Tatoareng Subdistrict

No.	X	Y	Location	HC (%)	DC (%)	SC (%)	OT (%)	Note
0	125.4459	3.2404	Kalama					Start
1	125.4465	3.2437	Kalama	25	50	20	5	Coral branching
2	125.4470	3.2493	Kalama	55	20	15	10	Coral branching
3	125.4533	3.2545	Kalama	30	50	15	5	3m-10m dominant CM
4	125.4605	3.2564	Kalama	20	50	20	10	3m- 10m broken
5	125.4632	3.2561	Kalama	15	60	15	10	
6	125.4687	3.2522	Kalama	15	50	25	10	
7	125.4722	3.2475	Kalama	10	55	20	15	CM
8	125.4672	3.2350	Kalama	20	20	50	10	
9	125.4573	3.2314	Kalama	15	55	20	10	CM, ASM
10	125.4491	3.2344	Kalama	10	60	20	10	ACB, ACT small
0	125.5385	3.1813	Kahakitang					Start
1	125.5339	3.1830	Kahakitang	40	40	10	10	Dominant CM
2	125.5353	3.1858	Kahakitang	20	30	30	20	Growth depth
3	125.5305	3.1902	Kahakitang	20	45	15	20	Only in 12 m
4	125.5269	3.1925	Kahakitang	15	55	20	10	
5	125.5243	3.1934	Kahakitang	25	40	30	5	
6	125.5219	3.1934	Kahakitang	10	60	20	10	Front of white sand
7	125.5206	3.1906	Kahakitang	5	80	10	5	Totally damaged
8	125.5226	3.1874	Kahakitang	30	30	30	10	
9	125.5215	3.1848	Kahakitang	40	30	20	10	CF dominant
10	125.5255	3.1797	Kahakitang	25	45	20	10	Sufficiently high
11	125.5264	3.1754	Kahakitang	15	50	20	15	Turbid
12	125.5182	3.1741	Kahakitang	15	45	25	15	
13	125.5169	3.1793	Kahakitang	15	50	25	10	
14	125.5159	3.1844	Kahakitang	30	30	30	10	Front of the village,
15	125.5147	3.1894	Kahakitang	30	35	25	10	mean %.
16	125.5128	3.1943	Kahakitang	15	25	30	30	
17	125.5096	3.1915	Kahakitang	15	15	50	20	
18	125.5056	3.1911	Kahakitang	20	15	50	20	*Acanthaster plancii*
19	125.5032	3.1871	Kahakitang	15	50	20	15	
20	125.5016	3.1808	Kahakitang	15	35	30	20	

Appendix 1: Location of manta tow survey in Tatoareng Subdistrict *(continued)*

No.	X	Y	Location	HC (%)	DC (%)	SC (%)	OT (%)	Note
21	125.5044	3.1788	Kahakitang	10	50	25	15	
22	125.5014	3.1751	Kahakitang	30	40	15	15	
23	125.5077	3.1757	Kahakitang	25	15	50	10	High turbidity
24	125.5076	3.1744	Kahakitang	10	50	30	10	
25	125.5023	3.1735	Kahakitang	15	45	25	15	ACB
26	125.4983	3.1715	Kahakitang	30	40	20	10	CM
27	125.5015	3.1676	Kahakitang	25	50	15	10	
28	125.5010	3.1625	Kahakitang	15	50	20	15	
29	125.5035	3.1586	Kahakitang	20	40	30	10	CM, ACB,
30	125.5079	3.1619	Kahakitang	10	45	25	20	
31	125.5099	3.1570	Kahakitang	15	45	25	15	
32	125.5152	3.1539	Kahakitang	10	40	25	25	Coral rubble
33	125.5183	3.1574	Kahakitang	15	40	30	15	Coral rubble
34	125.5246	3.1562	Kahakitang	25	45	15	15	CM
35	125.5258	3.1599	Kahakitang	25	45	20	10	
36	125.5309	3.1580	Kahakitang	15	50	15	20	Coral rubble
37	125.5341	3.1591	Kahakitang	30	50	15	5	
38	125.5361	3.1654	Kahakitang	30	45	20	5	
39	125.5397	3.1691	Kahakitang	30	40	25	5	CB
40	125.5414	3.1730	Kahakitang	25	45	20	10	
41	125.5359	3.1779	Kahakitang	30	50	15	5	ACB, CB 12 m
0	125.4449	3.1419	Mahengetang					Start
1	125.4464	3.1459	Mahengetang	60	5	15	20	Coral foliouse (CF)
2	125.4475	3.1511	Mahengetang	40	30	20	10	Coral foliouse (CF)
3	125.4547	3.1501	Mahengetang	30	45	15	10	CM
4	125.4588	3.1446	Mahengetang	25	50	10	15	ACM
5	125.4526	3.1395	Mahengetang	20	40	20	20	*Cheilinus undulatus*
6	125.4483	3.1389	Mahengetang	30	30	30	10	ACB, CSM
0	125.4760	3.0936	Siha and North Salingkere					Start
1	125.4786	3.0986	Siha and North Salingkere	10	55	25	10	SC, CR
2	125.4829	3.1020	Siha and North Salingkere	10	40	30	20	Coral rubble

Appendix 1: Location of manta tow survey in Tatoareng Subdistrict *(continued)*

No.	X	Y	Location	HC (%)	DC (%)	SC (%)	OT (%)	Note
3	125.4851	3.0990	Siha and North Salingkere	10	50	15	25	Small ACT
4	125.4858	3.0983	Siha and North Salingkere	15	60	10	15	Bolbometopon
5	125.4902	3.0995	Siha and North Salingkere	20	45	20	15	
6	125.4935	3.1029	Siha and North Salingkere	25	40	20	15	SC
7	125.4983	3.0977	Siha and North Salingkere	20	45	20	15	
0	125.4988	3.0912	Siha and North Salingkere					Start
1	125.4935	3.0927	Siha and North Salingkere	40	20	30	10	Massive coral
2	125.4865	3.0943	Siha and North Salingkere	40	30	20	10	Napoleon fish
3	125.4814	3.0907	Siha and North Salingkere	10	5	50	35	Spiny star
0	125.4938	3.0779	Para					Start
1	125.4961	3.0840	Para	15	45	30	10	CR, ACT small
2	125.5021	3.0941	Para	30	30	20	20	
3	125.5039	3.0953	Para	25	45	10	20	
4	125.5085	3.0877	Para	15	40	30	15	CR, ACT small
5	125.5119	3.0805	Para	35	30	10	25	*Acanthaster plancii*
6	125.5117	3.0713	Para	30	25	20	25	
7	125.5091	3.0584	Para	30	30	15	25	CM, ACB
8	125.5046	3.0570	Para	30	20	20	30	CM large
9	125.4990	3.0634	Para	20	45	20	15	Bolbometopon
10	125.4996	3.0709	Para	10	60	20	15	CR, ACT small
0	125.4822	3.0634	Nitu					Start
1	125.4856	3.0640	Nitu	25	40	25	10	CM, R
2	125.4879	3.0629	Nitu	20	50	20	10	
3	125.4908	3.0589	Nitu	10	50	15	25	CR, CM
4	125.4895	3.0568	Nitu	10	55	25	10	CR, CM
5	125.4824	3.0604	Nitu	5	5	30	60	CR

Appendix 2: Location of line intercept transect (LIT) and fish visual census in Tatoareng Subdistrict

No.	X	Y	Island	Location	Note
1	125.451.358	3.254.403	Kalama	Mangrove (Lindongan 4)	Survey 1
2	125.456.819	3.253.908	Kalama	White sand	Survey 1
3	125.470.217	3.248.761	Kalama	Cape	Survey 1
4	125.464.144	3.255.232	Kalama	Cape after nest (Lindongan 5)	Survey 1
5	125.446.830	3.245.080	Kalama	Apenglawo Lindongan 3,4,5	Survey 1
6	125.450.825	3.232.919	Kalama	Soa lindongan 1,2	Survey 1
7	125.466.133	3.234.531	Kalama	White sand Soa (South)	Survey 1
8	125.461.103	3.254.986	Kalama	North Kalama (front of the village)	Survey 2
9	125.460.215	3.232.017	Kalama	South (white sand)	Survey 2
10	125.471.423	3.240.012	Kalama	East	Survey 2
11	125.533.942	3.182.985	Kahakitang	Coast before tower	Survey 1
12	125.523.247	3.193.204	Kahakitang	Right Cape	Survey 1
13	125.521.583	3.184.944	Kahakitang	Front of Bembanehe (Mangrove)	Survey 1
14	125.515.850	3.185.160	Kahakitang	Bembanehe (Village)	Survey 1
15	125.500.103	3.173.417	Kahakitang	Taleko Cape	Survey 1
16	125.522.338	3.175.887	Kahakitang	Middle Bay	Survey 1
17	125.509.864	3.157.136	Kahakitang	South	Survey 1
18	125.508.391	3.190.567	Kahakitang	North (Left)	Survey 2
19	125.539.433	3.170.204	Kahakitang	East (Cape)	Survey 2
20	125.525.785	3.159.676	Kahakitang	South (Village)	Survey 2
21	125.502.581	3.161.987	Kahakitang	West 2	Survey 2
22	125.442.957	3.147.458	Mahengetang	Volcano	Survey 1
23	125.446.688	3.146.452	Mahengetang	Ngihade Coast	Survey 1
24	125.454.072	3.151.033	Mahengetang	Enematiang (Pasir Bunting)	Survey 1
25	125.449.050	3.139.206	Mahengetang	South Mahengetang (front of village)	Survey 1
26	125.446.480	3.150.286	Mahengetang	North 2	Survey 2
27	125.459.793	3.146.574	Mahengetang	East	Survey 2
28	125.499.539	3.068.961	Para	Para village (Damaged)	Survey 1
29	125.506.617	3.058.328	Para	South	Survey 1
30	125.511.617	3.081.003	Para	East Cape	Survey 1
31	125.501.586	3.093.106	Para	Strait (good)	Survey 1
32	125.495.897	3.085.274	Para	Para 1	Survey 2
33	125.493.636	3.078.314	Para	Cape Para	Survey 2

Appendix 2: Location of line intercept transect (LIT) and fish visual census in Tatoareng Subdistrict *(continued)*

No.	X	Y	Island	Location	Note
34	125.506.307	3.086.285	Para	North 2 of Para 1	Survey 2
35	125.510.292	3.069.391	Para	East 2 of Para	Survey 2
36	125.483.403	3.064.508	Nitu	West	Survey 1
37	125.487.625	3.063.125	Nitu	North white sand	Survey 1
38	125.486.615	3.059.840	Nitu	South	Survey 1
39	125.482.572	3.061.539	Nitu	West 2	Survey 2
40	125.490.900	3.059.932	Nitu	East	Survey 2
41	125.493.442	3.092.412	Salingkere	South white sand	Survey 1
42	125.497.837	3.096.840	Salingkere	North boulder of white sand	Survey 1
43	125.489.778	3.099.880	Salingkere	Stone Cape – white sand – village	Survey 1
44	125.494.404	3.101.426	Salingkere	North of Tanjung 2	Survey 2
45	125.488.237	3.093.831	Salingkere	South 2	Survey 2
46	125.498.859	3.094.002	Salingkere	East	Survey 2
47	125.481.495	3.099.898	Siha	North Siha	Survey 1
48	125.478.985	3.098.571	Siha	North Siha 2	Survey 2
49	125.483.611	3.092.975	Siha	South	Survey 2
50	125.476.358	3.092.004	Siha	West 2	Survey 2

Appendix 3: Status of coral reefs in Kalama Island

Sites	Depth	Number of Species	Number of Individuals	Hard Coral Cover (%)	H' = Shannon Diversity Index	E = Similarity Index	D = Dominance Index (Simpson's)	Hmax = Diversity Maximum
Site 1	3m	12	18	34.040	0.962	0.387	0.154	1.079
	10m	14	29	9.000	1.044	0.396	0.111	1.146
Site 2	3m	12	26	31.400	0.924	0.372	0.163	1.079
	10m	5	12	6.500	0.536	0.333	0.389	0.699
Site 3	3m	10	21	21.000	0.893	0.388	0.156	1.000
	10m	4	11	23.800	0.549	0.396	0.306	0.602
Site 4	3m	14	26	9.680	1.183	0.448	0.115	1.146
	10m	12	18	34.240	0.962	0.387	0.154	1.079
Site 5	3m	14	29	9.700	1.044	0.396	0.111	1.146
	10m	12	33	67.320	0.818	0.329	0.264	1.079
Site 6	3m	12	26	37.600	0.924	0.372	0.163	1.079
	10m	14	29	16.500	1.145	0.434	0.127	1.146
Site 7	3m	9	16	25.480	0.865	0.394	0.164	0.954
	10m	12	24	26.640	0.979	0.394	0.128	1.079
Site 8	3m	11	20	27.680	0.924	0.386	0.155	1.041
	10m	5	11	28.080	0.614	0.382	0.289	0.699
Site 9	3m	13	25	31.300	1.082	0.422	0.123	1.114
	10m	12	25	14.840	0.951	0.383	0.142	1.079
Site 10	3m	15	32	31.800	1.291	0.477	0.092	1.176
	10m	11	18	24.060	0.929	0.387	0.160	1.041

Appendix 4: Status of coral reefs in Kahakitang Island

Sites	Depth	Number of Species	Number of Individuals	Hard Coral Cover (%)	H' = Shannon Diversity Index	E = Similarity Index	D = Dominance Index (Simpson's)	Hmax = Diversity Maximum
Site 11	3m	11	20	40.96	0.924	0.386	0.155	1.041
	10m	20	52	52.92	1.176	0.393	0.085	1.301
Site 12	3m	13	22	31.60	1.021	0.398	0.124	1.114
	10m	12	25	14.84	0.951	0.383	0.142	1.079
Site 13	3m	15	32	46.88	1.500	0.554	0.092	1.176
	10m	11	18	51.88	0.929	0.387	0.160	1.041
Site 14	3m	6	8	47.80	0.724	0.404	0.219	0.778
	10m	20	52	41.80	1.176	0.393	0.085	1.301
Site 15	3m	11	36	66.56	1.082	0.451	0.279	1.041
	10m	2	12	70.80	0.125	0.180	0.847	0.301
Site 16	3m	5	17	14.00	0.637	0.396	0.253	0.699
	10m	14	29	21.40	1.044	0.396	0.111	1.146
Site 17	3m	5	17	23.04	0.637	0.396	0.253	0.699
	10m	14	29	38.36	1.044	0.396	0.111	1.146
Site 18	3m	17	24	21.56	1.664	0.587	0.066	1.230
	10m	8	16	30.24	0.828	0.398	0.172	0.903
Site 19	3m	13	18	24.72	1.119	0.436	0.123	1.114
	10m	9	17	43.98	0.836	0.381	0.190	0.954
Site 20	3m	14	29	14.80	1.176	0.446	0.111	1.146
	10m	14	29	9.90	1.176	0.446	0.111	1.146
Site 21	3m	11	31	41.00	0.805	0.336	0.226	1.041
	10m	2	8	46.56	0.164	0.236	0.781	0.301

Appendix 5: Status of coral reefs in Mahengetang Island

Sites	Depth	Number of Species	Number of Individuals	Hard Coral Cover (%)	H' = Shannon Diversity Index	E = Similarity Index	D = Dominance Index (Simpson's)	Hmax = Diversity Maximum
Site 22	3m	21	28	23.36	1.297	0.426	0.054	1.322
	10m	8	16	40.40	0.828	0.398	0.172	0.903
Site 23	3m	13	18	31.98	1.028	0.401	0.123	1.114
	10m	11	19	88.56	0.926	0.386	0.158	1.041
Site 24	3m	9	11	10.90	1.477	0.672	0.124	0.954
	10m	6	7	9.90	0.916	0.511	0.184	0.778
Site 25	3m	12	26	30.60	1.531	0.616	0.163	1.079
	10m	9	13	28.96	1.329	0.605	0.160	0.954
Site 26	3m	8	8	17.20	1.344	0.646	0.125	0.903
	10m	5	13	53.44	0.625	0.388	0.266	0.699
Site 27	3m	9	11	19.36	1.477	0.672	0.124	0.954
	10m	12	18	33.28	1.646	0.662	0.154	1.079

Appendix 6: Status of coral reefs in Para Island

Sites	Depth	Number of Species	Number of Individuals	Hard Coral Cover (%)	H' = Shannon Diversity Index	E = Similarity Index	D = Dominance Index (Simpson's)	Hmax = Diversity Maximum
Site 28	3m	14	30	11.70	1.181	0.448	0.107	1.146
	10m	14	32	10.56	1.238	0.469	0.105	1.146
Site 29	3m	10	35	57.68	0.709	0.308	0.295	1.000
	10m	5	12	63.20	0.477	0.297	0.472	0.699
Site 30	3m	11	11	22.56	1.041	0.434	0.091	1.041
	10m	11	20	26.56	0.924	0.386	0.155	1.041
Site 31	3m	13	17	29.16	1.148	0.447	0.107	1.114
	10m	11	19	55.52	0.926	0.386	0.158	1.041
Site 32	3m	13	19	8.30	1.133	0.442	0.108	1.114
	10m	8	8	36.20	0.903	0.434	0.125	0.903
Site 33	3m	6	7	36.88	0.759	0.424	0.184	0.778
	10m	11	18	38.28	0.929	0.387	0.160	1.041

Appendix 6: Status of coral reefs in Para Island *(continued)*

Sites	Depth	Number of Species	Number of Individuals	Hard Coral Cover (%)	H' = Shannon Diversity Index	E = Similarity Index	D = Dominance Index (Simpson's)	Hmax = Diversity Maximum
Site 34	3m	13	32	17.30	1.078	0.420	0.113	1.114
	10m	14	29	21.40	1.176	0.446	0.111	1.146
Site 35	3m	8	10	31.20	0.880	0.423	0.140	0.903
	10m	6	7	17.60	0.759	0.424	0.184	0.778

Appendix 7: Status of coral reefs in Nitu Island

Sites	Depth	Number of Species	Number of Individuals	Hard Coral Cover (%)	H' = Shannon Diversity Index	E = Similarity Index	D = Dominance Index (Simpson's)	Hmax = Diversity Maximum
Site 36	3m	11	18	51.88	0.929	0.387	0.160	1.041
	10m	11	17	37.48	0.920	0.384	0.170	1.041
Site 37	3m	14	28	7.10	1.156	0.438	0.125	1.146
	10m	7	7	23.36	0.845	0.434	0.143	0.845
Site 38	3m	9	9	21.04	0.954	0.434	0.111	0.954
	10m	9	18	23.83	0.837	0.381	0.185	0.954
Site 39	3m	11	18	38.20	0.929	0.387	0.160	1.041
	10m	10	15	34.64	0.865	0.376	0.200	1.000
Site 40	3m	14	28	11.92	1.156	0.438	0.125	1.146
	10m	10	12	33.16	0.979	0.425	0.111	1.000

Appendix 8: Status of coral reefs in Salingkere Island

Sites	Depth	Number of Species	Number of Individuals	Hard Coral Cover (%)	H' = Shannon Diversity Index	E = Similarity Index	D = Dominance Index (Simpson's)	Hmax = Diversity Maximum
Site 41	3m	9	11	32.00	0.932	0.424	0.124	0.954
	10m	6	7	17.30	0.759	0.424	0.184	0.778
Site 42	3m	12	26	31.40	0.924	0.372	0.163	1.079
	10m	9	13	28.96	0.882	0.402	0.160	0.954
Site 43	3m	8	8	17.20	0.903	0.434	0.125	0.903
	10m	5	13	17.19	0.625	0.388	0.266	0.699
Site 44	3m	6	21	19.00	0.727	0.406	0.202	0.778
	10m	14	29	26.30	1.176	0.446	0.111	1.146
Site 45	3m	9	9	21.04	0.954	0.434	0.111	0.954
	10m	9	18	36.13	0.837	0.381	0.185	0.954
Site 46	3m	6	7	17.30	0.759	0.424	0.184	0.778
	10m	9	11	32.00	0.932	0.424	0.124	0.954

Appendix 9: Status of coral reefs in Siha Island

Sites	Depth	Number of Species	Number of Individuals	Hard Coral Cover (%)	H' = Shannon Diversity Index	E = Similarity Index	D = Dominance Index (Simpson's)	Hmax = Diversity Maximum
Site 47	3m	10	18	21.60	0.820	0.356	0.235	1.000
	10m	8	12	25.76	0.860	0.413	0.153	0.903
Site 48	3m	12	26	31.40	0.924	0.372	0.163	1.079
	10m	9	13	25.96	0.882	0.402	0.160	0.954
Site 49	3m	8	9	29.60	0.887	0.427	0.136	0.903
	10m	9	19	27.60	0.817	0.372	0.202	0.954
Site 50	3m	10	12	20.56	0.979	0.425	0.111	1.000
	10m	12	18	26.08	0.962	0.387	0.154	1.079

Appendix 10: Status of reef fishes in Kalama Island

Sites	Depth	Number of Species	Number of Individuals	H' = Shannon Diversity Index	E = Similarity Index	D = Dominance Index (Simpson's)
Site 1	3m	108	895	3.959	0.846	0.038
	10m	103	781	3.927	0.847	0.034
Site 2	3m	89	694	3.835	0.854	0.034
	10m	121	923	4.087	0.852	0.032
Site 3	3m	98	806	3.834	0.836	0.038
	10m	99	754	3.792	0.825	0.046
Site 4	3m	120	965	4.033	0.842	0.039
	10m	101	629	3.885	0.842	0.042
Site 5	3m	73	359	3.792	0.884	0.036
	10m	141	1278	4.184	0.845	0.037
Site 6	3m	111	790	3.910	0.830	0.040
	10m	91	516	3.893	0.863	0.034
Site 7	3m	71	297	3.859	0.905	0.030
	10m	102	686	4.029	0.871	0.030
Site 8	3m	101	646	4.167	0.903	0.023
	10m	96	552	3.955	0.866	0,036
Site 9	3m	78	462	3.998	0.918	0.024
	10m	105	670	4.065	0.873	0.032
Site 10	3m	98	568	4.060	0.885	0.027
	10m	102	677	3.897	0.843	0.037

Appendix 11: Status of reef fishes in Salingkere Island

Sites	Depth	Number of Species	Number of Individuals	H' = Shannon Diversity Index	E = Similarity Index	D = Dominance Index (Simpson's)
Site 1	3m	101	593	3.973	0.861	0.043
	10m	102	613	3.714	0.803	0.073
Site 2	3m	87	614	3.914	0.876	0.032
	10m	107	821	3.969	0.849	0.039
Site 3	3m	84	596	3.996	0.902	0.026
	10m	112	962	3.834	0.813	0.049
Site 4	3m	88	481	4.028	0.900	0.027
	10m	102	674	3.882	0.839	0.044
Site 5	3m	83	472	4.011	0.908	0.024
	10m	96	569	4.082	0.894	0.025

Appendix 12: Status of reef fishes in Kahakitang Island

Sites	Depth	Number of Species	Number of Individuals	H' = Shannon Diversity Index	E = Similarity Index	D = Dominance Index (Simpson's)
Site 1	3m	109	895	3.960	0.844	0.037
	10m	124	973	4.019	0.834	0.033
Site 2	3m	84	734	3.688	0.832	0.046
	10m	71	504	3.646	0.855	0.042
Site 3	3m	69	397	3.799	0.897	0.029
	10m	92	703	3.786	0.837	0.043
Site 4	3m	109	687	4.124	0.879	0.029
	10m	97	729	3.865	0.845	0.038
Site 5	3m	97	485	4.187	0.915	0.019
	10m	100	760	3.832	0.832	0.046
Site 6	3m	78	418	3.878	0.890	0.033
	10m	75	434	3.880	0.899	0.030
Site 7	3m	96	524	4.144	0.908	0.022
	10m	108	915	3.760	0.803	0.053
Site 8	3m	111	918	4.068	0.864	0.035
	10m	123	985	4.035	0.838	0.041

Appendix 12: Status of reef fishes in Kahakitang Island *(continued)*

Sites	Depth	Number of Species	Number of Individuals	H' = Shannon Diversity Index	E = Similarity Index	D = Dominance Index (Simpson's)
Site 9	3m	96	659	4.049	0.887	0.026
	10m	99	699	3.959	0.861	0.034
Site 10	3m	88	522	4.089	0.913	0.024
	10m	96	682	3.897	0.854	0.040
Site 11	3m	91	540	4.005	0.888	0.030
	10m	103	723	3.918	0.845	0.037

Appendix 13: Status of reef fishes in Mahengetang Island

Sites	Depth	Number of Species	Number of Individuals	H' = Shannon Diversity Index	E = Similarity Index	D = Dominance Index (Simpson's)
Site 1	3m	71	733	2.820	0.661	0.146
	10m	125	843	4.067	0.842	0.038
Site 2	3m	101	851	3.797	0.823	0.047
	10m	117	1187	3.804	0.799	0.053
Site 3	3m	95	612	4.029	0.885	0.027
	10m	81	633	3.577	0.814	0.053
Site 4	3m	88	640	3.945	0.881	0.029
	10m	125	1133	4.021	0.833	0.038
Site 5	3m	97	608	4.030	0.881	0.026
	10m	106	868	3.912	0.839	0.038
Site 6	3m	86	521	3.914	0.879	0.031
	10m	103	712	3.968	0.856	0.034

Appendix 14: Status of reef fishes in Para Island

Sites	Depth	Number of Species	Number of Individuals	Shannon Diversity Index	Similarity Index	Dominance Index (Simpson's)
Site 1	3m	85	573	3.834	0.863	0.039
	10m	57	392	3.145	0.778	0.101
Site 2	3m	88	571	3.919	0.875	0.030
	10m	125	1188	3.952	0.818	0.035
Site 3	3m	97	583	4.086	0.893	0.024
	10m	97	848	3.956	0.865	0.031
Site 4	3m	94	851	3.564	0.784	0.075
	10m	142	1491	3.914	0.790	0.047
Site 5	3m	82	456	3.914	0.888	0.034
	10m	58	441	2.992	0.737	0.134
Site 6	3m	91	477	4.021	0.892	0.030
	10m	98	725	3.914	0.854	0.032
Site 7	3m	106	649	3.993	0.856	0.034
	10m	99	847	3.924	0.854	0.033
Site 8	3m	90	691	3.774	0.839	0.049
	10m	113	918	3.881	0.821	0.046

Appendix 15: Status of reef fishes in Siha Island

Sites	Depth	Number of Species	Number of Individuals	Shannon Diversity Index	Similarity Index	Dominance Index (Simpson's)
Site 1	3m	97	757	3.732	0.816	0.056
	10m	100	824	3.991	0.867	0.028
Site 2	3m	85	552	3.761	0.846	0.050
	10m	92	667	3.702	0.819	0.055
Site 3	3m	91	499	4.047	0.897	0.028
	10m	94	582	3.607	0.794	0.080
Site 4	3m	84	461	4.036	0.911	0.025
	10m	103	740	3.920	0.846	0.039

Appendix 16: Status of reef fishes in Nitu Island

Sites	Depth	Number of Species	Number of Individuals	Shannon Diversity Index	Similarity Index	Dominance Index (Simpson's)
Site 1	3m	91	619	3.926	0.870	0.033
	10m	81	754	3.460	0.787	0.063
Site 2	3m	66	256	3.819	0.912	0.031
	10m	107	670	4.151	0.888	0.025
Site 3	3m	84	618	3.728	0.841	0.046
	10m	104	961	3.632	0.782	0.066
Site 4	3m	91	593	3.880	0,860	0.038
	10m	87	766	3.731	0.835	0.049
Site 5	3m	94	651	3.919	0.863	0.031
	10m	112	981	3.910	0.829	0.042

Appendix 17: The mangrove ecosystem in Tatoareng Subdistrict


Mangrove in Kahakitang Island


Mangrove in Kalama Island


Mangrove in Para Island

Appendix 18: Seagrass species recorded in Tatoareng Subdistrict


Enhalus acoroides


Thalassia hemprichii


Cymodocea rotundata


Cymodocea serrulata


Syringodium isoetifolium


Halodule uninervis


Halophila ovalis

Appendix 19: Algae species recorded in Tatoareng Subdistrict


Halimeda macroloba

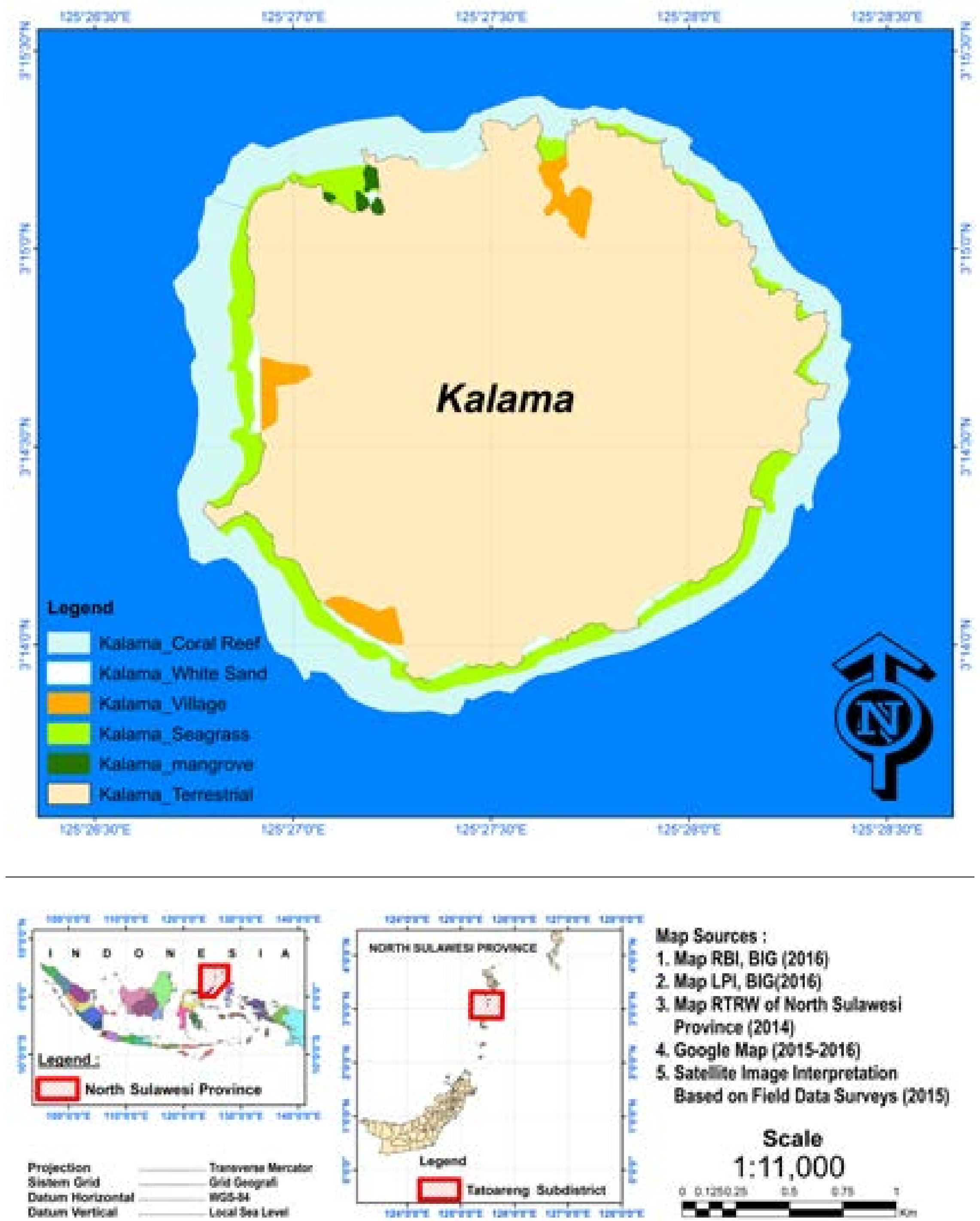

Halimeda opuntia


Udotea orientalis

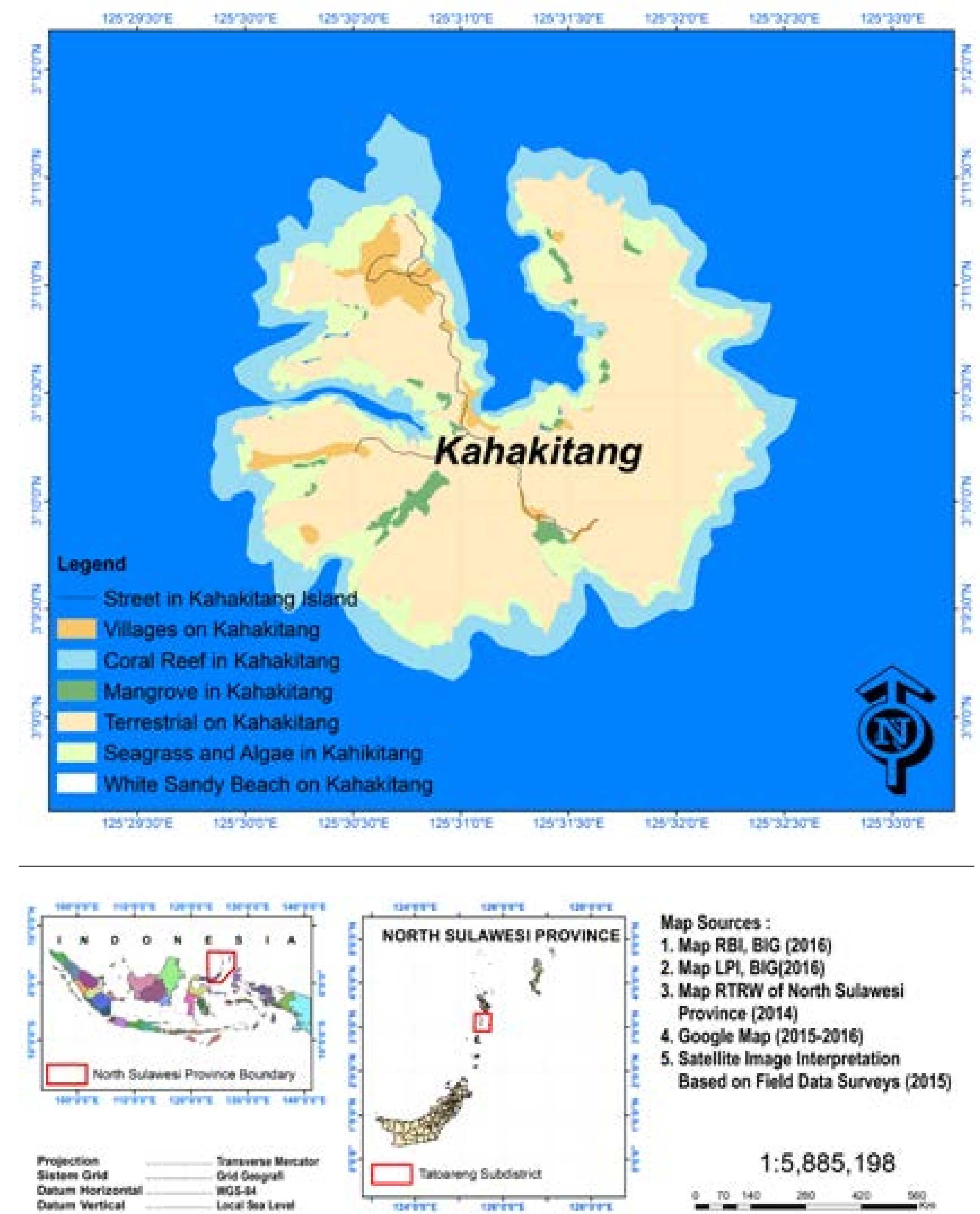

Sargassum polycystum


Gracilaria edulis

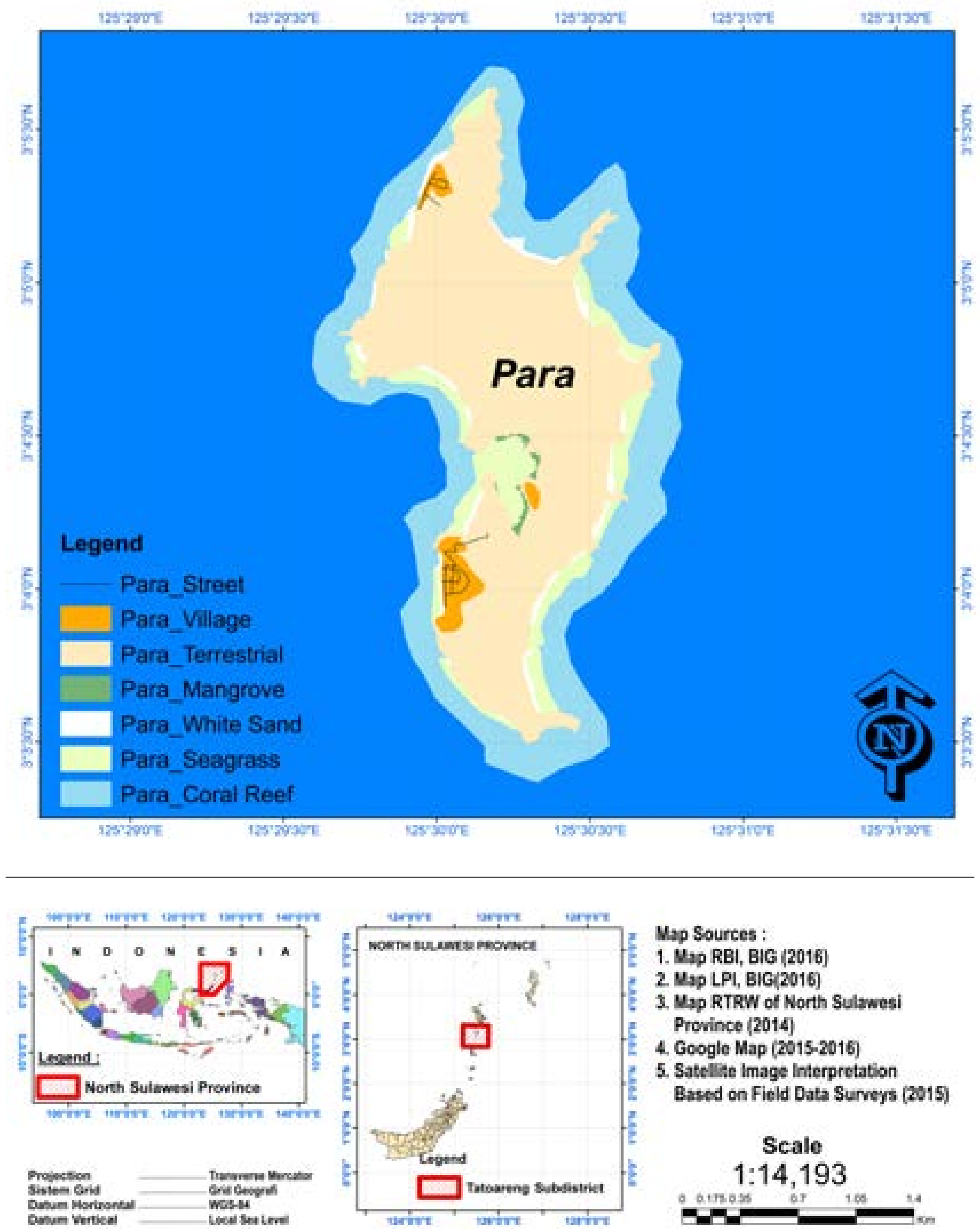
Appendix 20: Map of mangrove, seagrass, and algae distribution in Kalama Island



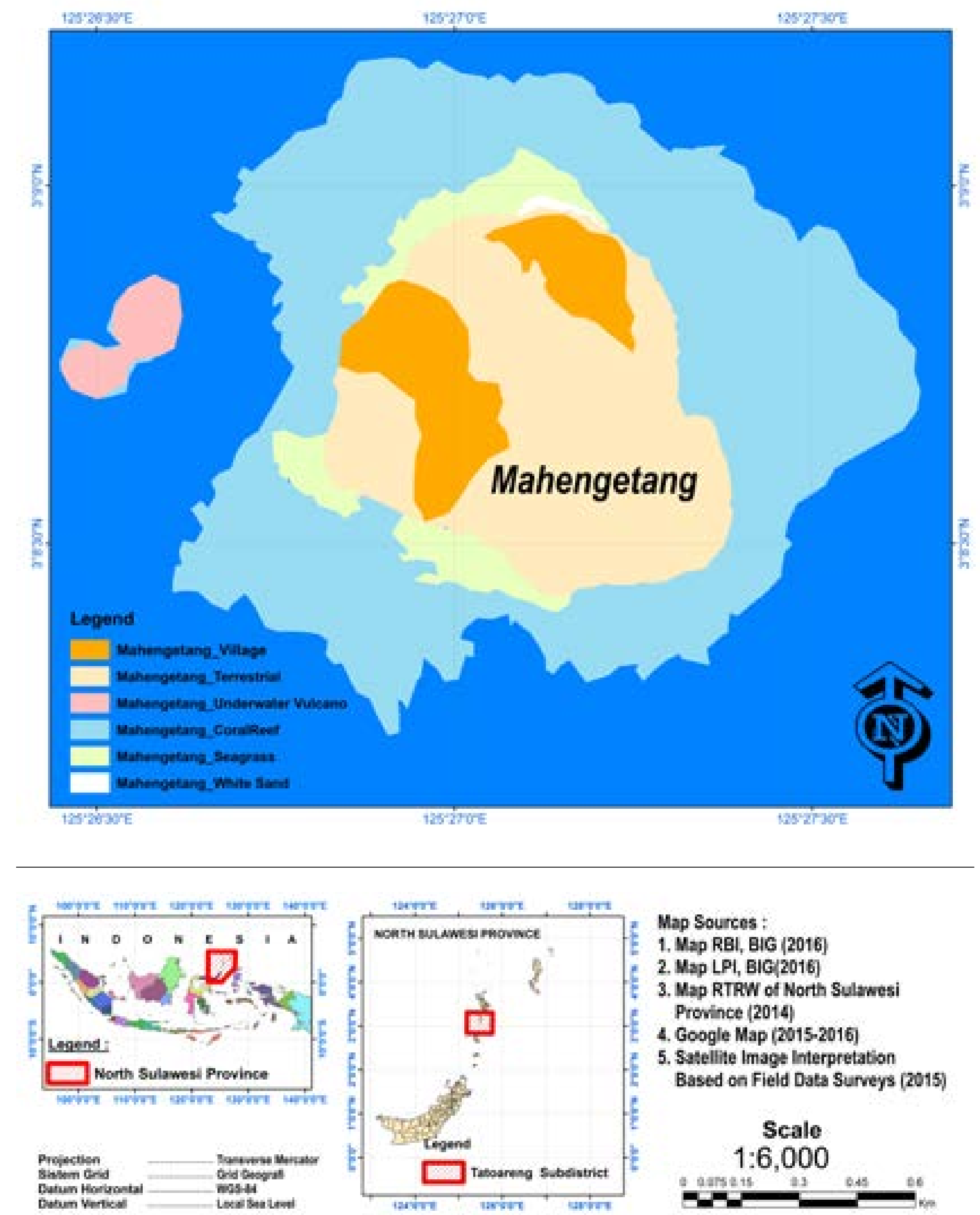
Appendix 21: Map of mangrove, seagrass, and algae distribution in Kahakitang Island



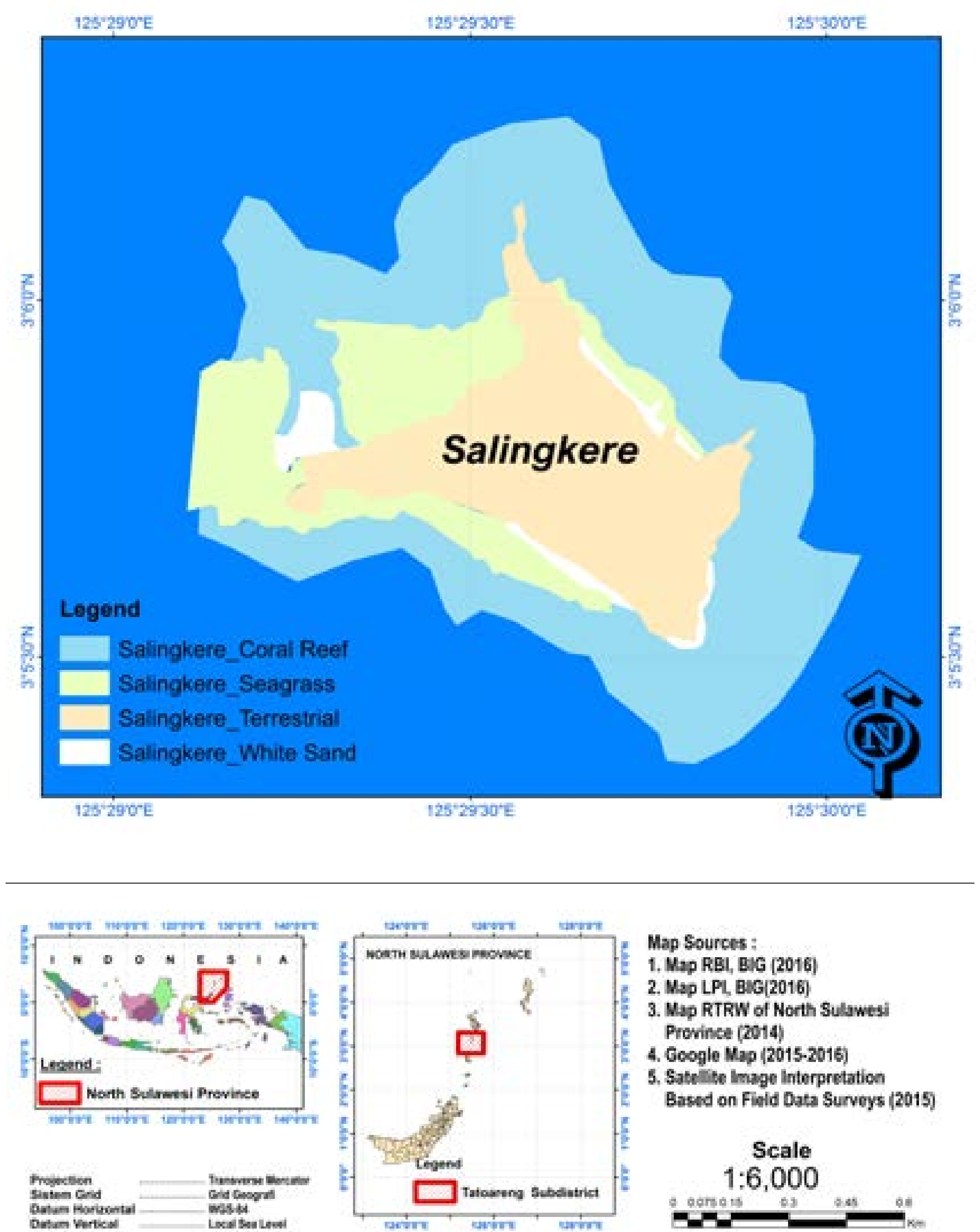
Appendix 22: Map of mangrove, seagrass, and algae distribution in Para Island



Appendix 23: Map of mangrove, seagrass, and algae distribution in Mahengetang Island

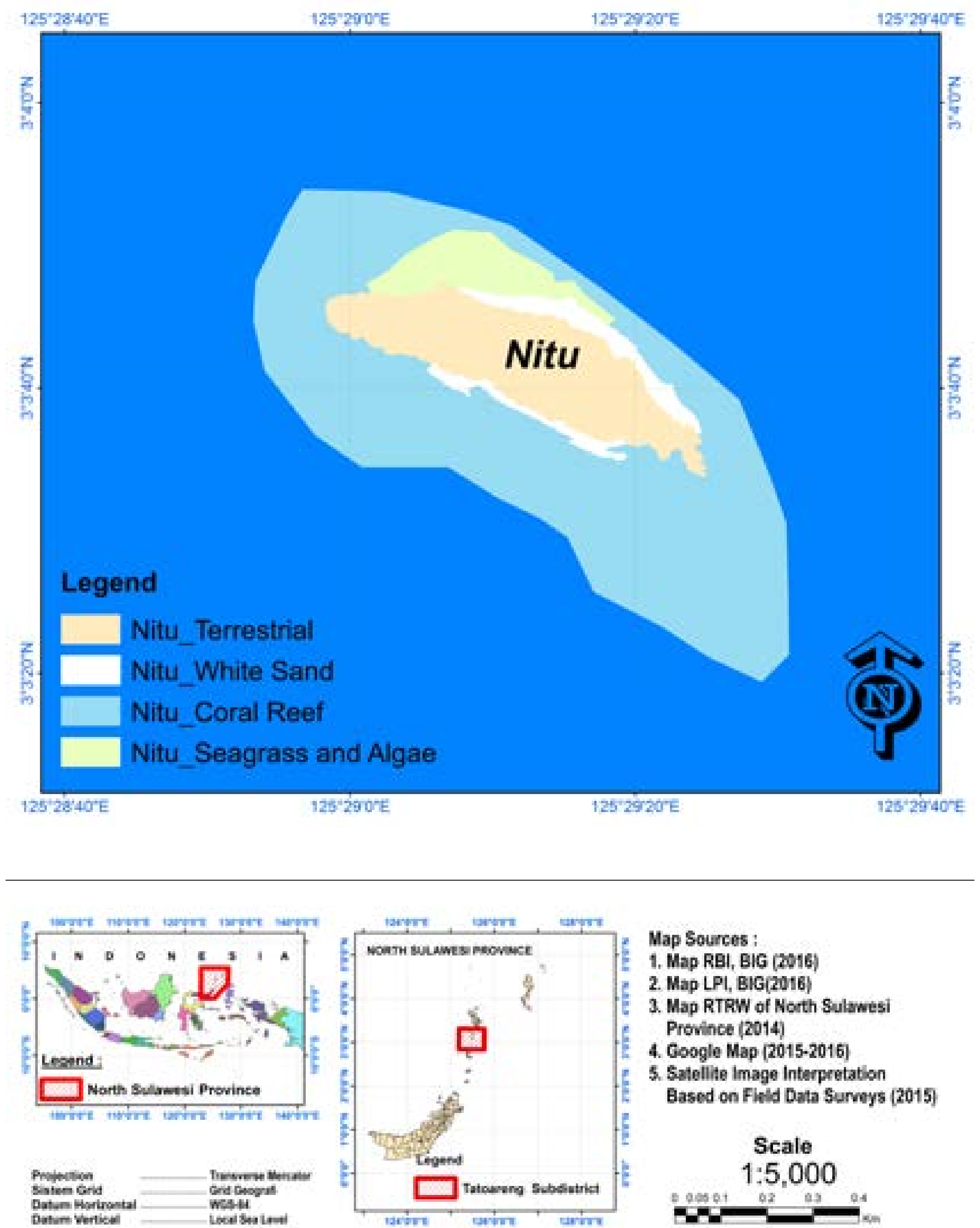


Appendix 24: Map of mangrove, seagrass, and algae distribution in Salingkere Island

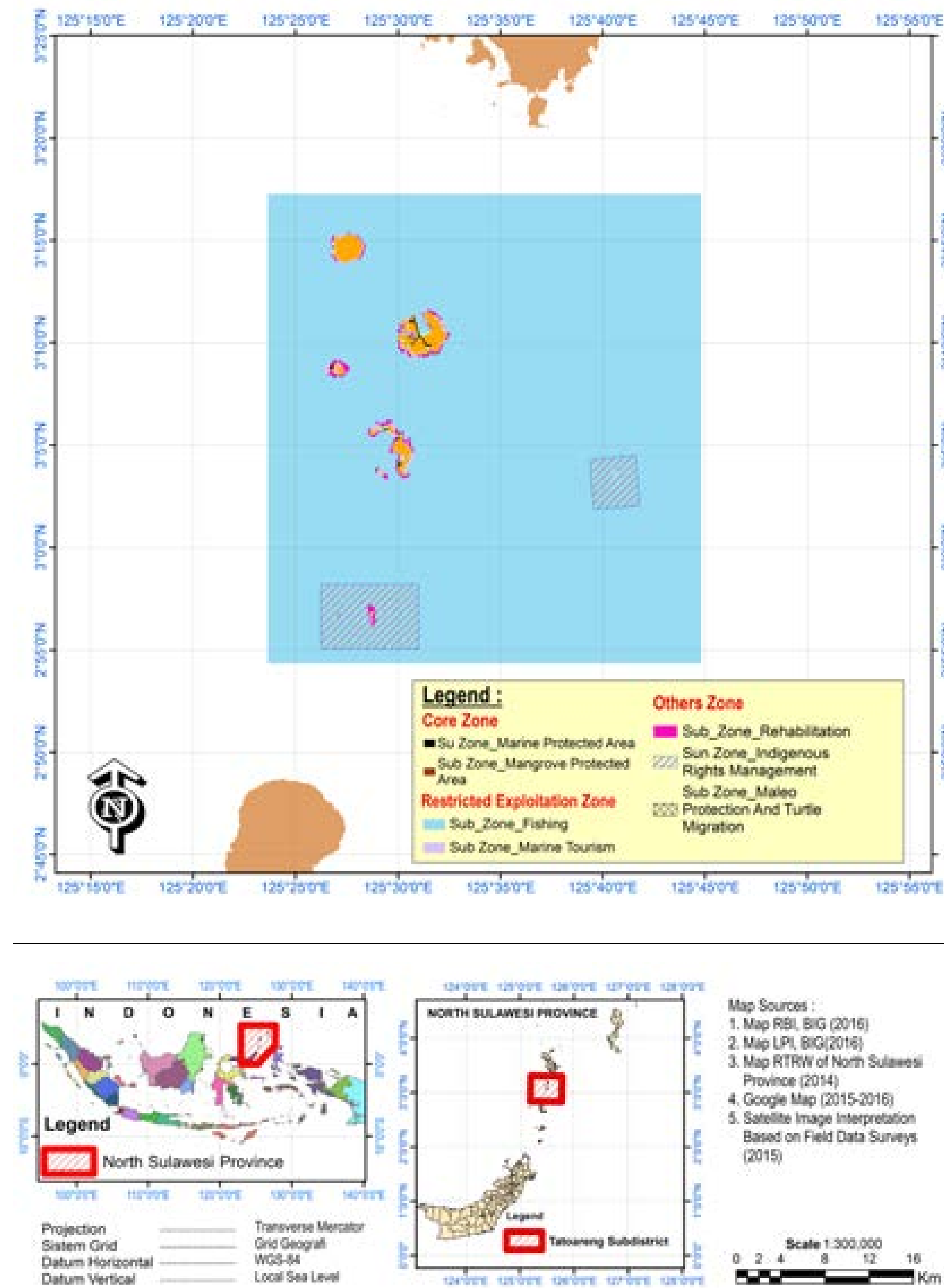


Appendix 25: Map of mangrove, seagrass, and algae distribution in Siha Island

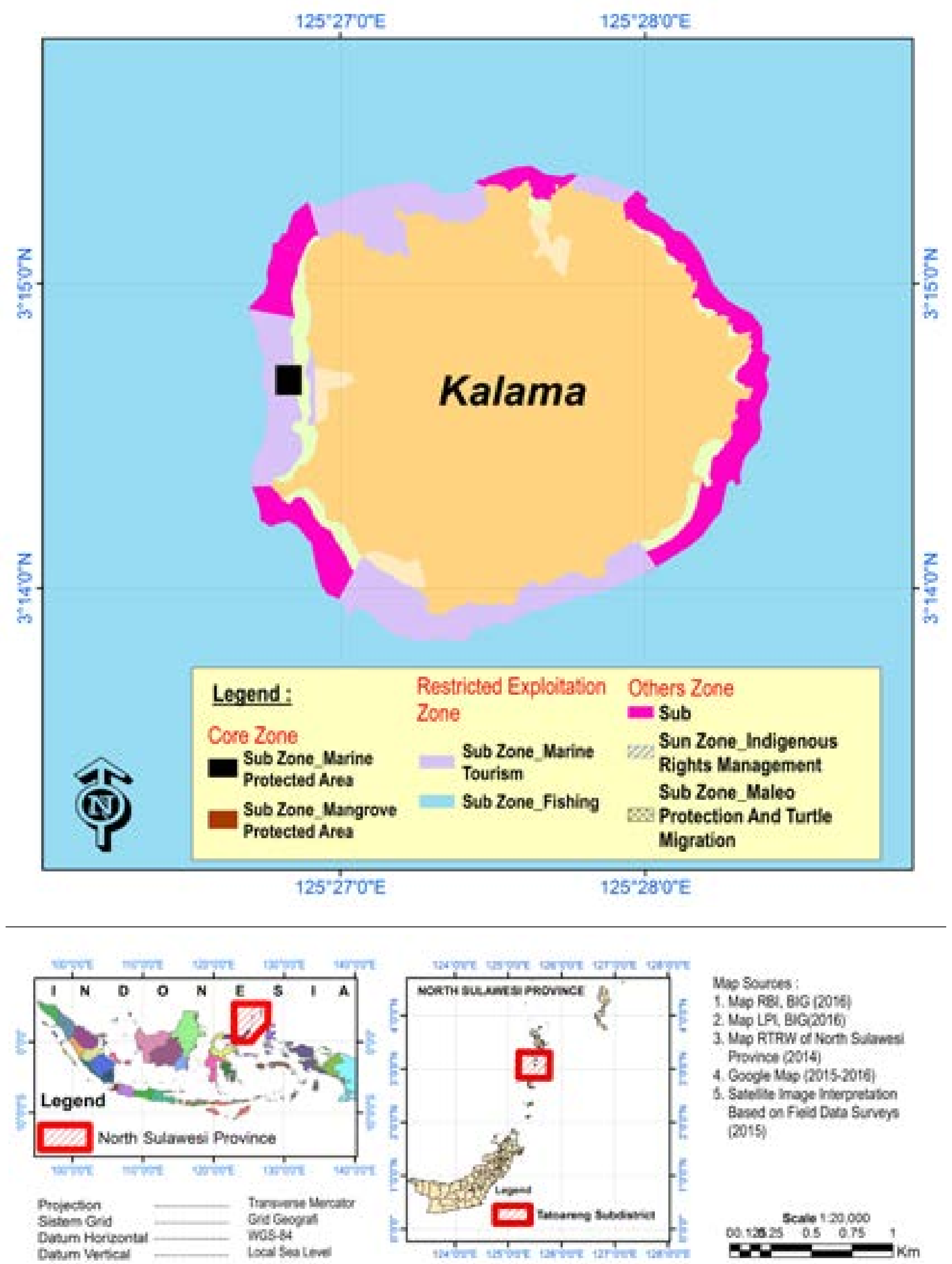
Appendix 26: Map of mangrove, seagrass, and algae distribution in Nitu Island



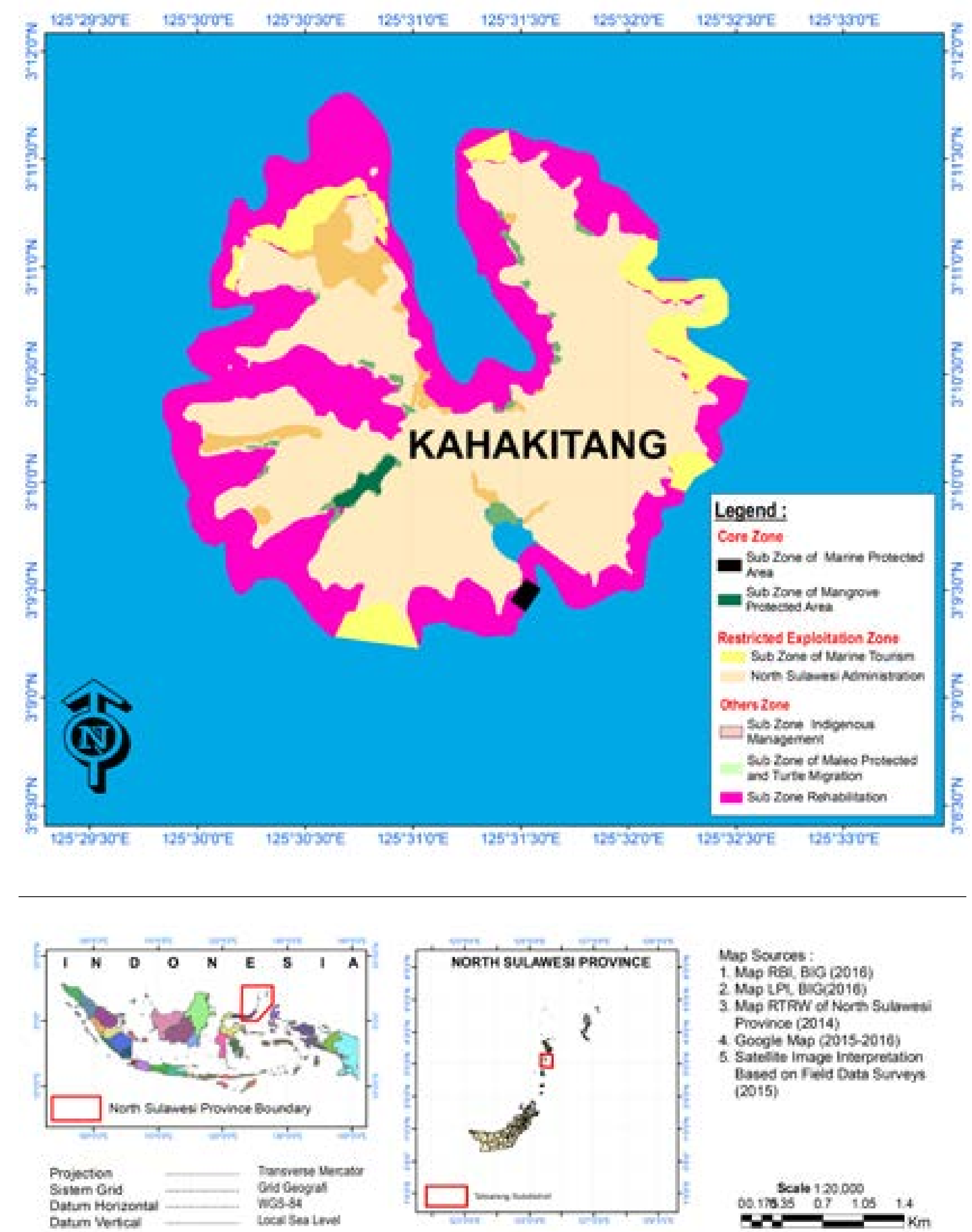
Appendix 27: Zoning plan of Tatoareng small island park



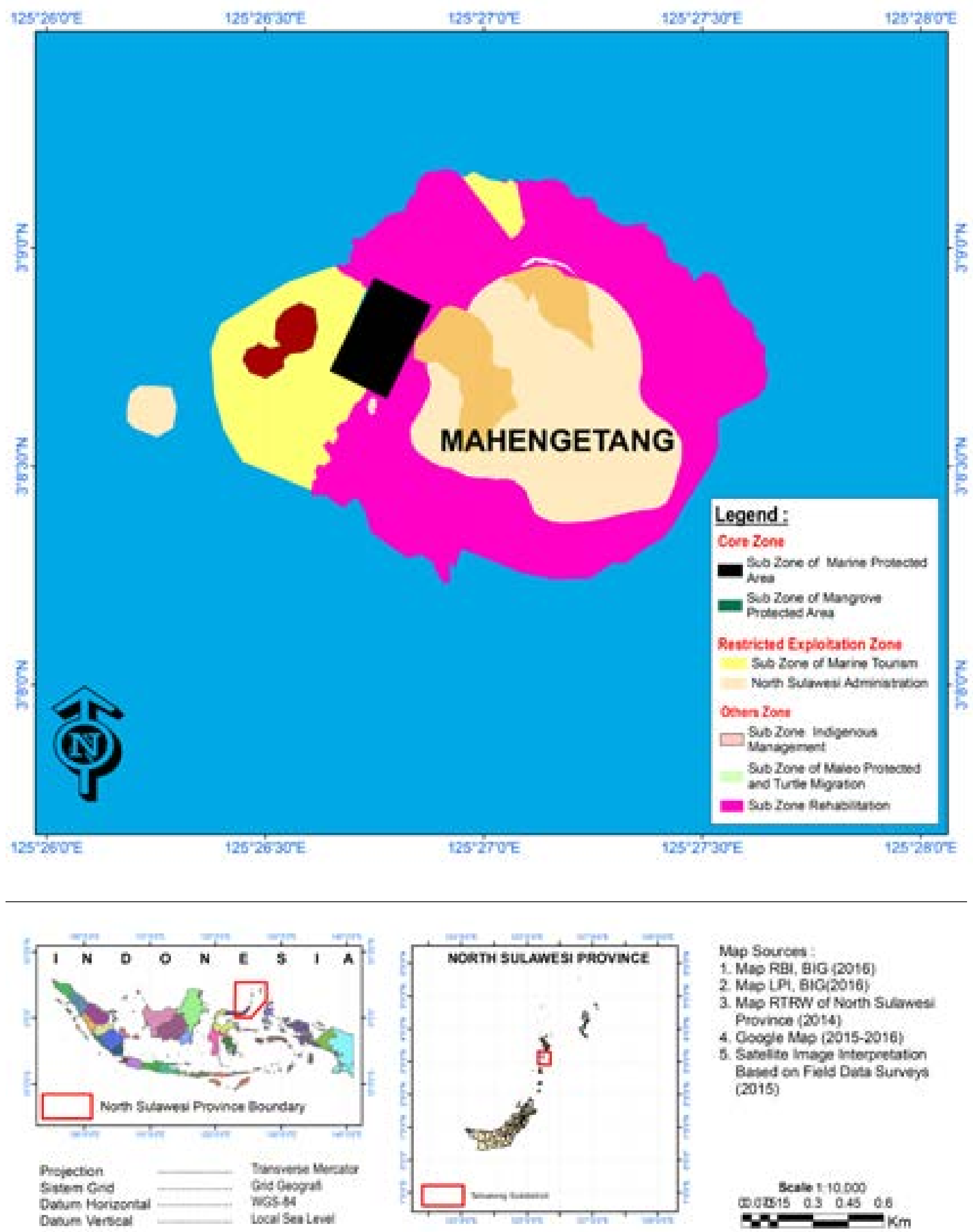
Appendix 28: Zoning plan of small island park in Kalama Island



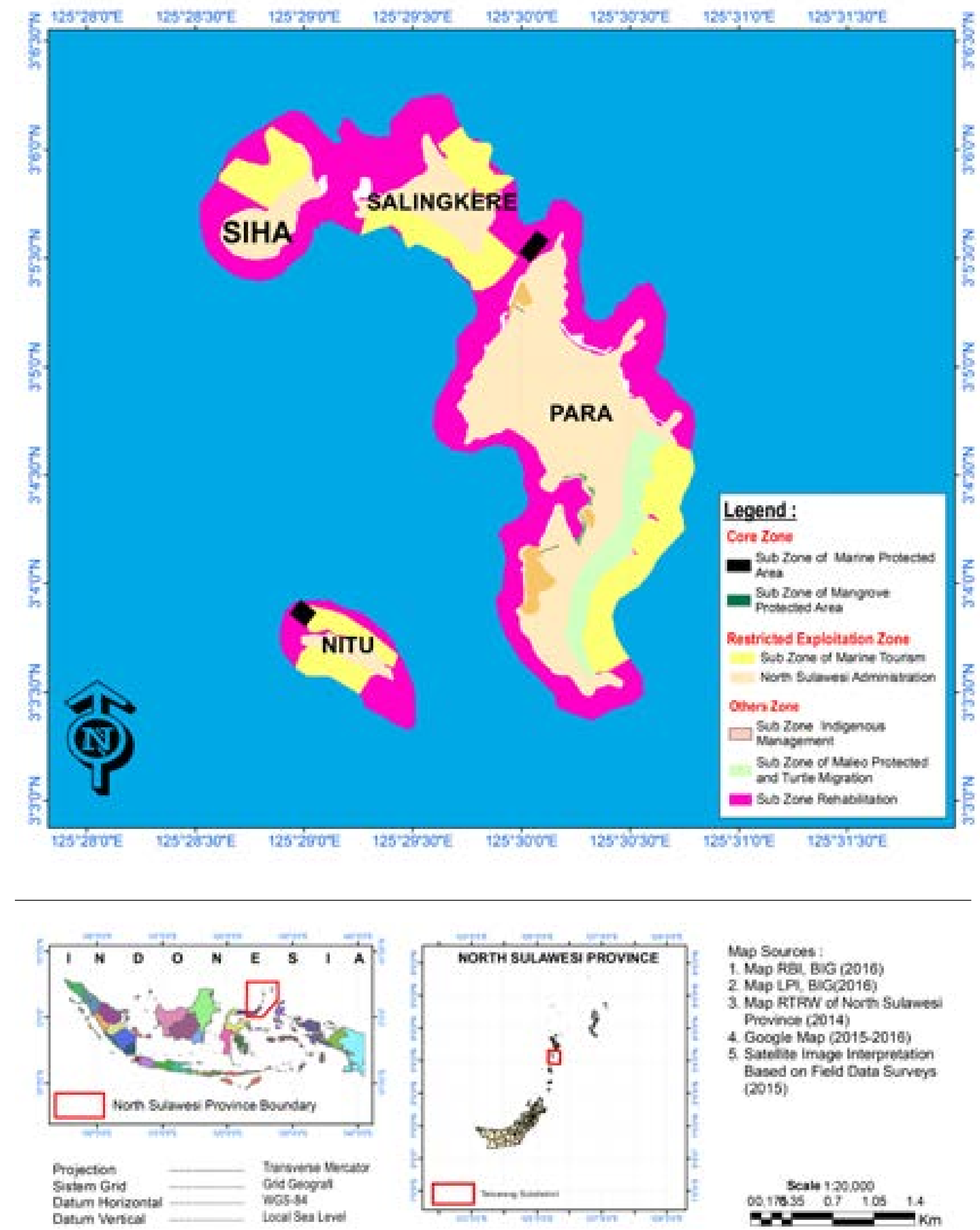
Appendix 29: Zoning plan of small island park in Kahakitang Island



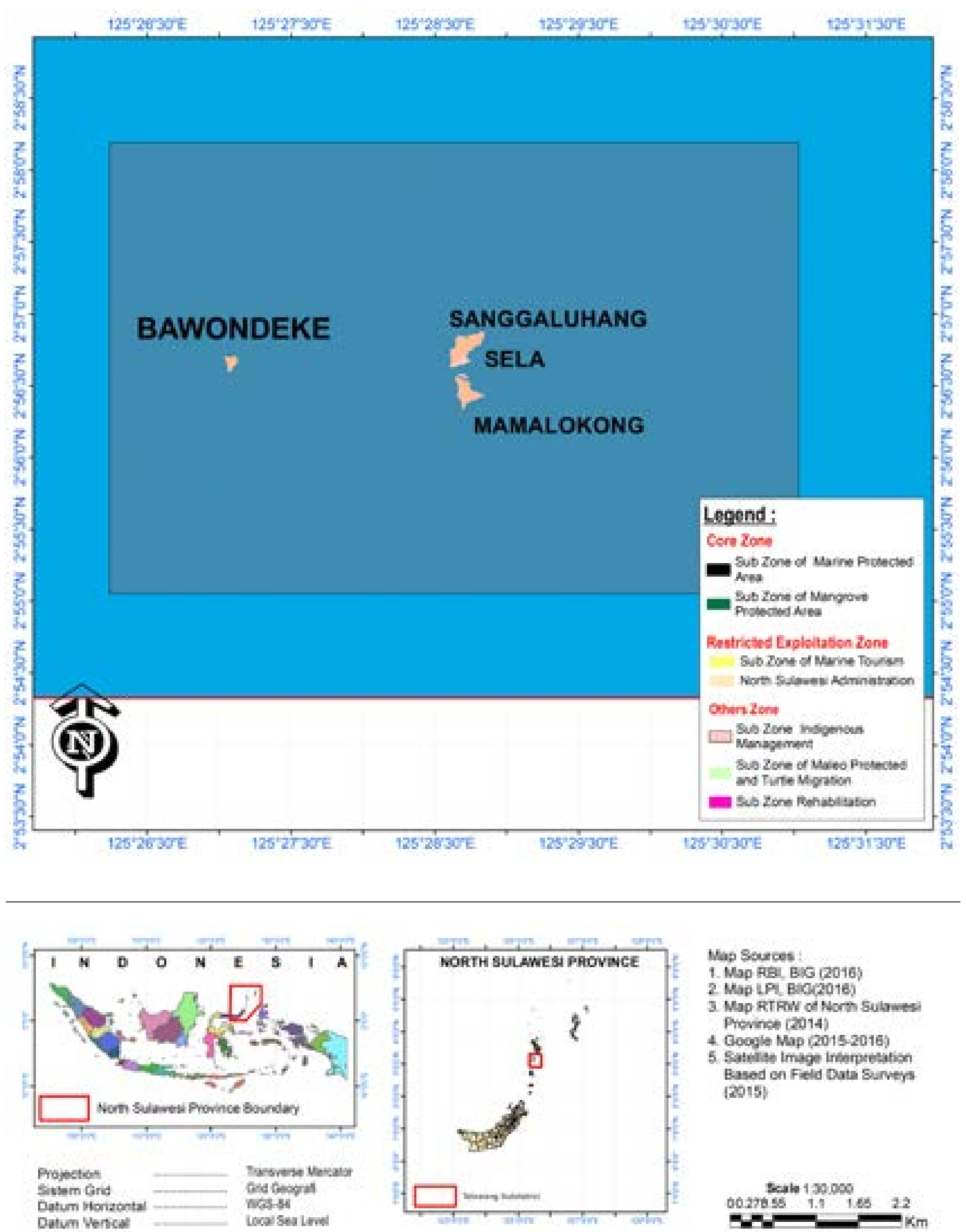
Appendix 30: Zoning plan of small island park in Mahengetang Island



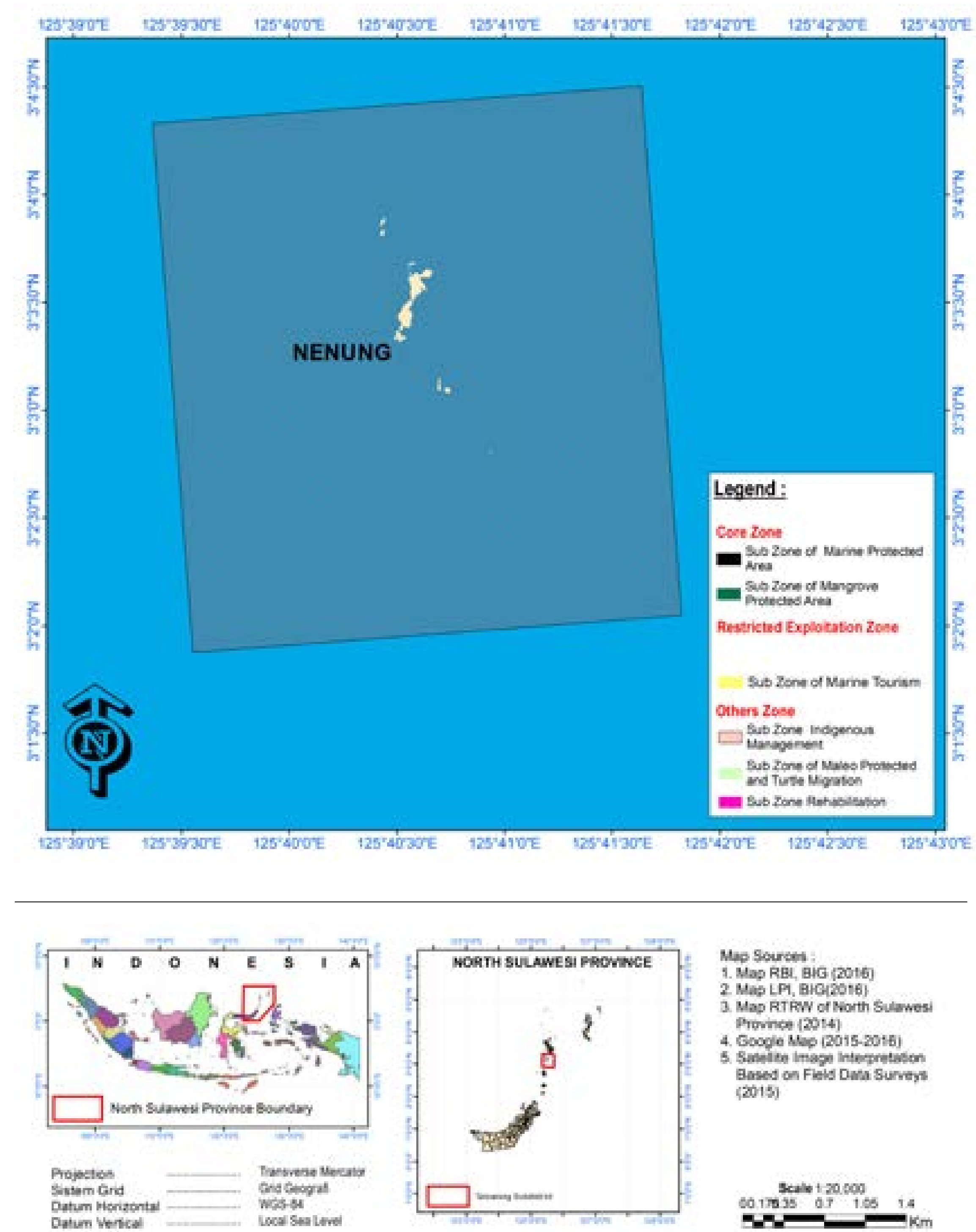
Appendix 31: Zoning plan of small island park in Para, Salingkere, Siha, and Nitu Islands



Appendix 32: Zoning plan of small island park in Sanggaluhang, Sela, Mamalokong, and Bawondeke Islands



Appendix 33: Zoning plan of small island park in Nenung Islands



Appendix 34: Questionnaire used to determine the community profile of Tatoareng Subdistrict

Village : ....

Subdistrict : Tatoareng

Kota/Kab. : Sangihe Islands District

Fishermen's Household

a) Respondent's name : ....

b) Age : ....

c) Education : .... (graduated / not graduated)

d) Occupation : ....

e) Status : married / unmarried

d) Family's dependent : .... person

Social Aspect

a) Ethnic group of respondent : ....

b) Religion : ....

c) Inhabitant : Native or Not?

d) If not, how did you come to the village?

Through: 1) marriage; 2) job; 3) followed a relative; 4) migrated

If you are an immigrant, how long have you stayed in the village? .... tahun

f) Have you ever gone out of the village? Yes ( ) or No ( )

If yes, where did you go and why?

g) Financial ability to support children's education:

1) Elementary School ( )

2) Secondary School ( )

3) High School ( )

4) College ( )

5) University ( )

Social, Cultural, and Economic Institutions

Do you diligently follow village activities? Yes ( ) No ( )

Types of Social Activities	Always	Sometimes	Never
1. Mosque	....	....	....
2. Church	....	....	....
3. Tadzkir	....	....	....
4. Evangelization	....	....	....
5. Community Service	....	....	....
6. Mutual cooperation	....	....	....
7. Party/Thanksgiving	....	....	....
8. Dolor	....	....	....
9. Social group	....	....	....
10. Talk/Extension	....	....	....

a) Are you a member of a group or social organization? Yes ( ) No ( )

b) If Yes, what social group is it? 1) kinship; 2) village institution; 3) religion; 4) ....

c) Did you join any fishermen's group? Yes ( ) No ( )

d) If Yes, which fishermen's group? ....

e) Among which of the following figures do you most enjoy? 1) Government; 2) Religion; 3) Traditional figures; 4) community leaders; 5) teacher.

f) If a member of the community is sick, where do you obtain healing? 1) physicians; 2) health centers; 3) shaman; 4) paramedics; 5) others ....

g) Where do you get medical help? ....

h) What do you do during holidays? 1) watch TV; 2) go to the beach; 3) go to the mountain; 4) go to the mall; 5) others ....

i) Media hiburan yang ada di rumah: 1) TV; 2) radio and tape; 3) VCD; 4) others ....

j) Please enumerate the composition/combination of your daily food: 1) rice, fish, vegetables, fruit; 2) potatoes, fish, vegetables, fruits; 3) corn, fish, vegetable; 4) rice, fish; 5) potatoes, fish; 6) rice, vegetables; 7) others ....

k) From the food composition above, which do you often consume? 1, 2, 3, 4, 5, 6, 7.

l) For your daily needs, what food ingredient do you purchase weekly? ....

Food	Purchased			
	From outside the village/Kg	IDR	From local village /Kg	IDR
a. Rice	....	....	....	....
b. Egg	....	....	....	....
c. Milk	....	....	....	....
d. Salt	....	....	....	....
e. Coconut oil	....	....	....	....
f. Kerosene/gas	....	....	....	....
g. Sugar	....	....	....	....
h. Coffee	....	....	....	....
i. Tea	....	....	....	....
j. Red onion	....	....	....	....
k. Garlic	....	....	....	....
l. Vegetable	....	....	....	....
m. others	....	....	....	....

m) Do your household often have difficulty in meeting the daily basic needs? Yes ( ) or No ( )

n) How many fish does your family consume everyday? .... Kg / individuals

o) Do you eat fish everyday? Yes ( ) No ( ) Sometimes ( )

p) If, sometimes, how many times do you eat fish in a week? .... times

Economic Aspect

a. Fishing gear used ....

b. Status of the fishing gear : 1) owned; 2) borrowed from others; 3) rented, 4) ....

c. Fishing gear price per unit ....

d. Seine: Length .... m; Width .... m

e. Mesh size: wings .... inches; body .... inches; and purse .... inches

f. In this fishing operation, do you use ship or boat? If yes, the boat has a dimension of .... m long, ... m wide, and .... m high.

g. Type of outboard motor used: .... How many? ....

h. How much money do you need to buy an outboard motor IDR ....

i. Types of auxiliary equipment owned

Type	Number	Price (IDR)
1.	....	....
2.	....	....
3.	....	....
4.	....	....
5.	....	....

j. How far do you go in your fishing operation? .... km

k. Condition of fishing ground 1) sandy, stony, and muddy; 2) stony sandy; 3) muddy sandy; 4) ....

l. Water depth .... m

m. Fishing season (month): from .... to ....

n. When is the fishing operation done? Day ( ) Night ( )

o. Duration of one fishing trip: .... Hours or days

p. Quantity of catches in one fishing trip .... kg

q. How many fishing operations are done in a month? ....

r. How much is the fish selling price? IDR .... kg

s. Fish catches

Fish species	Total length (cm)	Volume (Kg)	price (IDR)
Big Pelagic fish besar			
1.	....	....	....
2.	....	....	....
3.	....	....	....
4.	....	....	....
5.	....	....	....
Small pelagic fish			
1.	....	....	....
2.	....	....	....
3.	....	....	....
4.	....	....	....
5.	....	....	....
Demersal and others			
1.	....	....	....
2.	....	....	....
3.	....	....	....
4.	....	....	....
5.	....	....	....

t. How much is the cost of one fishing trip? ....

u. Number of labors needed in fishing operation: .... people

Profit-sharing system: a. Fishing gear .... %

b. Owner .... %

c. Operational cost .... %

d. Labor .... %

v. How many years have you run the fisheries business ? .... Tahun

w. Where do you sell your catch? 1) in the village; 2) to intermediate sellers; 3) wholesellers; 4) Fish Auction Center; 5) ....

x. How much is your monthly income ? ....

y. How much is your additional income per month ? Island of ....

z. How much is your daily household expenditure ? Island of ....

Fish Culture

a. Type of fish culture: ....

b. Business Status: 1) owner; 2) rented; 3) others ....

c. Cost for juvenile fish per individual ....

d. How many fish are stocked in a one-hectare area ? ....

e. How much is the additional food cost per day ? .... kg.

f. How much is spent for fertilizer in the production process ? IDR ...., and .... Kg/month.

g. Number of laborers: .... people

h. Sistem upah a. daily wage: Island of .... /person

b. monthly wage: Island of .... /person

c. profit sharing IDR .... /person

i. Catch marketing ...., marketing location ...., marketing cost ...., Selling price .... kg.

j. How many kilograms of fish are obtained in one harvest? .... Kg

k. Fish farm condition: 1) sandy; 2) muddy; 3) coral-rich; 4) ....

l. Fish farm area: .... m2 or Ha

m. How much capital is needed for the fish culture ? IDR ....

n. Capital source: 1) self-supporting; 2) bank loan; 3) sharing; and 4) ....

o. How much is the net income in one harvest ? IDR ....

p. Household's daily consumption ... IDR ....

Resources condition in relation with conservation

1. What can you tell about the condition of your coastal resources, such as fish, coral, mangrove? very bad .... bad .... slightly bad .... good .... very good ....

2. Why do you say so ? ....

3. What can you tell about the recent condition of the coast ? very bad .... bad .... slightly bad .... good .... very good ....

4. Why do you say so ? ....

5. If there had been changes, has it been damaged by fishermen communities ? Yes ( ) No ( )

6. If yes, why ? ....
Since when did the change occur ? ....

7. If no, what are the causes of damages ? ....
Since when did the change occur ? ....

8. Do you agree if the conservation area will be established in the Subdistrict of Tatoareng ? ....
Explain why ? ....

Occupation

1. What is your main occupation ? ....

2. What is your additional occupation ? ....

3. Major income: IDR .... per mo.

4. Additional income IDR .... per mo.

5. If you changed your job, could you give some reasons ? ....

6. How many hours do you spend for your main job ? .... h/d

Income

1. What is the most important source of income in your household? ....

2. What is the second important source of income in your household? ....

3. If there is a change in your major source of income, can you give the reason? ....

4. Had there been a change in your household's income (including income of wife, child, or money transfer) change in the last five years? increase ...., decrease ...., no change ....

5. Why and how ? ....

6. Had there been a change in your personal income in the last five years? increase ...., decrease ...., no change ....

7. Is the change in your income a result of changes in fishing technology ? Yes.............., No ....

8. What change in fishing technology do you use? Please describe. ....

Communities

1. Do you get any economic benefit from fisheries activities in terms of better infrastructures, such as water supply and basic services (school and health). Yes ( ) No ( )

2. Do you think that the villagers can collaborate to solve the problems of the village? (illegal fishing termination, peace, and better arrangement). Yes ( ) No ( )

Law/Regulation Enforcement

1. Are there any marine animals (fish, turtle, dugong, clam, coral, etc.) or plants (tree, seaweed, etc.) in the sea or along the coast where you are not permitted to catch or harvest?........... If Yes, what are they ? .... Who told you that you cannot do it ? ...., What is/are the consequence(s) of doing it? ....

2. Is there a certain technique or gear that is prohibited in fishing and exploitation in the sea or along the coast? .... If Yes, What is it ? .... If Yes, who told you that you cannot use the technique? ...., If Yes, what is/are the consequence(s) of doing it? ....
3. Are the coastal resources regulations often violated by the villagers? Yes ( ) No ( ) Do not know ( )
4. Does your local government like to improve the legal and regulation enforcement? Yes ( ) No ( ) Do not know ( )
5. Are you aware of any violation of coastal recources law and regulations occur? Increase .... no change .... decrease ....
6. Does this change affect your decision to support the activity? Yes ( ) No ( )
7. Give details ....

Women's Role

1. Besides working as a housewife, do you help your husband in making a living ? Yes ( ) No ( ) If Yes, working as ...., how many hours do you spend working in a day ? .... hours. How long have you worked ? .... years. How much is your daily income ? IDR .... day.
2. If you are a fish seller, where do you sell fish ? in the village .... outside the village .... market .... and shop ....
3. How many fish do you sell everyday ? .... ind/clip.
4. Price: IDR ....
5. Who makes decisions in the family ? Wife ( ) Husband ( ) Give some reasons if the wife does ...., and give some reasons if the husband does ....
6. How much is the wife's income ? IDR .... Per mo.

List of References

Adger, W., N. Brooks, M. Kelly, G. Bentham, M. Agnew, and S. Eriksen. 2004. "New Indicators of Vulnerability and Adaptive Capacity." Tyndall Centre, Technical Report.

Adrim, M., M. Hutomo, and S. R. Suharti. 1991. "Chaetodontid Fish Community Structure and Its Relation to Reef Degradation at the Seribu Island Reefs, Indonesia." Proceedings of the Regional Symposium on Living Resources in Coastal Areas, edited by A. C. Alcala. Manila, Philippines: 163-74

Agardy T. 2000. "Opportunities and Constraints for Using Marine Protected Areas to Conserve Reef Ecosystems." Proceedings of the 9th International Coral Reef Symposium. Bali, Indonesia 23-27 October 2000.

Alcala A.C., and G.R. Russ. 2006. "No-take Marine Reserves and Reef Fisheries Management in the Philippines: A New People Power Revolution." *Ambio* 35:245–54.

Allen, G., 1997. *Marine Fishes of Tropical Australia and South-East Asia. A Field Guide for Anglers and Drivers.* Western Australia Museum.

Allen, G., R. Steene, P. Humann, and N. Deloach. 2003. *Reef Fish Identification Tropical Pacific.* Jacksonville, Florida USA: New World Publications, Inc. 457 p.

Aliño P.M., and A.J. Uychiaoco. 1999. "Clarifying the Objectives of Marine Protected Areas." In *Marine Protected Areas in the Philippines* (Proceedings of a Workshop), edited by A.J. Uchiaoco, S. Schoppe, P.M. Aliño, and R. Hermes, 15-16 December 1997, Quezon City, Philippines: 14-21.

Bengen, D.G. 2001. *Ekosistem dan Sumberdaya Alam Pesisir dan Laut.* Institut Pertanian Bogor. 66 hal.

Calumpong, H.P, and E.G. Menez, 1997. *Field Guide to the Common Mangroves, Seagrasses, and Algae of the Philippines.* Makati City: 197 pp.

Carter, D.W. 2003. "Protected Areas in Marine Resource Management: Another Look at the Economics and Research Issues." *Ocean and Coastal Management* 46:439–56.

Charles, A.T. 2001. *Sustainable Fishery System.* London: Blackwell Science, Ltd. Oxford University Press.

Christie P., and A.T. White. 2007. "Best Practices for Improved Governance of Coral Reef Marine Protected Areas." *Coral Reefs* 26:1047–56.

Costanza, R.B., and J. Farleya. 2007. "Ecological Economics of Coastal Disasters: Introduction to the Special Issue." *Ecological Economics* 63 (2007) 249 – 53.

Dartnall, A.J. dan, and M. Jones. (ed.) 1986. *A Manual of Survey Methods: Living Resources in Coastal Areas, ASEAN. Australia Cooperative Program on Marine Science Handbook.* Townsville: Australia Institute of Mar. Sci. 167 pp.

Dawes, C. J. 1981. *Marine Botany*. New York: John Wiley and Sons, Inc. 628 pp.

Den Hartog, C. 1970. *The Lamunes of the World.* Amsterdam: North Holland Publications. 275 pp.

Duxbury, J, S. Dickinson. 2007. "Principles for Sustainable Governance of the Coastal Zone: In the Context of Coastal Disasters." *Ecological Economics* 63:319–30.

Emor Dj., W. Emor, A. Rondonuwu, U.N.W.J. Rembet, and F. Runtukahu. 2009. Pemantauan Teluk Buyat (September, 2009). Ekologi Kelautan dan Kandungan Logam Dalam Ikan (Sub Topik Terumbu Karang). Dipersiapkan untuk Panel Ilmiah Independen, Yayasan Pembangunan Sulawesi Utara Berkelanjutan. Lembaga Penelitian Universitas Sam Ratulangi Manado.

English, S, C. Wilkinson, and V. Baker. 1994. *Survey Manual for Tropical Marine Resources.* Australia: Mc Graw Publication.

Jentoft, S. 2007. "Limits of Governability: Institutional Implications for Fisheries and Coastal Governance." *Marine Policy* 33:1-11.

Jentoft, S., T.S. Son, and M. Bjorkan. 2007. "Marine Protected Areas: A Governance System Analysis." *Human Ecology* 35: 611-62.

Kementerian Kelautan dan Perikanan RI. 2008. Peraturan Menteri KP Nomor PER.17/MEN/2008 tentang Kawasan Konservasi di Wilayah Pesisir dan Pulau-Pulau Kecil.

________. 2010. Peraturan Menteri KP Nomor PER.30/MEN/2010 Tentang Rencana Pengelolaan dan Zonasi Kawasan Konservasi Perairan.

________. 2012. Keputusan Direktur Jenderal KP3K Nomor Kep. 44/ KP3K/2012 Tentang Pedoman Teknis E-KKP3K. Direktorat Konservasi Kawasan dan Jenis Ikan Direktorat Jenderal Kelautan, Pesisir dan Pulau-Pulau Kecil.

________. 2013. Petunjuk Teknis Penataan Batas Kawasan Konservasi Perairan, Pesisir dan Pulau-pulau Kecil. Direktorat Konservasi Kawasan dan Jenis Ikan Direktotat Jenderal Kelautan, Pesisir dan Pulau-pulau Kecil. 45 Halaman.

Krebs, C.J. 1999. *Ecological Methodology* (2nd ed). Menlo Park, California: Benjamin Cummings, 620 pp.

Lalamentik, L.T.X., A.B. Rondonuwu, U.N.W.J. Rembet, and A.S. Wantasen. 2014. *Vulnerability Assessment/Climate Change Adaptation in South Minahasa.* SouthEast Asia (RETA 7813): Coastal and Marine Resources Management in the Coral Triangle.

Law of the Republic of Indonesia. 2007. "Law Number 27 on Management of Coastal Area and Small Island."

Lovelock. 1964. *Field Guide to the Mangroves of Queensland.* Australian Institute of Marine Science.

Lubis, B.L. dkk. 2014. Panduan Identifikasi, Inventarisasi dan Pencadangan Kawasan KonservasiPerairan, Pesisir dan Pulau-pulau Kecil (Suplemen 1). Direktorat Konservasi Kawasan dan Jenis Ikan Direktorat Jenderal Kelautan, Pesisir dan Pulau-Pulau Kecil Kementerian Kelautan dan Perikanan.43 Halaman.

Rondonuwu, AB., U.N.W.J. Rembet, and Dan F. Runtukahu. 2014. Pemantauan Teluk Buyat (Mej, 2014). Ekologi Kelautan (Sub Topik Terumbu Karang). Dipersiapkan untuk Panel Ilmiah Independen, Yayasan Pembangunan Sulawesi Utara Berkelanjutan. Lembaga Penelitian Universitas Sam Ratulangi Manado.

Rudd, M, M. Tupper, H. Folmer, and C. Van Kooten. 2003. "Policy Analysis for Tropical Marine Reserves: Challenges and Directions." *Fish and Fisheries* 4:65–85.

Rusila, Noor, Y., M. Khazali, and dan I N.N. Suryadiputra. 2006. Panduan Pengenalan Mangrove di Indonesia. PHKA/WI-IP, Bogor.

Sale, P.F., R.K. Cowen, B.S. Danilowicz, G.P. Jones, J.P. Kritzer, K.C. Lindeman, S. Planes, N.V.C. Polunin, G.R. Russ, Y.J. Sadovy, and R.S. Steneck. 2005. "Critical Science Gaps Impede Use of No-take Fishery Reserves." *Trends in Ecology and Evolution* 20:74-80.

Susanto, Hanoko A. 2011. Progres Pengembangan Sistem Kawasan Konservasi Perairan Indonesia. Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security (CTI-CFF). 48 Halaman.

Tomascik, T., A.J. Mah., A. Nontji dan, and M.K. Moosa. 1997. *The Ecology of the Indonesian Sea.* Part II. London: Periplus Edition (HK). 138 pp.

Tomlinson, P. B. 1986. *The Botany of Mangroves.* United Kingdom: Cambridge University Press, Cambridge.

UNEP (United Nation Environmental Program). 1993. "Monitoring Coral Reefs for Global Change. Regional Seas." Reference Methods for Marine Pollution Studies 61. Australian Institute of Marine Science. 60 pp.

White, A.T., P.M. Alino, and A.T. Meneses. 2006. *Creating and Managing Marine Protected Areas in the Philippines. Fisheries Improved for Sustainable Harvest Project.* Cebu City, Philippines: Coastal Conservation and Education Foundation, Inc. and University of the Philippines Marine Science Institute, 83 p.

Yap, H.T., and E.D. Gomez. 1984. "Coral Reef Degradation and Pollution in the East Asian Seas Region. UNEP Regional Seas Reports and Studies." No. 69: 185-208.

Zagonari, F. 2008. "Integrated Coastal Management: Top–down vs. Community-based Approaches." *Journal of Environmental Management* 88:796–804.