COASTAL AND MARINE RESOURCES MANAGEMENT IN THE CORAL TRIANGLE: SOUTHEAST ASIA (RETA 7813)

VULNERABILITY ASSESSMENT/CLIMATE CHANGE ADAPTATION IN SOUTH MINAHASA

Final Report
February 2015

PACIFIC RIM INNOVATION AND MANAGEMENT EXPONENTS, INC., PHILIPPINES

IN ASSOSIATION WITH

THE WORLD FISH CENTER, MALAYSIA

AND

PT TRANS INTRA ASIA (TIA), INDONESIA

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ABBREVIATIONS

BMKG	:	Badan Meteorologi Klimatologi dan Geofisika (Indonesian Agency for Meteorology, Climatology and Geophysics)
BPBD	:	Badan Penanggulangan Bencana Provinsi (Regional Disaster Management Agency)
CDD	:	Consecutive Dry Days
CT3	:	Coral Triangle 3 (Indonesia, Malaysia, and the Philippines)
CTI	:	Coral Triangle Initiative
CWD	:	Consecutive Wet Days
El Niño	:	Climate pattern that describes the unusual warming of surface waters in the eastern tropical Pacific Ocean; the “warm phase” of ENSO
ENSO	:	El Niño Southern Oscillation
FAO	:	Food and Agriculture Organization
FEV	:	Fishermen Exchange Value
FGD	:	Focus group discussion
GIS	:	Geographic Information System
GCM	:	General Circulation Model
GDP	:	Gross Domestic Product
IOD	:	Indian Ocean Dipole
IPCC	:	Intergovernmental Panel on Climate Change
La Niña	:	Climate pattern that describes the unusual cooling of surface waters n the eastern tropical Pacific Ocean; the “cool phase” of ENSO
LIT	:	Line Intercept Transect
Mb	:	Millibar
Mg/l	:	Milligrams per liter
Mm	:	Millimeter
MRI	:	Meteorological Research Institute
NCC	:	National Coordination Committee
NOAA	:	National Oceanic and Atmospheric Administration
OLR	:	Outgoing Longwave Radiation
Ppt	:	Parts per thousand
RDI	:	Relative Density Type
RFI	:	Relative Frequency Type
SCUBA	:	Self-Contained Underwater Breathing Apparatus
SRTM	:	Shuttle Radar Topography Mission
SST	:	Sea Surface Temperature
UNEP	:	United Nations Environment Programme
UNSRAT	:	Universitas Sam Ratulangi (Sam Ratulangi University)
VA-LEAP	:	Vulnerability Assessment and Local Early Action Planning
WG	:	Working Group

ACKNOWLEDGMENT

As a follow up to the Coral Triangle Initiative (CTI), the Coastal and Marine Resource Management in the Coral Triangle: Southeast Asia (RETA 7813) conducted activities in coastal areas, one of which was a "survey for socioeconomic and environmental parameters, sensitivities, and adaptive capacity." This activity was directed within the context of climate change adaptation, since climate change poses a serious threat to the preservation of ecosystems around the world, including the coastal ecosystem. The target area of the survey or vulnerability assessment for climate change adaptation was the district of Tatapaan in South Minahasa, Indonesia.

Sam Ratulangi University (UNSRAT) and the Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG) would like to show its gratitude and appreciation to PRIMEX for giving us the opportunity to conduct the vulnerability assessment for climate change adaptation in South Minahasa. We would also like to thank the other parties that participated in the activity. Without them, we would not have succeeded in conducting the assessment and completing this report.

Manado, Indonesia
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EXECUTIVE SUMMARY

Climate change is a real threat to the Indonesian tropical marine environment as well as to its people who depend on marine resources. Amurang Bay in South Minahasa, Indonesia, is at the center of convection and ocean atmosphere circulation. The presence of a large body of water that supplies a large quantity of water vapor contributes to extreme weather in the region. Thus, a coastal area in Amurang Bay is a good place to demonstrate best practices for a climate change adaptation (CCA) planning strategy.

The Coastal and Marine Resources Management in the Coral Triangle: Southeast Asia (CTI–SEA) is an ADB regional technical assistance project (RETA 7813) designed to assist Indonesia, Malaysia, and the Philippines (CT3) in implementing the Coral Triangle Initiative (CTI). One of the regional foci is to implement activities that will allow the CT3 countries to adapt to climate change through early actions. For Indonesia, the initial step was to do a vulnerability analysis for Amurang Bay in South Minahasa regency of North Sulawesi province, with a detailed focus on Arakan village. A qualitative, bottom-up approach was done through community consultations using the Local Early Action Planning (LEAP) approach on 11-14 February 2014. In support of this activity, Sam Ratulangi University (UNSRAT) in cooperation with the Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG) carried out a quantitative assessment from July 2014 to January 2015.

The objectives of the assessment study were to (i) conduct a survey on the socioeconomic and environmental parameters and adaptive capacity of the Arakan community; (ii) provide climate trends and projections as well as projected socioeconomic and environmental parameters for Amurang Bay; (iii) map current and future vulnerabilities; and (iv) present the results of the assessment study to stakeholders.

Vulnerability consists of exposure, sensitivity, and adaptive capacity. *Exposure* refers to the probability or likelihood that a given location (including the natural ecosystem, human settlements, infrastructure, and all other natural and man-made elements found in the said location) will be affected by natural or human-induced hazards. *Sensitivity* refers to the level of expected injury or damage that may be experienced due to exposure to climate hazards. *Adaptive capacity* refers to the ability of human or natural communities to (i) act and respond to climate change in ways that would reduce its impact so that the loss is less than it would otherwise be, and/or (ii) exploit the beneficial effects of climate change, if any.

The assessment activities in Amurang Bay focused on two aspects: (i) physical vulnerability analysis based on climate parameters, and (ii) socioeconomic vulnerability aspects of the ecosystem. An integrated formulation of vulnerability combines and overlays the two sets of information in the context of hazard/exposure, sensitivity, and adaptive capacity. The study included stocktaking from stakeholder meetings, field surveys, and literature review. Primary data were derived from climate observations and *in situ* surveys of the coastal areas. Secondary data from the disaster management authority and socioeconomic data from the local Bureau of Statistics were used for further analysis.

Physical parameters. Based on a long observation period in North Sulawesi, rainfall, temperature, and wind speed showed increasing trends. Total precipitation increased by 11.3 millimeters per year (mm/yr) at the Sam Ratulangi Station, 23.6 mm/yr at the Kayuwatu Station, and 6.6 mm/yr at the Bitung Station. Temperature parameters in the three stations in North Sulawesi also showed increasing trends: 0.0026^{o}C/yr at the Sam Ratulangi Station, 0.0157^{o}C/yr at the Kayuwatu Station, and 0.0082^{o}C/yr at the Bitung Station. Increasing trends were also observed in average wind speed in North Sulawesi: wind speed increased by 0.0157 millimeters per second per year (mm/sec/yr) at the Kayuwatu Station and by 0.0172 mm/sec/yr at the Bitung Station.

Seasonal rainfall in South Minahasa regency showed a positive trend, but the value changes were insignificant.

Climate projections for rainfall, temperature, wind speed, and sea surface temperature in the near future all showed increases compared with the present climate (baseline condition).

The physical assessment in Amurang Bay showed the most important factors affecting vulnerability to climate change in terms of exposure index, sensitivity index, and adaptive capacity index. Rain greater than 50 mm/day, which resulted in flash floods (highest climate hazard index), is presented as the exposure index. The sensitivity index, which indicates the degree of being affected or prone to be affected, is represented by population density. Adaptive capacity index is represented by the number of schools, health officers, and health facilities.

Based on these criteria, it appears that there are areas in Amurang Bay that are more vulnerable than others: Arakan village (Tatapaan district), Kapitu village (West Amurang district), and the upper-middle area of Amurang Bay. As in the whole Amurang Bay, the most important factors contributing to the vulnerability of these villages are rainfall of over 50 mm/day for climate exposure; flood hazard for climate hazard; population density for sensitivity; and number of schools, health officers, and health facilities for adaptive capacity.

Marine and coastal environmental parameters. An assessment of the state of the marine and coastal environment was done to investigate another layer of sensitivity and adaptive capacity contributing to the vulnerability of Arakan village.

Water quality measurements from the field showed that pH[1] ranged from 8.24 to 8.41, implying that marine water is not yet acidic. Water salinity at the study sites ranged from 33.3 parts per thousand (ppt) to 34.1 ppt. These values did not show large variations and are within the natural salinity concentrations for seawater. It is related to the dynamic characteristics of coastal waters affected by tides. The dissolved oxygen (DO) levels of 8.53–8.70 milligrams per liter (mg/l) in the coral fishing zone of Arakan indicate favorable conditions for aquatic life and marine biota.

[1] The pH value is a measurement of acidity. A pH of 7 is neutral, a pH <7 is **acidic**, and a pH >7 is basic. Each whole **pH value** <7 is ten times more **acidic** than the next higher value.

The condition of Arakan's **coral reefs** varies from fair to good. The coral reefs are supported by algae and other fauna (such as sponges) at the bottom of the reef area. The low number of large-sized coral fish populations and species in the 0–20 m depth is believed to be the result of coral reef destruction, overfishing (which interferes with natural growth and reproduction), and blast fishing. If this situation persists, the coral reef fisheries potential in Arakan will be increasingly threatened and will adversely affect the lives of coastal fishers and their families who depend on marine resources for food and livelihood.

Mangrove condition was surveyed at three sampling transects: right front, inside part, and left front. Mangrove vegetation in Arakan is sufficiently diverse. At the right front transect, seven species were identified, dominated by *Rhizophora apiculata* with 33 individuals. But the species with the largest tree diameter in the right front transect was *Bruguiera.* Meanwhile, in the three transects, there was high relative frequency of *Rhizophora* sp. and *Sonneratia* sp., suggesting that members of the families *Rhizophoraceae* and *Sonneratiaceae* possess the ability to grow well in the area.

Results showed that among the three transects, *Rhizophora* sp. has the highest importance value index (IVI), ranging from 45.6% to 129.17%. Other mangrove species have IVIs lower than 129.17%. Thus, based on the transect data for mangroves in Arakan, the genus *Rhizophora* plays a more important role in the community than the other genera. Furthermore, mangrove diversity analysis showed that the mangrove ecosystem in Transect I (right front) has the highest diversity, while Transect II (inside) has the lowest diversity. Species diversity is higher in Transect I, while only three species were found in Transect II (inside) and four species in transect III (left front).

Based on the fact that small trees are predominant in the mangrove area, it can be said that the mangove forest is not in good condition. Thus, the local community in Arakan started a small-scale mangrove planting activity in an attempt to rehabilitate the mangrove area.

The condition of **algae** was analyzed using the community index, diversity index, dominance index, and similarity index. The condition of the seagrass community on the Arakan coast was found to be good and stable based on its relatively high diversity index and evenness index. However, the relatively small seagrasses have a dominance index of under 0.50. Two species, *Enhallus acaroides* and *Thallasia hemprichii*, were found to dominate the seagrass communities in Arakan. Based on percent cover in each location, the expanse of seagrass in the Arakan coastal area is still high, especially at the three sites adjacent to the mangroves. This indicates good growth of seagrasses in the area.

Socioeconomic vulnerability. Mapping of the local community in Arakan village showed high vulnerability to climate change because of high sensitivity and low adaptive capacity. The most important factors contributing to high vulnerability are rainfall over 50 mm, flooding, high population density, and the low number of schools, health officers, and health facilities.

Ecosystem vulnerability. Arakan village has a moderate level of ecosystem vulnerability to climate change. The most important ecosystem conditions that local communities have to be made aware of are: (i) sea level rise, which is on an increasing trend; (ii) declining percentage of coral reefs; (iii) low level of education of community members; and (iv) low level of public awareness about ecosystem vulnerability.

Planning for adaptation. Following the vulnerability assessment in Amurang Bay and Arakan village, adaptation planning should be carried out by the local government with the communities, and could include both high-level and community actions. There is a need to disseminate information about the results of the assessment to include the local government and communities. Implementation of adaptation actions in Arakan should be made a priority, with working groups from the local government and national agencies steering the direction of implementation of community-level actions. These activities can include the following:

- (i) waste management;
- (ii) mangrove planting;
- (iii) livestock management, especially of goats;
- (iv) sustainable management of coral reefs to maintain the abundance of coral fishes and conserve important fish habitats, including the implementation of the following measures:
  - (a) banning illegal fishing activities using explosives and poison;
  - (b) establishment of marine protected areas (MPAs), marine sanctuaries, and fishery reserves;
  - (c) regulation of fishing gears, including banning the use of fine-meshed nets, to prevent the capture of small and juvenile fish;
  - (d) regulation of the exploitation of ornamental coral reef fishes to stop illegal fishing practices; and
  - (e) habitat protection and rehabilitation;
- (v) building capacity through the promotion of seaweed culture as a means of livelihood and the formation of cooperatives for buying and selling high-quality seaweed seedlings;
- (vi) building capacity to enhance public awareness on climate change through the transfer of knowledge and technology (training, seminars, etc.), production and dissemination of climate change materials, inclusion of the topic of climate change in the school curriculum, and more intensive use of BMKG weather and climate information for the community's daily activities;
- (vii) strengthening of natural resources management, including enhancing the capacity of Bunaken National Park staff in law enforcement for reef conservation; and
- (viii) building of infrastructure, especially of education and health facilities, and provision of additional health officers.

INTRODUCTION

The impact of climate change in Indonesia is predicted to be very high but difficult to measure. The estimated economic losses for the country, by direct and indirect effects, are significant. For example, by 2100, Indonesia's gross domestic product (GDP) losses may reach 2.5%, and if catastrophic events are taken into account, the loss may reach 7% of GDP.

Indonesia has one of the longest coastlines in the world, with high productivity in agriculture and fisheries, and rich marine biodiversity that supports nearly two thirds of Indonesian coastal villagers. However, climate change threatens the poor rural and coastal communities, which have limited access to the resources for dealing with climate change impacts.

To protect the poorest coastal communities and limit the economic costs of the impacts of climate change, the Indonesian Government needs to implement climate change adaptation (CCA) measures. Sectors for which development and implementation of CCA options are needed include water resources, agriculture, forestry, fisheries, and health. These options in the planned development and implementation of CCA are a big challenge for the country.

A key project to support Indonesia in meeting these challenges is RETA 7813: Coastal and Marine Resources Management in the Coral Triangle–Southeast Asia. It is a project designed to assist Indonesia, Malaysia, and the Philippines (CT3) in implementing actions under their Coral Triangle Initiative (CTI) National Plans of Action (NPOAs), which address the issues of coastal and marine degradation, poverty in coastal communities, coastal and marine management policy, and institutional weaknesses in the three countries.

The RETA 7813 project consists of two national and three regional level activities that require concerted efforts to address trans-boundary issues. The national activities are implemented by each CT3 country to meet key indicators of their NPOAs. The National Coordination Committee (NCC) and Working Group (WG) support the project to meet agreed goals and targets.

One of the regional projects addresses the impacts of climate change on coastal and marine ecosystems and marine resources by building the capacity of national and local government planners, decision makers, and the coastal communities to adapt to the impacts of climate change.

In Indonesia, climate change adaptation analysis is based on a vulnerability assessment of selected sites in South Minahasa regency, North Sulawesi province, in combination with remote sensing techniques and on-ground activities. The vulnerability assessment determines the areas or communities and resources that will be affected by sea level rise, increasing land and sea temperatures, increasing frequency and severity of storms, and changing patterns of rainfall.

Arakan village in South Minahasa was the chosen site for the implementation of this project, which produced the Accelerated Climate Change Vulnerability Assessment and Adaptation Planning at Arakan Village, South Minahasa Report. The report provides qualitative results; describes the quantitative work on the agreed socioeconomic and environmental parameters, conducted by Sam Ratulangi University (UNSRAT); and makes climate projections calculated through simulation and downscaling by the Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG).

The general objective of this study is to conduct (i) a vulnerability assessment (VA) in Amurang Bay and Arakan village, Tatapaan district, South Minahasa, and (ii) a socioeconomic survey in Arakan village.

The key project activities were the following:

(i) A survey of socioeconomic and environmental parameters and adaptive capacity to collect local knowledge and information on climate change exposure, sensitivities, impacts, and adaptive capacities through local knowledge and expertise, information from the local meteorological department, community consultations, previous studies, and data obtained from geographic information system (GIS) sources. The survey was conducted to understand the perceived status of target (natural, cultural, and economic) resources and the vulnerability of these resources to current climate and non-climate threats and sensitivities;

(ii) Climate projections using projected socioeconomic and environmental parameters from the local meteorological department, government reports, and previous studies, including vulnerability assessments at regional and national scales, and simulation and downscaling methods;

(iii) Mapping of current and future vulnerabilities through the GIS layering technique in combination with remote sensing techniques and ground truth verification exercises; and

(iv) Presentation to the community of the quantitative vulnerability assessment results in support of and to validate the local adaptation plan.

METHODOLOGY

Climate change adaptation (CCA) is based on a vulnerability assessment (VA) of selected sites in South Minahasa to determine the areas or communities and resources that will be affected by sea level rise, increasing land and sea temperatures, increasing frequency and severity of storms, and changing patterns of rainfall.

Vulnerability consists of exposure, sensitivity, and adaptative capacity. Exposure is the probability or likelihood that a given location (including the natural ecosystem, human settlements, infrastructure, and other natural and man-made elements in the said location) is impacted by natural or human-induced hazards. Sensitivity is the level of estimated injury or damage that may be experienced due to exposure to the hazards of climate change. Adaptative capacity refers to the ability of human or natural communities to (i) act and respond to climate change to reduce its impact, and/or (ii) exploit the positive effects of climate change, if any.

One of the most important components in assessing the level of climate change vulnerability is climate exposure, which describes the changing nature of climate variability and characteristic due to global warming. Other vulnerability components include (i) the level of sensitivity of impacted systems such as people, ecosystems, and topography, and (ii) the socioeconomic adaptive capacity, which together determine the level of vulnerability in South Minahasa (Figure 1).

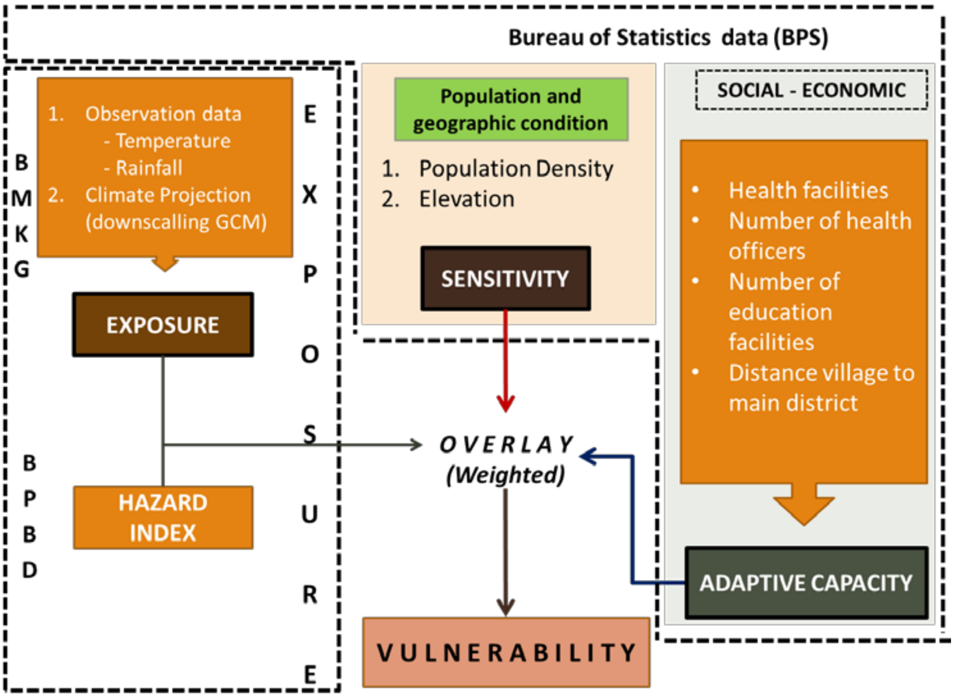


Figure 1. Framework of Vulnerability Analysis and Climate Change Impact in South Minahasa

Study Area

Activities for the study were conducted in Amurang Bay and Arakan village, Tatapaan district of South Minahasa regency, North Sulawesi province.

Description of Amurang Bay

South Minahasa is one of the regencies of North Sulawesi province. Geographically, South Minahasa regency is located between 0°, 47'-1°, 24' North and 124°, 18'-124° 45' East. Its capital, Amurang, is located about 64 kilometers (km) from Manado. South Minahasa has a strategic position because it is located on the traffic lanes of Trans Sulawesi, which connects all the provinces on the island of Sulawesi. The northern coastal sea lanes are a strategic area for the development of fisheries production in eastern Indonesia and for the flow of passengers, goods, and services in central and eastern Indonesia, and even the Asia Pacific.

South Minahasa regency is bounded by Minahasa regency to the north, Southeast Minahasa regency to the east, Bolaang Mongondow regency to the south, and Sulawesi Sea to the west. It has an area of 1484.47 square kilometers (km^2) and is composed of 17 districts. In 2011, it had a population of about 196,000, with the highest concentration of people in Amurang (17,184) and Tenga district (16,200).

South Minahasa regency has a coastal and undulating terrain, with hills and mountains reaching up to a height of 1,500 meters above sea level. Mountains located in South Minahasa include Mt. Lolombulan (1,780 m), Mt. Manimporok (1,661 m), Mt. Tagui (1,550 m), and Mt. Lumedon (1,425 m). Plains are located in the Modoinding area (2,350 ha) and Tompaso Baru (2,587 ha). The location of Amurang Bay is shown in Figure 2.

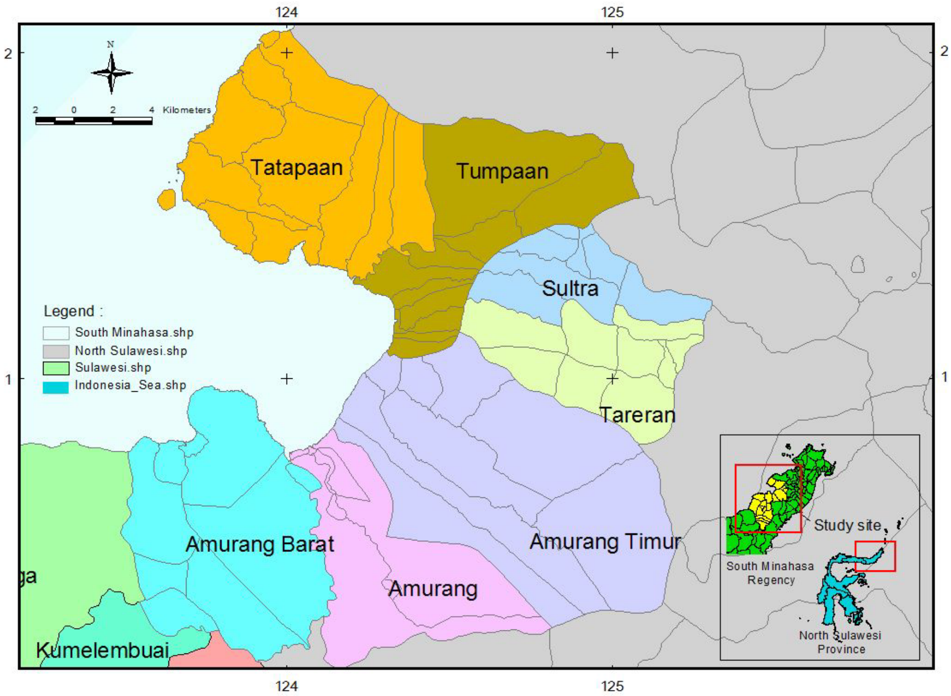


Figure 2. Location of Amurang Bay, South Minahasa Regency

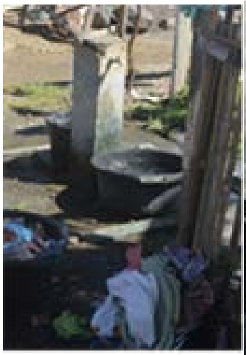
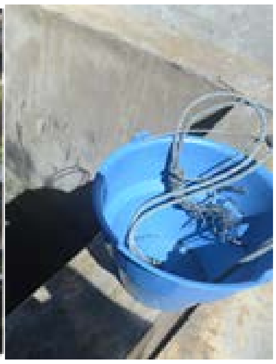
Description of Arakan Village

Arakan is a coastal village and a rural buffer for Bunaken National Park. Majority of its population belong to the Sangir and Bajo ethnic groups. Tarred roads connect homes and other structures such as churches and mosques. Existing water sources in Arakan originate from springs. Most of the villagers work as farmers and fishermen. There are only two schools—an elementary school and a junior high school—in the village. For higher education, villagers go to Tanahwangko and Manado.

Arakan can be reached by car on a good but narrow road in about two hours from Manado and one hour from Tanawangko. It has a V-shaped sandy beach with coconut trees. The width of its shoreline mangrove forest is about 200 m.

(a) View of the village from Amurang Bay (b) Tarred village road

(c) Water well (d) Groundwater

(e) Educational facilities (SD, SMP)

Figure 3. Aspects of Arakan Village

The community in Arakan village, Tatapaan district, South Minahasa regency, makes a living mostly from limited mariculture and fishing activities using fishing gears such as hand line and monofilament ‘gill-net’ and a small outboard motor boat called *ketinting*. The average fisherman’s catch is about 5 kg/trip, including coral reef fish, skipjack, scad, mackerel, and anchovy. Fishing operations are done daily, except on Fridays (when people go to the mosque), religious days, burials, and weddings.

The dominant mariculture activity involving the community is seaweed farming. Fish and oyster farming only involve several people due to limited capital available for these activities. The village has not yet attracted capital investments from fishing companies.

Each seaweed farm has 10–40 tying ropes. The seaweed varieties cultured are *Kappaphycus alvarezii* (trade name: *Eucheuma cottoni*) and *Eucheuma denticulatum* (trade name: *Eucheuma spinosum*). Arakan Bay has more than 2,500 ha of potential seaweed culture area, but only about 4 ha are currently being used for seaweed culture. Initially, the village had five seaweed farmer groups, each of which comprised 10 people. But now, only the Inti Murni group is active. In 2014, there was no seaweed farming activity because only poor seeds easily infected by disease were available.

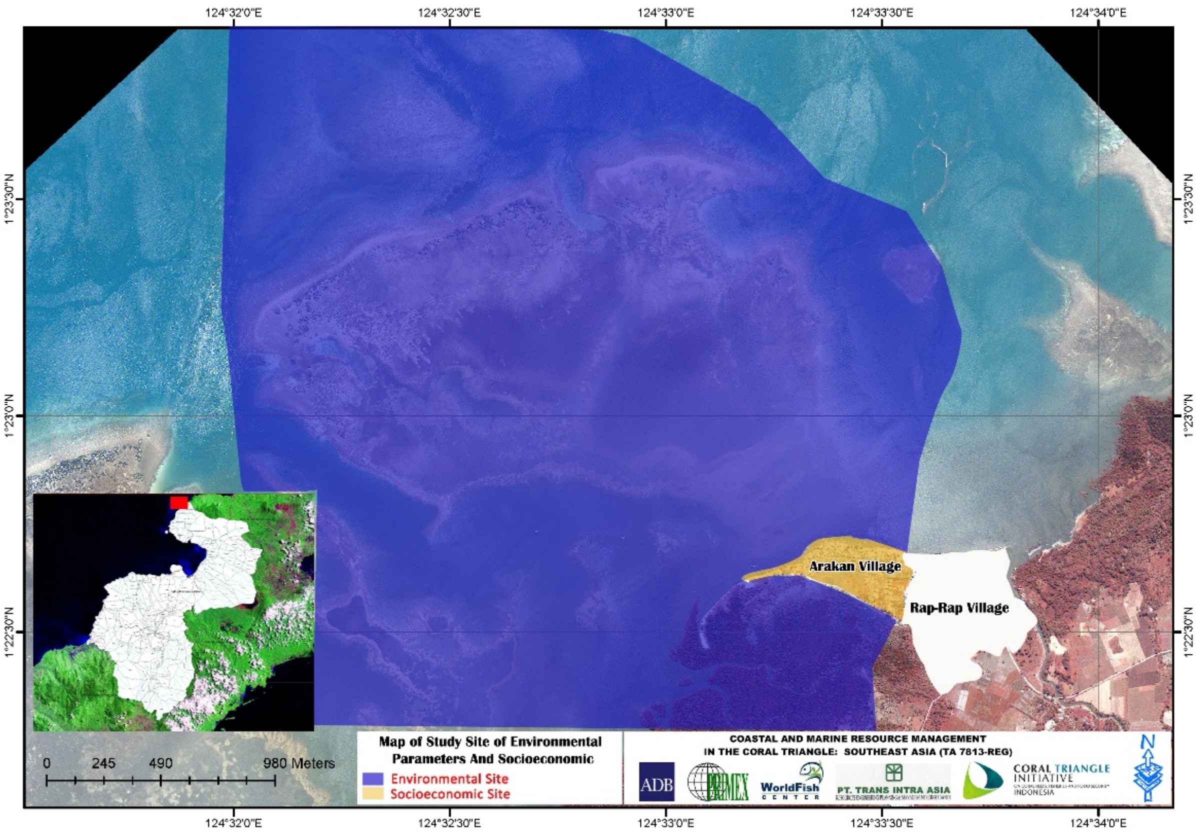


Figure 4. Map of Environmental Parameters and Socioeconomic Study in Arakan Village

Seaweed farming in Arakan began in1988 and developed since 1993 with a culture area of 500 ha, making Arakan village the second biggest seaweed producer in North Sulawesi province after Nain island in North Minahasa regency. However, since 2006, seaweed farming in Arakan has declined drastically.

Data Collection

Physical Exposure

a. Data for Physical Exposure

Current and future data needed are as follows:

- Historical meteorology data (temperature, precipitation, wind speed) from local BMKG stations;
- Current and future projections (temperature, precipitation, wind speed, sea surface temperature or SST) from the regional climate model of the Meteorological Research Institute (MRI) of Japan. The baseline period is determined for 1981-2007, and the near period for 2014-2038;
- Historical SST data from NOAA-COBE-SST2 Sea Surface Temperature (http://esrl.noaa.gov/psd/data/gridded/tables/monthly.html);
- Sea level rise scenario using NASA Shuttle Radar Topography Mission (SRTM) datasets;
- Analysis of global phenomena impact on the local climate condition (monsoon, El Niño Southern Oscillation or ENSO, Indian Ocean Dipole or IOD Mode); and
- Coastal hazard data from the National Disaster Management Authority (BPBD).

b. Climate Conditions: Variations and Changes Based on Historical Data

Generally, North Sulawesi province has a tropical climate that is influenced by monsoon winds. From November to April, westerly winds bring rainfall to the province, while from May to October, the province has dry southerly winds. To analyze climate conditions in North Sulawesi, climate data from BMKG stations were used. The BMKG stations in North Sulawesi whose data were used in this analysis are shown in Figure 5 and Table 1.

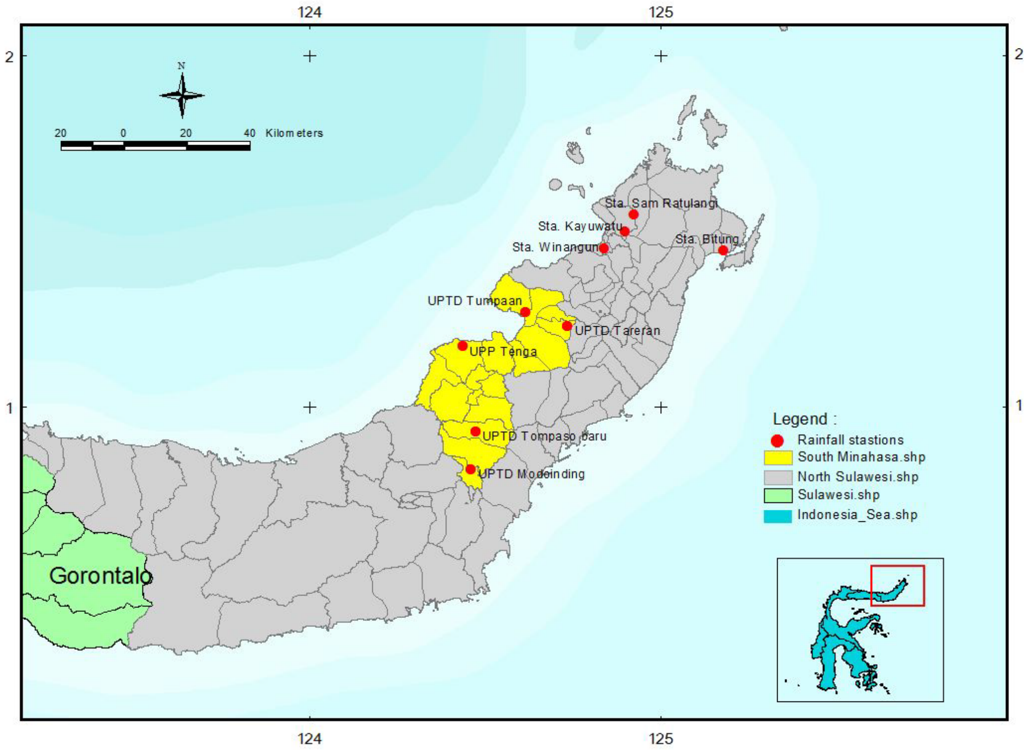


Figure 5. Location of BMKG (Indonesian Agency for Meteorology, Climatology and Geophysics) Stations in North Sulawesi

Table 1. List of BMKG Stations in North Sulawesi

No.	Name of Station	Lat.	Lon.	Alt.	Parameters			Periods of Data
					Precip.	Temp.	Wind Speed	
1	Tondano Winangun Station	1.45	124.84	124	v	v	v	1993-2012
2	Bitung Maritime Station	1.443	125.18	3.5	v	v	v	1980 - 2012
3	Sam Ratulangi Meteorological Station	1.545	124.925	80	v	v	v	1973 - 2012
4	Kayuwatu Climate Station	1.498	124.898	85	v	v	v	1973 - 2012
5	UPTD Tumpaan	1.269	124.615	31	v	-	-	1998 - 2013
6	UPTD Tareran	1.229	124.735	599	v	-	-	2002 - 2013
7	UPP Tenga	1.172	124.435	67	v	-	-	1992 - 2014
8	UPTD Modoinding	0.820	124.460	1079	v	-	-	2003 - 2013
9	UPTD Tompasobaru	0.928	124.472	325	v	-	-	1986 - 2013

v = data available, (-) = data not available

c. Observed Seasonality

Present Climate Condition

Indonesia is a tropical country with two seasons: rainy and dry. The rainy season in most areas of Indonesia occurs from October to March, while the dry season occurs from April to September. In areas with monsoon rainfall, the difference in the two seasons is obvious from the difference in the amount of rainfall. The weather in these areas is greatly influenced by ENSO, IOD, and the regional monsoon phenomenon. These phenomena are inextricably linked to the dynamics of atmospheric ocean change.

Variability of rainfall change is greatly influenced by conditions in the atmosphere and the ocean. Based on the hydrological cycle, rainfall is greatly influenced by the amount of water vapor content in the earth's atmosphere. Water vapor content in the earth's atmosphere is highly dependent on the amount of evaporation that occurs on the earth's surface, where the evaporation process is greatly influenced by surface temperature.

Global warming has triggered an increasing amount of evaporation, which increases the water vapor capacity in the earth's atmosphere and affects the hydrological cycle. Changes in the hydrological cycle affects rainfall patterns in an area, where changes may occur in the amount, frequency, and intensity of rainfall. The impact of global warming is not always the same between one area and another as it is caused by the complexity of phenomena affecting rainfall.

To know how rainfall change in South Minahasa regency is linked to global warming, a comparison may be made between two periods: (i) 1980s to 1990s (past period), and (ii) 2000s to 2010s (current period).

Extreme Climate Analysis

Based on the observed changes in seasonal rainfall in South Minahasa regency, the climate extremes were derived. Aside from water surface temperature, wind movement near the top of the "free" atmosphere level[1] may also influence rainfall anomaly (changes relative to the 30-year average) in Indonesia (Prabowo, 2010).

[1] Free atmosphere layer where the effects of surface friction becomes negligible

Climate Projection

The analysis of climate projection was conducted using Japan's Meteorological Research Institute (MRI) projection data, which has been corrected with the observation data from rainfall stations in South Minahasa and North Sulawesi. The correction methods used a bias correction, as the model data is compared to the observation data to get the correction factor for each month. This correction factor was used to correct the model data so that the corrected model data will be relevant to the observation data. The baseline period was determined for 1983-2007, and the near period for 2014-2038.

The climate projection consists of the following:

(i) rainfall projection,
(ii) temperature projection, and
(iii) sea surface temperature (SST) projection.

Exposure and Sensitivity Data for Ecosystem and Socioeconomic Conditions

Data was collected for socioeconomic conditions, coastal ecosystems, and infrastructure conditions. Parameters observed covered population, fisheries activities, condition and quality of housing, infrastructure, information technology, extreme events due to climate change, adaptation to climate change in the population, and climate change policy. The data collection methods used in this study are illustrated in Figure 6.

The secondary socioeconomic data for district level in Amurang Bay, South Minahasa, was taken from Statistics Indonesia (BPS).

Data collection was done by finding documents from previous research and studies of relevant institutions, direct observations, and running questionnaires. Questionnaire contents were executed following the Vulnerability Assessment and Local Early Action Planning (VA-LEAP) of the Coral Triangle Initiative (CTI) Support Program of the United States.

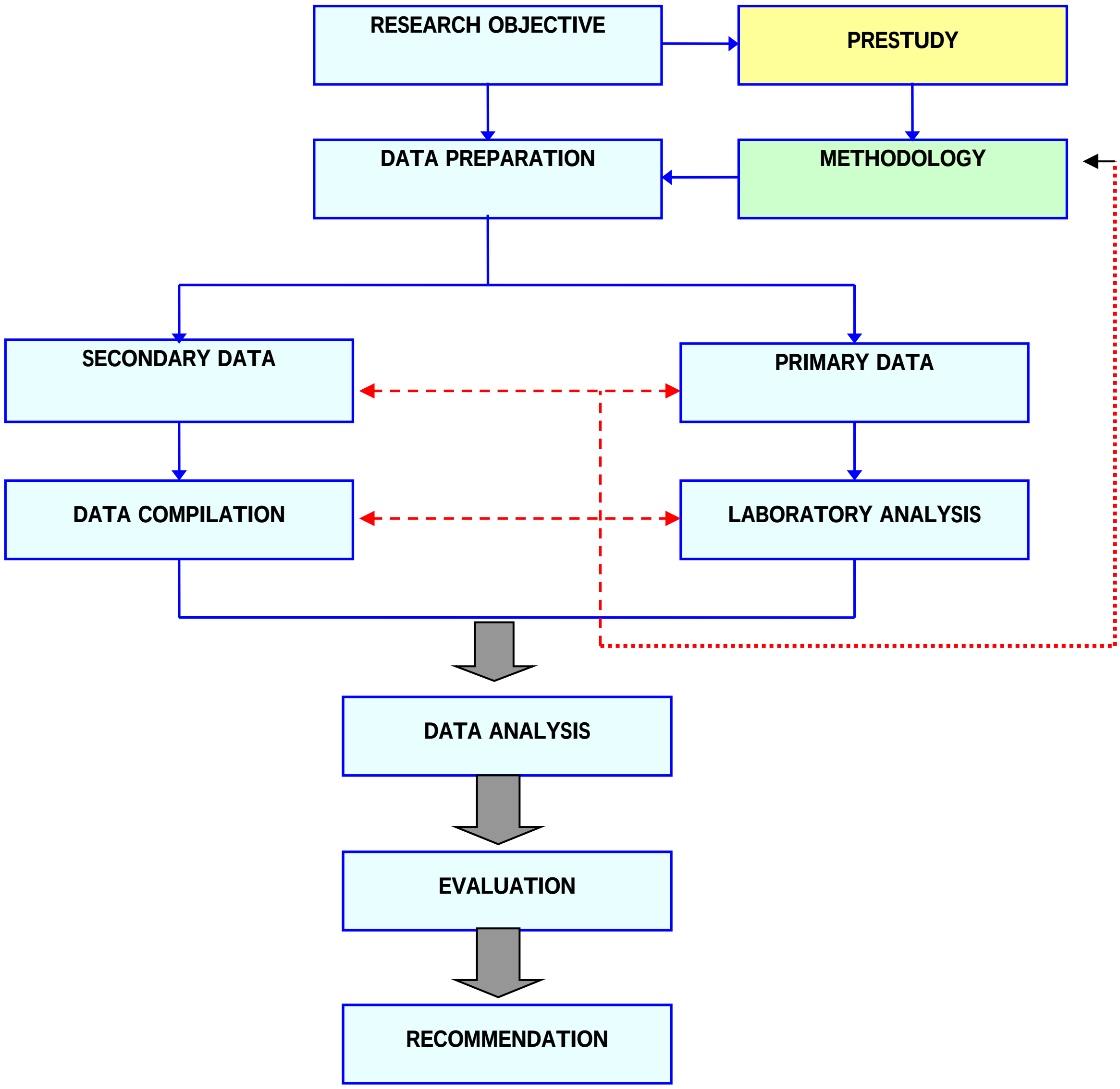


Figure 6**.** Flow Chart, Data Collection, and Analysis

Water Quality: Physical-Chemical Parameters

A survey collected the data related to the environment of the coastal areas, including physical (geographical position, size, and classification of objects) and water quality (physical and chemical properties of water) data (Table 2). Figure 7 shows the sampling points.

Data collection was done through direct measurement of water quality (*in situ*). This method obtained the distribution of some water surface parameters, such as temperature, salinity, brightness, turbidity, conductivity, and dissolved oxygen. Measurements were conducted in coastal areas where natural resources such as coral reefs, reef fish, seagrass, and seaweed are found. Water quality parameter measurements used Horiba U-10.

Table 2. Water Quality: Physical-Chemical Parameters Observed and Measuring Methods

No.	Parameter	Unit	Method	Equipment	Information
1	Brightness	M	Visual	Secchi disc	*In situ*
2	Turbidity	NTU	Turbidity meter	Horiba	*In situ*
3	Temperature	0 C	Expansion	Horiba	*In situ*
4	Salinity	‰	Conductivity meter	Horiba	*In situ*
5	pH	-	Electrometer	Horiba	*In situ*
6	DO	mg/l	Electrochemical	Horiba	*In situ*

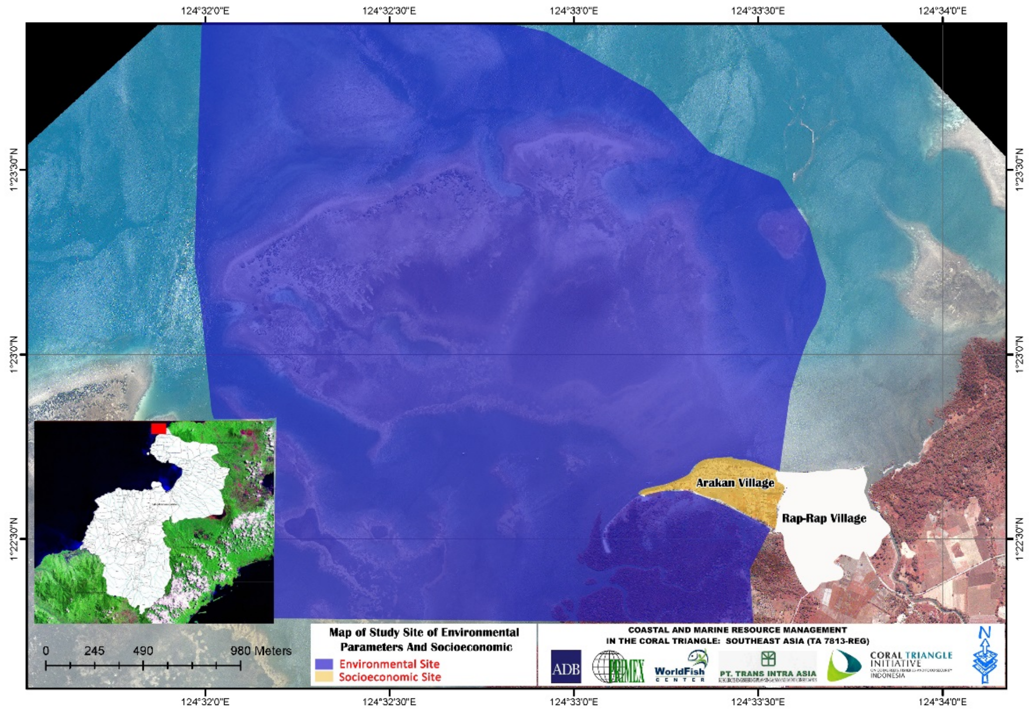


Figure 7. Map of Water Quality Sampling Points

Biological Parameters

The biological parameters observed were taken using specific methods and equipment, as outlined in Table 3.

Table 3. Biological Parameters Observed and Measuring Methods

No.	Parameter	Unit	Method	Equipment	Information
1.	Coral reefs	-	Line Intercept Transect (LIT)	SCUBA	*In situ*
2.	Coral reef fishes		Visual census	SCUBA	*In situ*
3.	Mangrove and seagrass	-	Line transect	Quadrat	*In situ*

a. Coral Reef

In the coral reefs survey, the following activities were undertaken:

(i) Topographic maps, photographs, and satellite imagery were analyzed and interpreted. In locations with agreed characteristics, Manta Tow and Line Intercept Transect (LIT) methods were used to determine the condition of coral reefs.

(ii) Videos and photographs were taken in potentially exploited locations using an underwater digital camera.

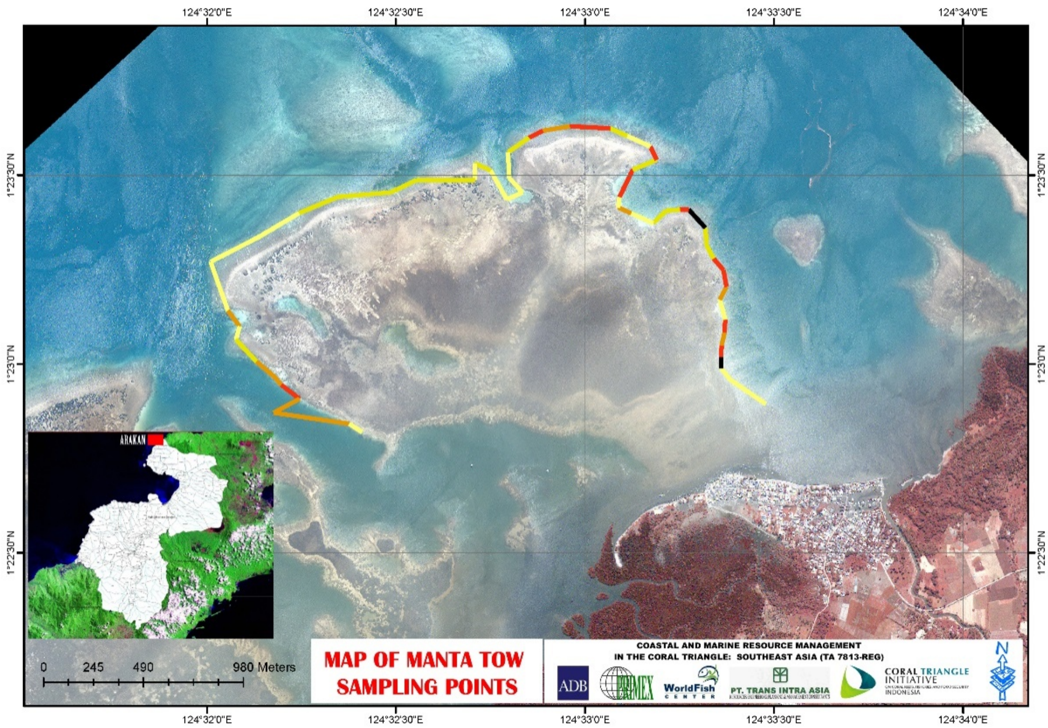


Figure 8. Map of Manta Tow Sampling Points

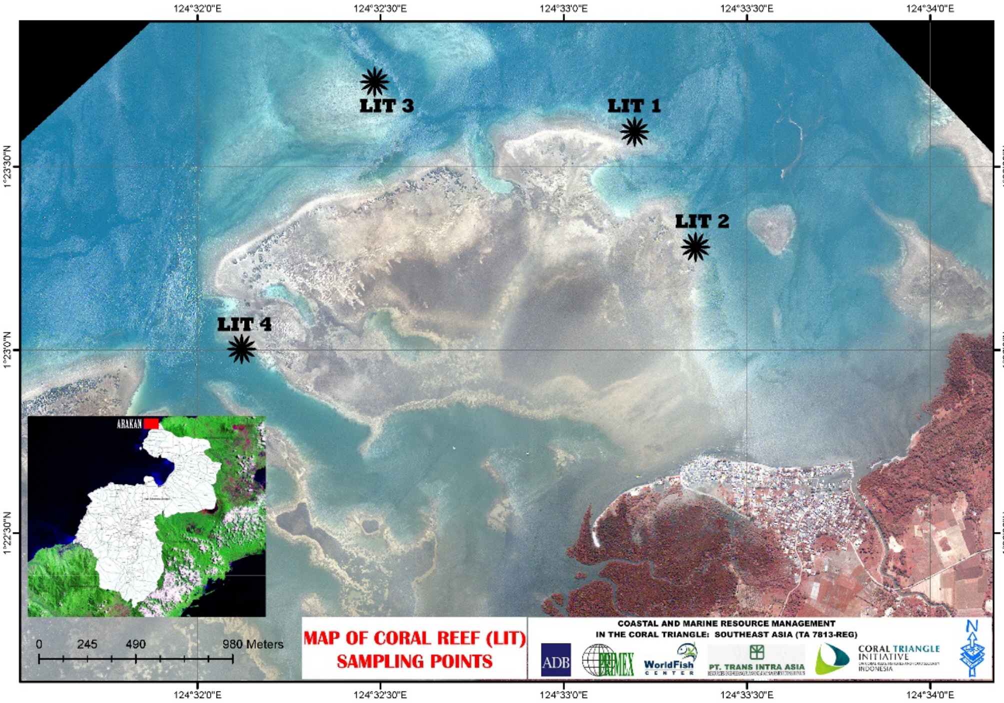


Figure 9**.** Map of Line Intercept Transect (LIT) Sampling Points

b. Coral Fishes

Reef fish data collection used a combination of LIT and Visual Census methods (Dartnall and Jones, 1986). This study used 50m transects in 3m and 10m depths to obtain a detailed picture of coral reef conditions in the study areas. Species abundance and number of individuals of each species were counted within a distance of 5 m to the left, right, and top of the data recorder, with a survey area coverage of 2500 m^2.

Census activity was based on waters in normal condition, 15 minutes after transect linesetting. Data collection was based on three categories: indicator species (*Chaetodontidae*), target species, and major species. Parameters measured included species composition, species richness, and fish abundance (UNEP, 1993). The sites for these activities are shown in Figure 10.

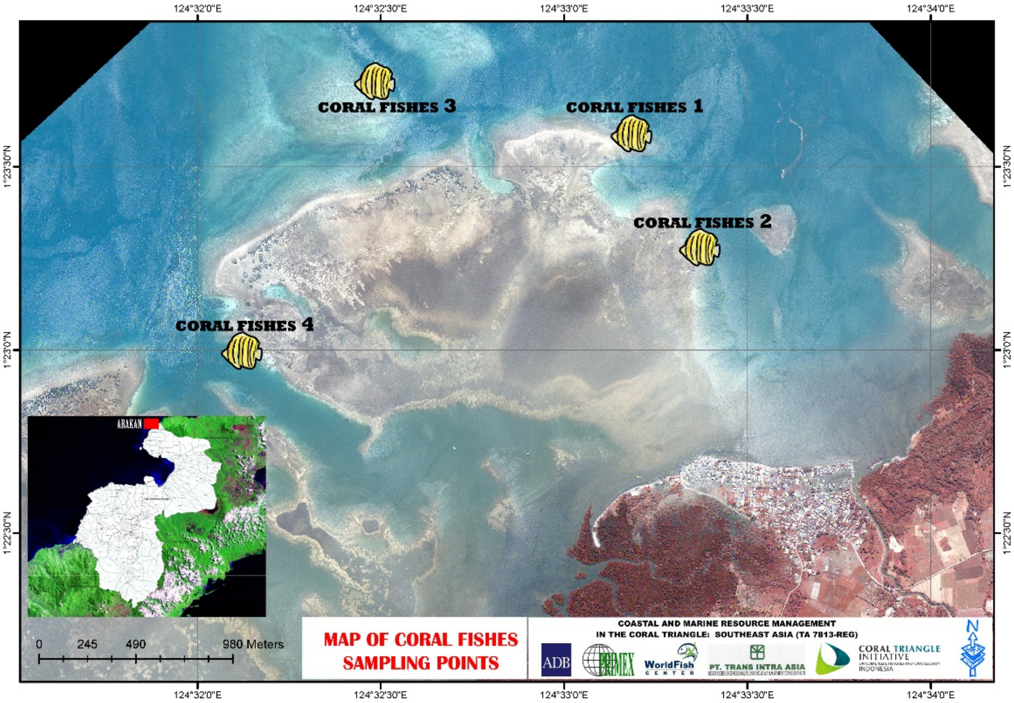


Figure 10. Map of Coral Fishes Sampling Points

c. Mangroves

Mangrove data collection was performed by "spot check" method (English *et al*, 1994; Bengen, 2003). Transects were set perpendicular to the coastline along the 100m contour. In each transect, vegetation data was sampled using a 10m x 10m plot for category trees (diameter >4 cm), a 5m x 5m plot for category saplings (diameter <4 cm, height >1 m), and a 2m x 2m plot for category seedlings (height <1 m). For purposes of identification, the mangrove vegetation, in the form of component leaves, flowers, fruits, stems, and roots, were measured at chest height. Mangrove vegetation identification was based on the guidelines of Lovelock (1964), Tomlinson (1986), and Calumpong and Menez (1997). The mangrove sites are mapped in Figure 11.

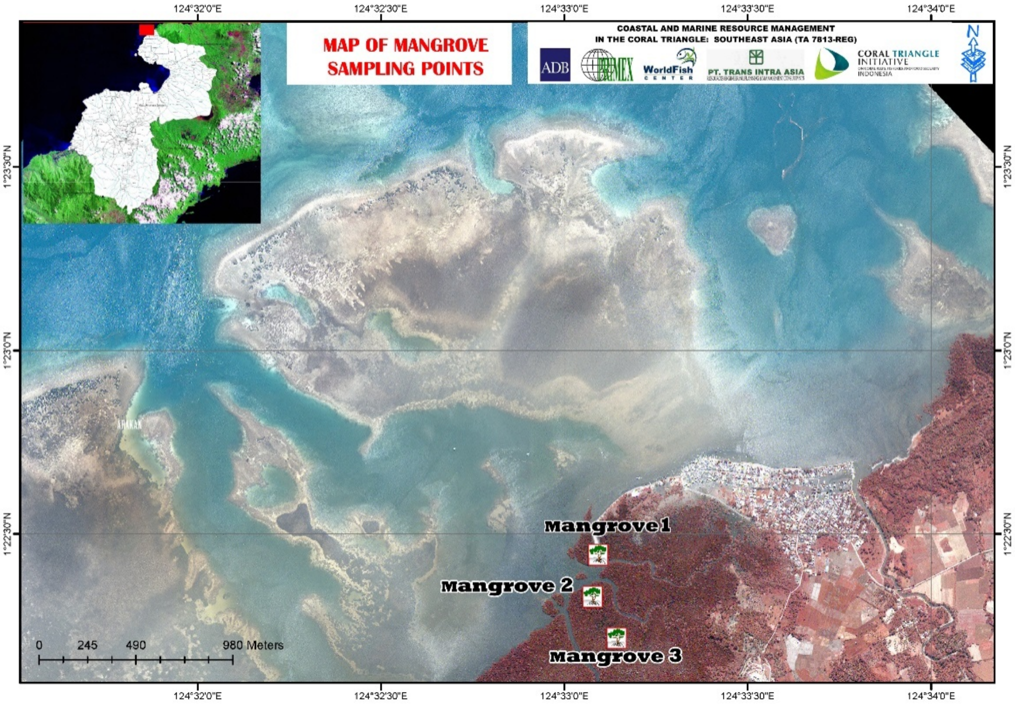


Figure 11**.** Map of Mangrove Sampling Points

d. Seagrass and Algae (Seaweed)

Seagrass sampling was done using the line transect method with the quadrat (Krebs, 1999). The transect placement was divided into three 50m transect lines placed perpendicular to the shoreline with sampling carried out at low tide. The distance between each line transect was 50 m. All seagrass individuals in each quadrat were identified directly in the field with the number of individuals of each species counted. The substrate type was also observed.

Algae (e.g. seaweed) sampling used the quadrat-transect line technique. Three transect lines, each of which was 50 m long, were used and placed perpendicular to the shore. The 50cm x 50cm quadrat was subdivided into small plots of 10cm x 10cm to calculate the total area of each species. Each transect had 10 quadrats. The distance between the quadrats was 5 m and the distance between the transects was 25 m. A quadrat was considered for sampling if more than 50% of the the quadrat contained seaweed**.** Sampling was also carried out through visual observation of the condition of the substrate where the marine algae grew.

The algae found in the quadrat was brought back to the laboratory, cleaned, and generally identified by looking at the morphological characteristics according to

Dogma *et al.*, (1986), Trono and Ganzon-Fortes (1988), Calumpong and Menez (1997), and Trono (1997).

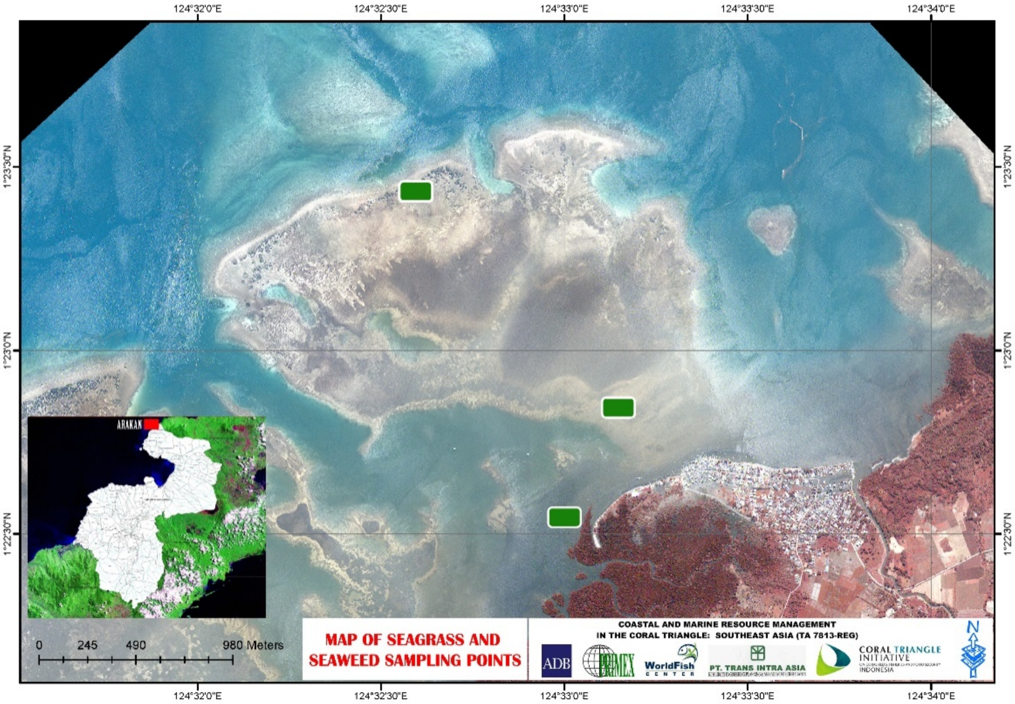


Figure 12**.** Map of Seagrass and Seaweed Sampling Points

Observed Social and Economic Conditions

Socioeconomic data collection used the survey questionnaires recommended by Vulnerability Assessment and Local Early Action Planning (VA-LEAP). VA-LEAP is a simple planning document that practitioners can use to guide critical actions that need to be taken to improve management of important resources while taking climate change impacts into consideration.

To supplement the earlier participatory and qualitative VA-LEAP, additional information was collected from respondents, as shown in Figure 13 and Table 4.

Table 4. Social, Economic, and Institutional Data Types

No.	Component Data	Attributes	Sources/Methods of Data Collection
1	Social and cultural characteristics	Utilization of natural resources, community participation, perception and behavior, knowledge of communities, fisheries, resource management, population growth, ethnic conflicts, local culture, quality of life	Primary and secondary data, interviews and questionnaires, FGD
2	Institutional	Regulation, formal rules, role of stakeholders, customary rules, decision making, economic institutions, supporting infrastructure, law enforcement	Primary and secondary data, interviews and questionnaires, FGD
3	Infrastructure	Roads (location, length, condition), bridges, housing, health facilities, communications, internet	Primary and secondary data, interviews and questionnaires, FGD
4	Identify weather conditions / extreme climate	Type, frequency, impact	Primary and secondary data, interviews and questionnaires, FGD
5	Climate change and its impact	Effects of climate change	Primary and secondary data, interviews and questionnaires, FGD
6	Identify government programs to mitigate the impact of climate change	Policy, system of early notification, evacuation centers, coastal resources management	Primary and secondary data, interviews and questionnaires, FGD
7	Marine resources	Fishing activities, condition, and quality of habitat	Primary and secondary data, interviews and questionnaires, FGD

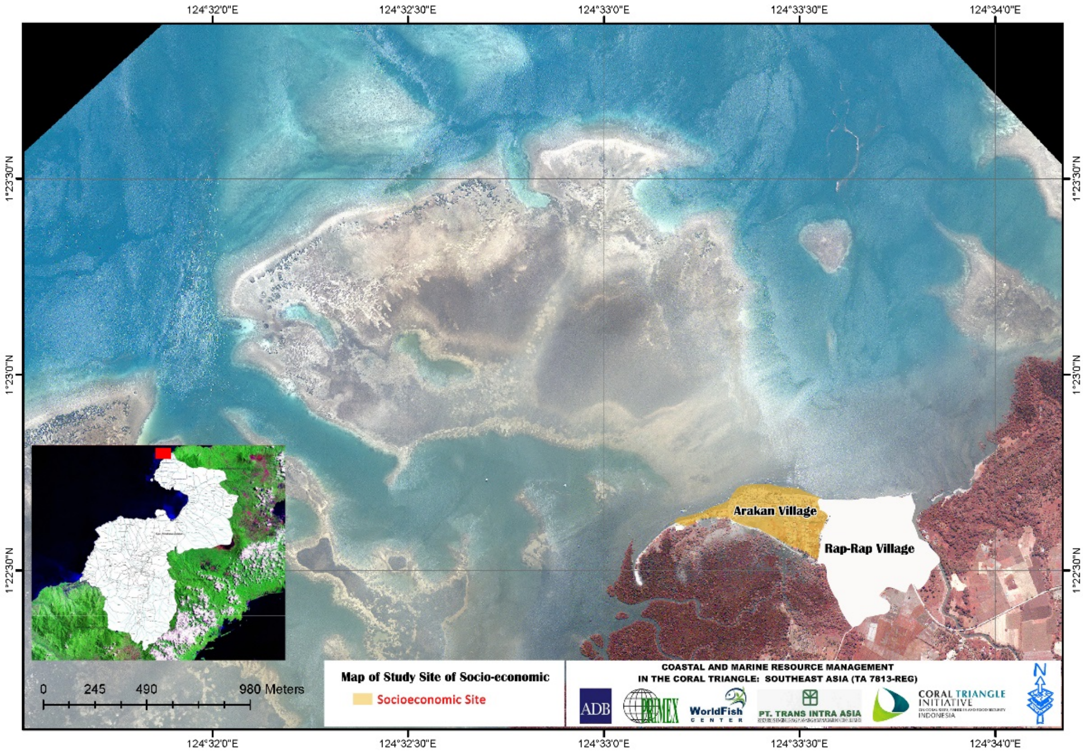


Figure 13**.** Map of Socioeconomic Site

Data Analysis

Climate Analysis and Exposure

The components analyzed were:

(i) characteristics such as precipitation, surface air temperature, wind speed, and SST;

(ii) trend analysis for precipitation, surface air temperature, wind speed, and SST;

(iii) analysis of global phenomena impact on the local climate condition (monsoon, ENSO, IOD);

(iv) climate exposure analysis using calculation of consecutive dry days (CDD), consecutive wet days (CWD), and rainfall over 50 mm/day; and

(v) Analysis and mapping of climate hazards that frequently occur in South Minahasa.

Analysis of Climate Projection for the Next 20–50 Years

The analysis of climate projection for the next 20-50 years was based on 0.5-1 km resolution (A1B scenario) for North Sulawesi, particularly South Minahasa. The following were included in the analysis:

(i) General Circulation Model (GCM) data correction based on the observation data for precipitation;

(ii) Analyis and mapping output of the current climate condition (precipitation, surface air temperature, wind speed, and SST) relative to the future projection (the next 20–50 years);

(iii) Analysis and mapping the projection of future level vulnerability based on the climate projection data;

(iv) Analysis of rainfall and temperature variability projections as an approach in assessing future climate extremes; and

(v) Sea level scenario of 3m mapping based on the Digital Elevation Model (DEM).

Vulnerability Assessment

(i) Vulnerability Assessment in Amurang Bay

The Intergovernmental Panel on Climate Change (IPCC) gives the most frequently quoted definition of vulnerability: “Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes” (IPCC, 2007, calculated as per Box 1).

The vulnerability assessment also includes the climate hazard risk for floods, flash floods, and extreme weather in South Minahasa to know how much variables affect the study area not only based on climate and socioeconomic parameters but also from natural hazards that frequently occur.

(ii) Vulnerability Assessment in Arakan Village

In determining vulnerability assessment on the village level, the three components of vulnerability (exposure, sensitivity, and adaptive capacity) must be quantified in the form of an index, based on village-level vulnerability assessment methods issued by the Human Resources Development and Training Center of the Indonesian Ministry of Marine Affairs and Fisheries and USAID-IMACS (Indonesian Marine and Climate Support) Project (Dirjen KKP, 2014). The index score for each component (exposure, sensitivity, and adaptive capacity) ranges from 1 to 3, where 1 indicates a low value, 2 indicates a moderate value, and 3 indicates a high value. Arakan was analyzed for socioeconomic vulnerability and ecosystem vulnerability.

BOX 1: Analysis of Vulnerability Assessment

The analysis of vulnerability assessment is the function of exposure, climate hazard, sensitivity, and adaptive capacity components. For each component, the following data were used:

- Exposure = Consecutive Dry Days (CDD), Consecutive Wet Days (CWD), Precipitation 50 mm/day (R50) using GCM model;
- Sensitivity = Elevation and density for each district in Amurang Bay, South Minahasa; and
- Adaptive Capacity = Number of schools, distance from village to district, number of health officers, number of health facilities for each district in Amurang Bay, South Minahasa.

Generally, each vulnerability component is given an index score using the following equation:

$$Y = abs ((X_i – X_{min})/X_{max}-X_{min})$$

With Y = score of each data, Xi = data ke-I, Xmin = minimum data, Xmax = maximum data, except for density of population index in which high density has higher sensitivity than low density.

Analysis of Water Quality: Physical-Chemical Parameters

Sea water quality measurements were compared with seawater quality standards based on the Ministerial Decree of the Environment No. 51 2004 on seawater quality standards for organisms.

Analysis of Coral Reef and Coral Fish Communities

Coral reef data were collected and described based on standard coral reef condition analysis, LIT, percent cover of hard corals, other biotic and abiotic components, genera diversity, and number of hard coral colonies. Coral fish communities were analyzed for species level identification, species abundance, and species diversity. The formula used to analyze the coral data is shown in Table 5.

Table 5. Formula for Coral Reefs Ecosystem Analysis

Parameters	Coral Reefs	Coral Fishes
Percent Cover (%)	$\frac{\text{Total Length of Category}}{\text{Transect Length}} \times 100$	-
Species Diversity Index	H' = -∑(ni/N x Log(ni/N) Ni = Number of i species N = Total number of individuals	H' = -∑(ni/N x Ln (ni/N) Ni = Number of I species N = Total number of individuals
Dominance Index	D = (ni/N x ni/N)	D = (ni/N x ni/N)
Species Evenness Index	E = H'/Log (S) S = Number of Species	E = H'/ln(S) S = Number of Species

Parameters used were reef fish species diversity (number of species per site), density (number of individuals per site), and species diversity index for "indicator" (*Chaetodontidae*) species, "target" species, and "major" species. (Dartnall and Jones, 1986).

Analysis of Seagrass and Seaweed Communities

Some formulas were used to get an idea about the condition of seagrass communities (seagrass) and algae (seaweed) in each sampling area, as shown by the Dominance Index (Odum, 1996).

$$C = \sum (ni / N)^2$$

Description:

ni = Number of individuals or the weight of each species

N = Number of individuals or the weight of all species

- Diversity Index (Shannon-Wiener)

$$H' = -\sum_{t=1}^{S} (ni / N) \ln \ (ni / N)$$

- Similarity Index (Ludwig dan Reynolds, 1988)

$$e = \frac{H'}{\ln S}$$

Description: H' = Average count

S = The frequency of the presence of individuals in each quadrat

Analysis of Mangrove Community Structures

To determination mangrove community structures at the study site, a statistical analysis approach was used (Box 2).

BOX 2: Analysis of Mangrove Community Structures

To determine the level of density, frequency, closure, and significant value (Bengen, 2003), the following formulas were used**:**

a. Density Type

Density of (In) is the number of type i individuals in an area measured:

$$D_i = {}^{ni}\!/\!_{A}$$

Description:

In = density of the i-th

ni = total number of type-*i*individuals

A = total area of sampling

b. Relative Density Type

Relative density type (RDI) is the ratio between the number of individuals of type-*i* (ni) and the total number of individuals of all species:

$$RD_i = (n_i / \sum n)x100$$

c. Frequency Type

Frequency type (Fi) is the discovery of a number of sample plots in all types of sample plots:

$$F_i = p_i / \sum p$$

Fi = frequency of type-i

Pi = number of sample plots in which are found the type-i

$\sum p$ = Total number of sample plots observed

d. Relative Frequency Type

Relative frequency type (RFI) is the ratio between the frequency of type-i (Fi) and the sum of the frequencies for all types of ($\sum F$) :

$$RF_i = (F_i / \sum F)x100$$

Description:

RFi = the relative frequency of the type

Fi = frequency of the i-th

$\sum F$ = Number of frequencies for all types

Analysis of Social, Economic, and Institutional Parameters

Social and environmental parameters observed included accessibility to the location, health, environmental safety, distance to other development centers, public response, and sociocultural circumstances. Social data and information on local culture were obtained by conducting interviews, while structured questionnaires were used to obtain the community perception data (readiness, desire, and participation).

The information or variables based on the above data can help explain public participation in climate change and the relationship between the variables used in analysis of Multi-Dimensional Scaling (MDS).

According to Basuki *et al* (2001), fishermen exchange value (FEV) is the ratio of total revenue to total fishermen household expenditure during a specific time period. In this case, the income in question is the gross income or receipts that may be cited by the fishing households. FEV can be formulated as shown in Box 3.

BOX 3: Calculation of Fishermen Exchange Value (FEV)

FEV = Yt / Et

Yt = YFt + YNFt

Et = EFT + EKT

Where:

YFt = Total fishermen revenue from fishing activity (US$)

YNFt = Total revenue from non-fishing activity (US$)

EFT = Total fishermen expenditure for fishing activity (US$)

EKT = Total fishermen expenditure for family consumption (US$)

t = time period (month, year, etc.)

The development of fishermen financial capability is indicated as Fishermen Exchange Value (FEV). It is the ratio between total revenue index to total fisher's household expenditure index for a certain time. It can be formulated as follows:

FEV = (IYT / IET) x 100%

IYT = (Yt / YTD) x 100%

IET = (Et / ETD) x 100%

Where:

IFEV = exchange rate index of fishermen in t period

IYT = index of total family income of the fishermen in t period

Yt = total family income of fishermen in t periodt (month price applies)

Ytd = total time-based fishermen family income (monthly base)

IET = index of total fishermen family expenditures in t period

Et = total fishermen family expenditure in t period

Etd = total expenditure based in t period = fishing period (month, year, etc.) now bp = base period (month, year, etc.). In this calculation IFEV base year = 100.

To understand the welfare of fishermen, several parameters are used, such as income from fishermen’s fish catch, in addition to the revenue generated from non-fishing activities and expenditure for family needs. These parameters are used in a descriptive tool called exchange rate (ER).

FEV is basically an indicator to measure the level of relative well-being of fishing communities. It is likewise a measure of a family’s ability to meet the needs of subsistence fishermen. Thus, FEV is also referred to as exchange subsistence.

CLIMATE TRENDS AND PROJECTIONS

Variations and Changes Based on Historical Data

North Sulawesi province has a tropical climate that is influenced by monsoon winds. From November to April, westerly winds blow bringing rainfall to the North Sulawesi coast, while from May to October, dry southerly winds blow in the province. To analyze the nature and change in climate in North Sulawesi, climate data from BMKG stations were used.

Rainfall Pattern in North Sulawesi

The climatological analysis was conducted to study the North Sulawesi climate from historical data, including rainfall patterns and trends in climate parameters (rainfall, temperature, wind speed). North Sulawesi has a monsoon rainfall pattern with one wet season peak (Oct-Apr) and one dry season peak (Jun-Sep) as shown in Figure 14.

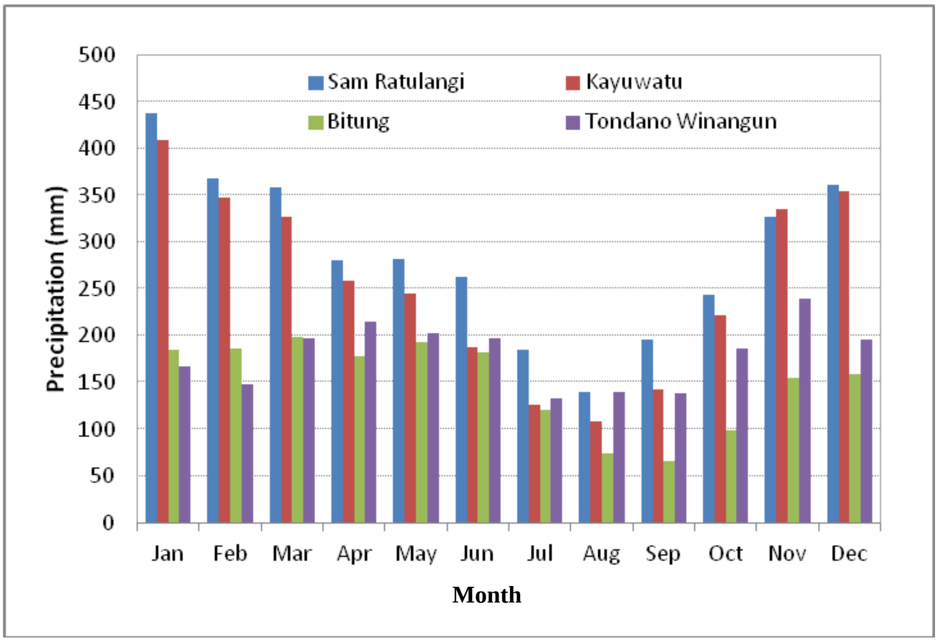
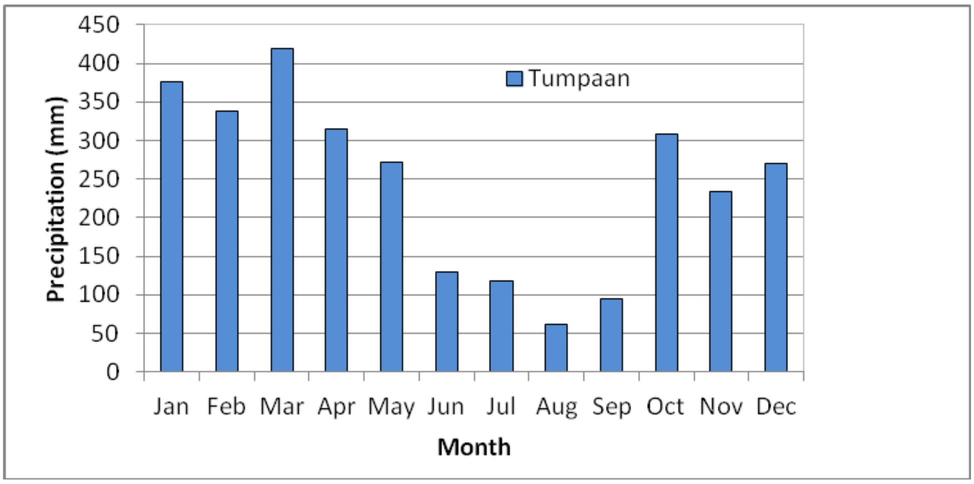


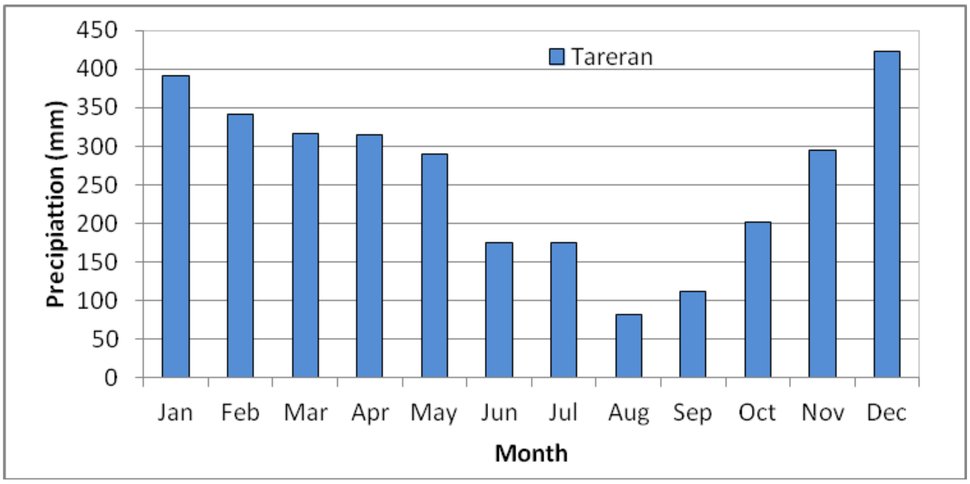
Figure 14. Precipitation Pattern in North Sulawesi

Rainfall Pattern in South Minahasa

Based on the calculation of average monthly rainfall in some observation spots in South Minahasa, the rainfall type in most areas of the regency is monsoonal, although there are some spots with insignificant monsoonal pattern in

Modoinding and Tompasu Baru districts. The rainfall pattern in the two areas tends to have two peak periods, November–December and April–May, with a discernible difference between dry season and rainy season. The rainfall patterns in five observation spots from 1986 to 2013 are shown in Figure 15.





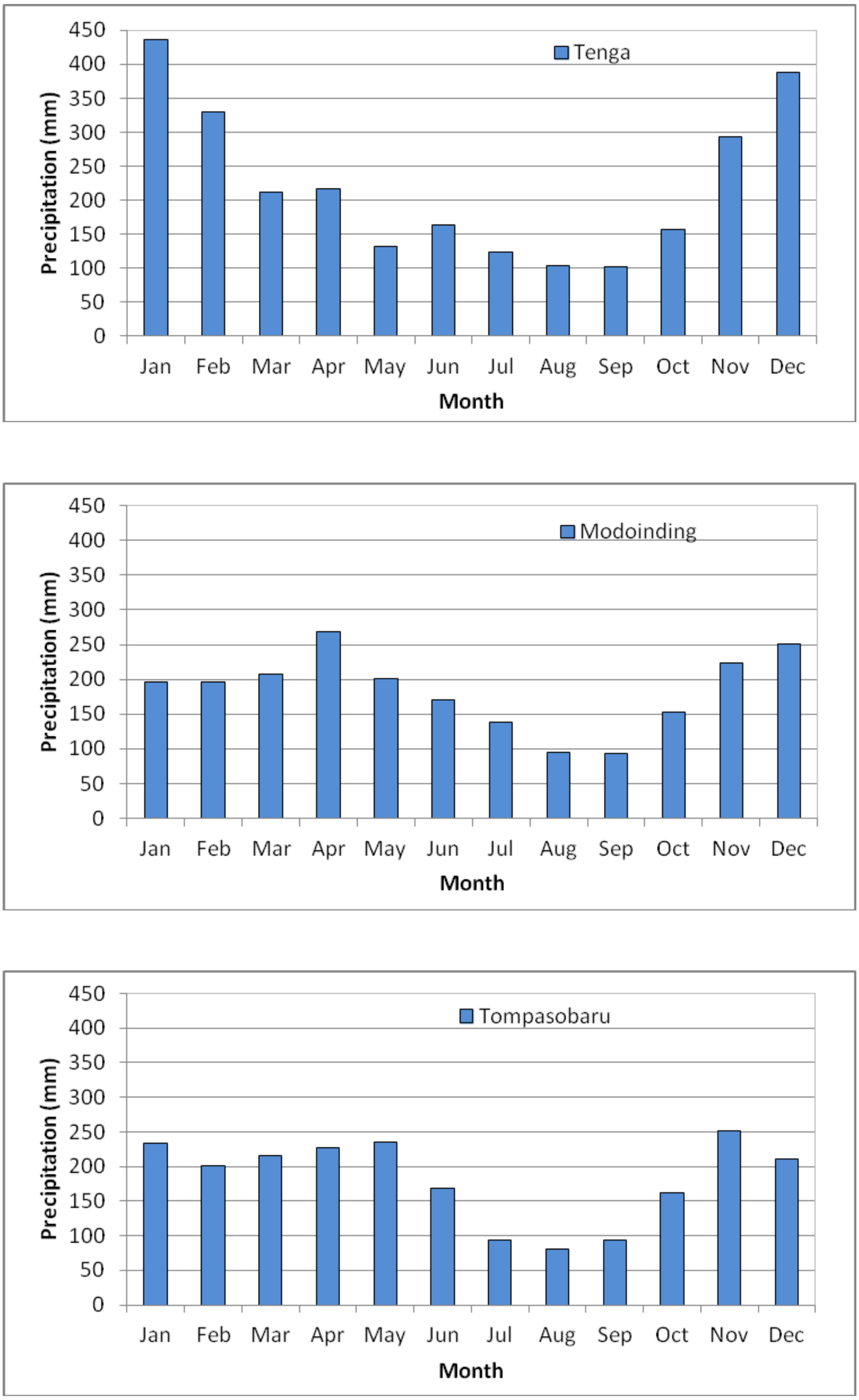


Figure 15. Rainfall Pattern in Each Station in South Minahasa

Based on the average monthly rainfall in all observation spots in South Minahasa, it is clear that rainfall in the regency is of the monsoon type, with the pattern resembling the normal V shape. Also based on the average monthly rainfall, the peak of rainfall in South Minahasa occurs in December, January, and February (DJF), while the dry season peaks in July, August, and September (JAS). During the DJF period, the wind that blows in South Minahasa is a moist north wind, while in the JAS period, the wind that blows in the regency is a hot south wind.

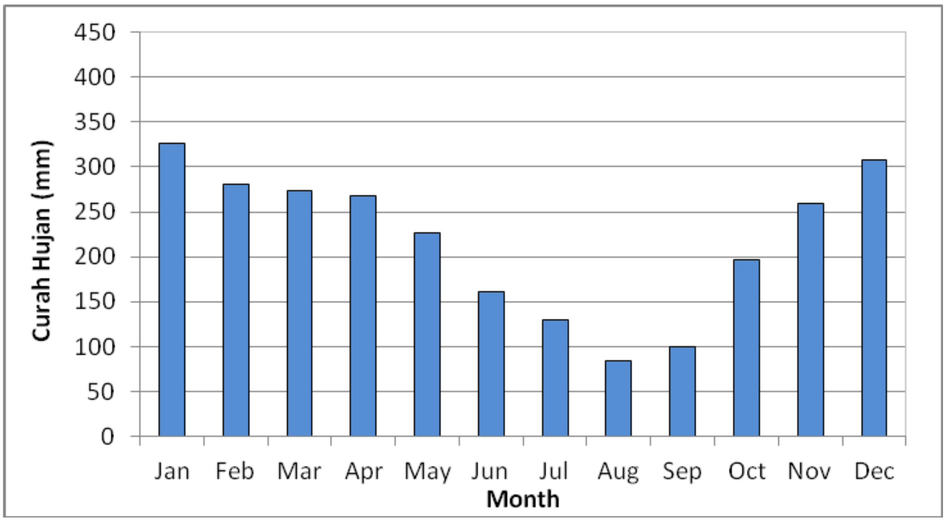


Figure 16. Rainfall Pattern in South Minahasa Based on Average Observation Data from All Stations in the Regency

Trends in Climate Parameters in North Sulawesi

Climate parameters were analyzed to determine the trends in total rainfall, temperature, and wind speed in North Sulawesi.

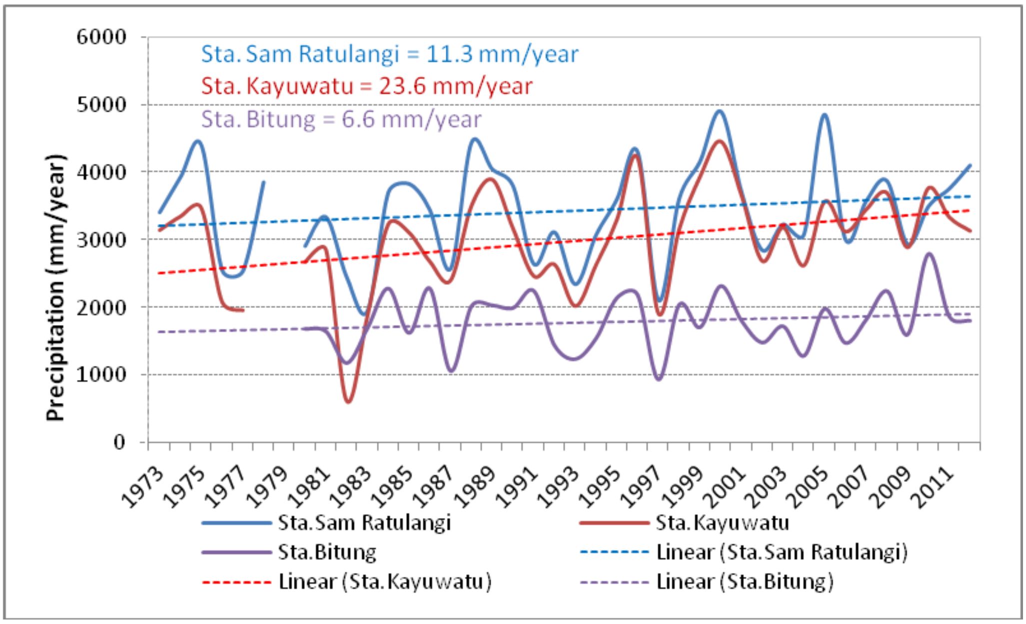


Figure 17. Trends in Total Yearly Rainfall in North Sulawesi

Yearly total rainfall in three stations in North Sulawesi shows that the rainfall trend has increased. The increasing trends in total rainfall at the Sam Ratulangi station (11.3 mm/year), .Kayuwatu station (23.6 mm/year), and Bitung station (6.6 mm/year) are shown in Figure 17.

Generally, the trends in the temperature parameter in the three stations in North Sulawesi have increased. Increasing temperature occurred at the Sam Ratulangi station (0.0026°C/year), Kayuwatu station (0.0157°C/year), and Bitung station (0.0082°C/year). The trend in average temperature in North Sulawesi is increasing (Figure 18). There was also an increasing trend in average wind speed in the province. The increase in inwind speed was 0.0157mm/s/year at Kayuwatu station and 0.0172 mm/s/year at Bitung station (Figure 19).

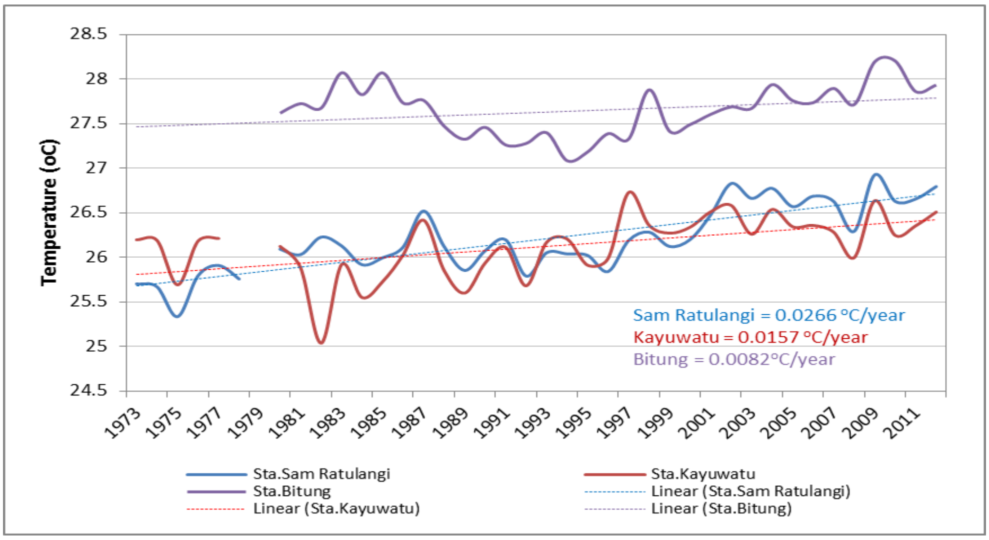


Figure 18. Trends in Average Yearly Temperature in North Sulawesi

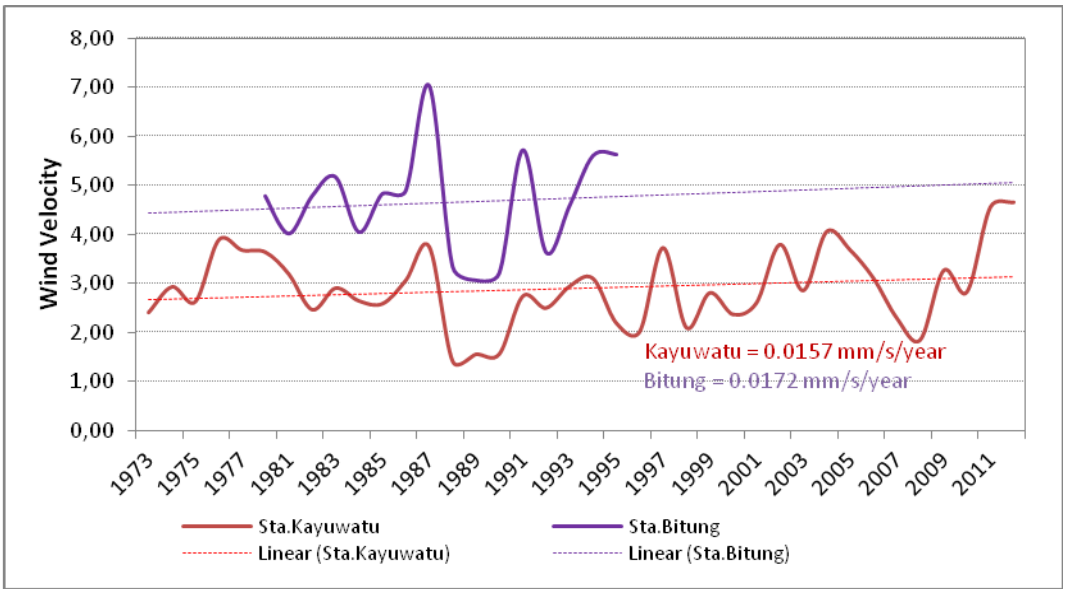


Figure 19. Trends in Average Wind Speed in North Sulawesi

Observed Seasonality: Present Climate Condition

A comparison of the two time periods using observation data estimated in South Minahasa shows that the level of rainfall in the current period tends to be higher than in the past period, especially during the peak of the rainy season (December-January-February-March), as shown in Figure 20.

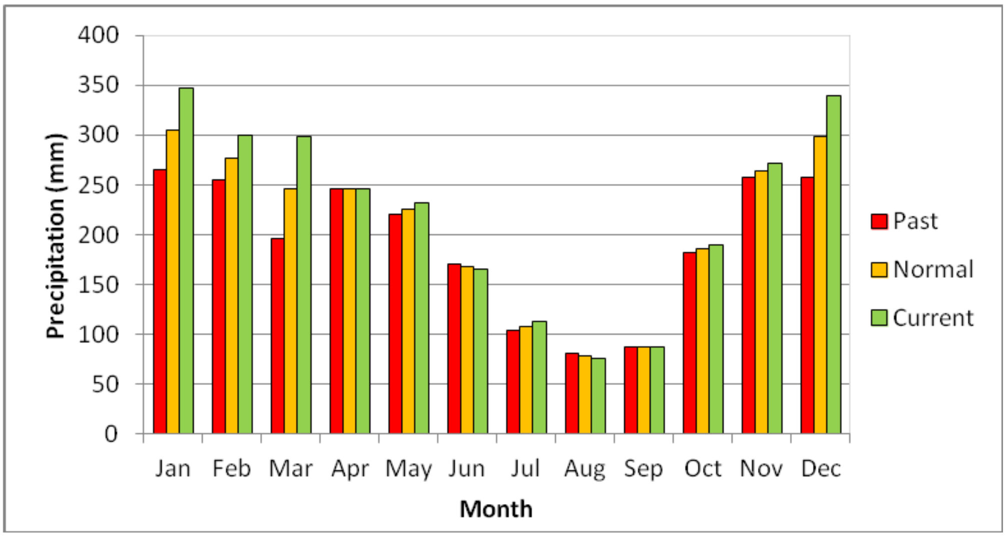


Figure 20. Comparison of Rainfall in Different Periods Based on Observation Data in South Minahasa

A comparison of Climate Research Unit (CRU) rainfall data for North Sulawesi also shows a tendency for the current period to be wetter than the past period (Figure 21). This condition may be due to the increasing rainfall in the current period being related to the increasing rainfall intensity per day, month, or season.

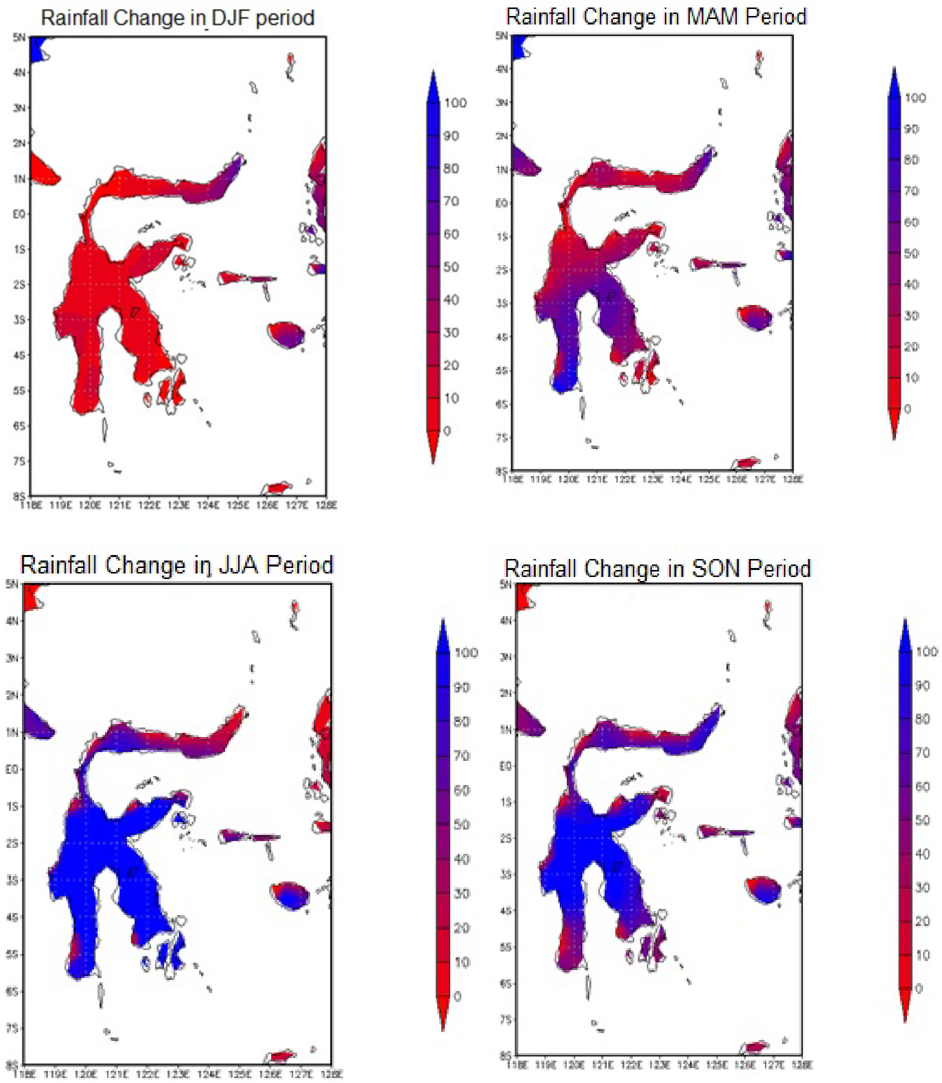
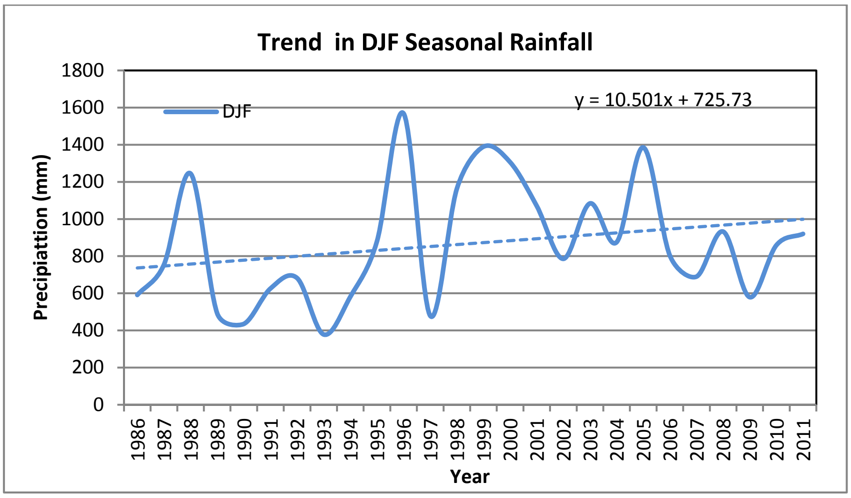
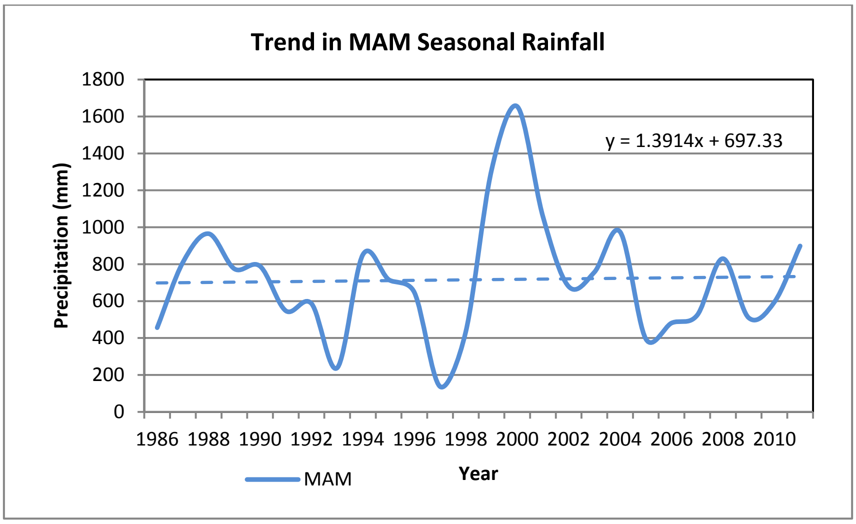
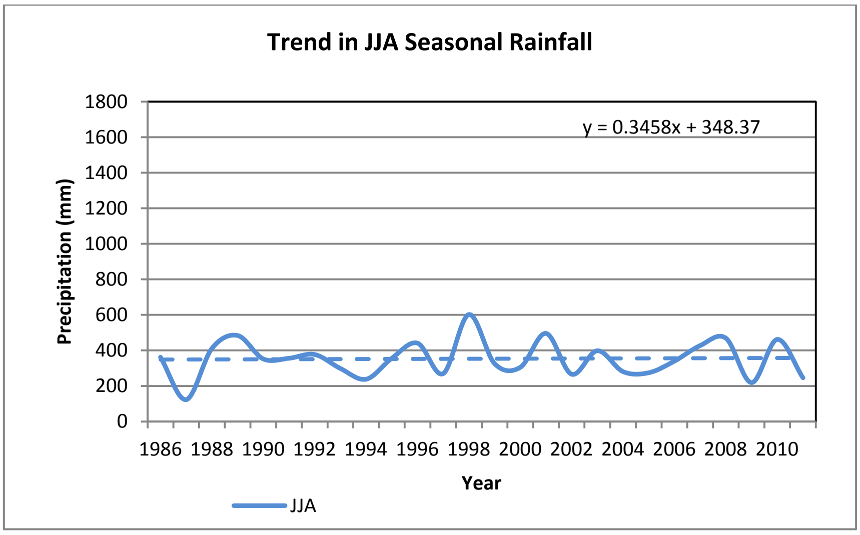


Figure 21. Comparison of Seasonal Rainfall Changing in Different Periods Based on Climate Research Unit 9 (CRU) Data

Seasonal rainfall observation in South Minahasa shows an insignificant positive trend. Figure 22 shows that seasonal rainfall in the DJF period tends to have the largest increase of 10 mm/year. During the rest of the year, increases are small: 1.4 mm/year in the March-April-May (MAM) period, 0.025 mm/year in the June-July-August (JJA) period, and 1.65 mm/year in the September-October-November (SON) period.


Trend in DJF Seasonal Rainfall
y = 10.501x + 725.73
DJF
Precipiattion (mm)
Year


Trend in MAM Seasonal Rainfall
y = 1.3914x + 697.33
Precipitation (mm)
Year
MAM


Trend in JJA Seasonal Rainfall
y = 0.3458x + 348.37
Precipitation (mm)
Year
JJA

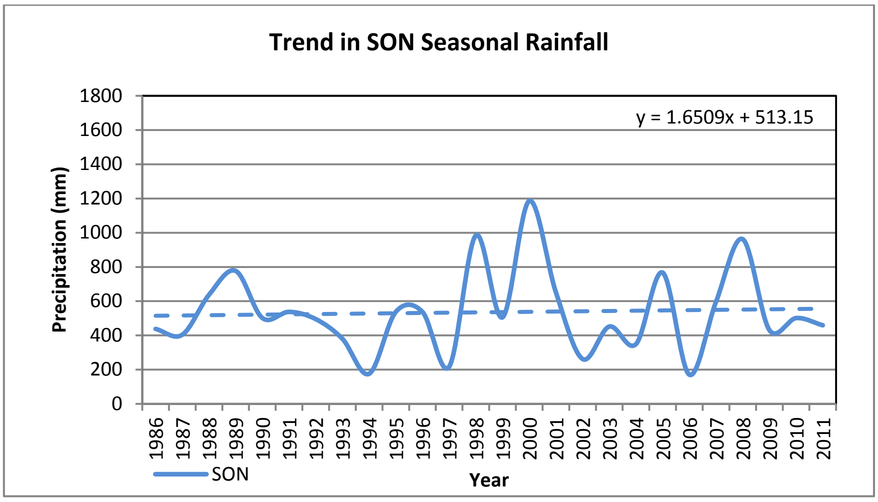


Figure 22. Trends in Seasonal Rainfall in South Minahasa Based on CRU Observation Data

Based on an estimation of seasonal rainfall using CRU data, the overall trend in seasonal rainfall in South Minahasa is slightly positive (Figure 22).

IPCC (2007) states that a rainfall trend is not linear as it is caused by the complexity of rainfall formation, with rainfall variability higher than other climate parameters such as temperature. However, Figures 23 and 24 indicate that rainfall in the current period tends to be higher than in the past period.

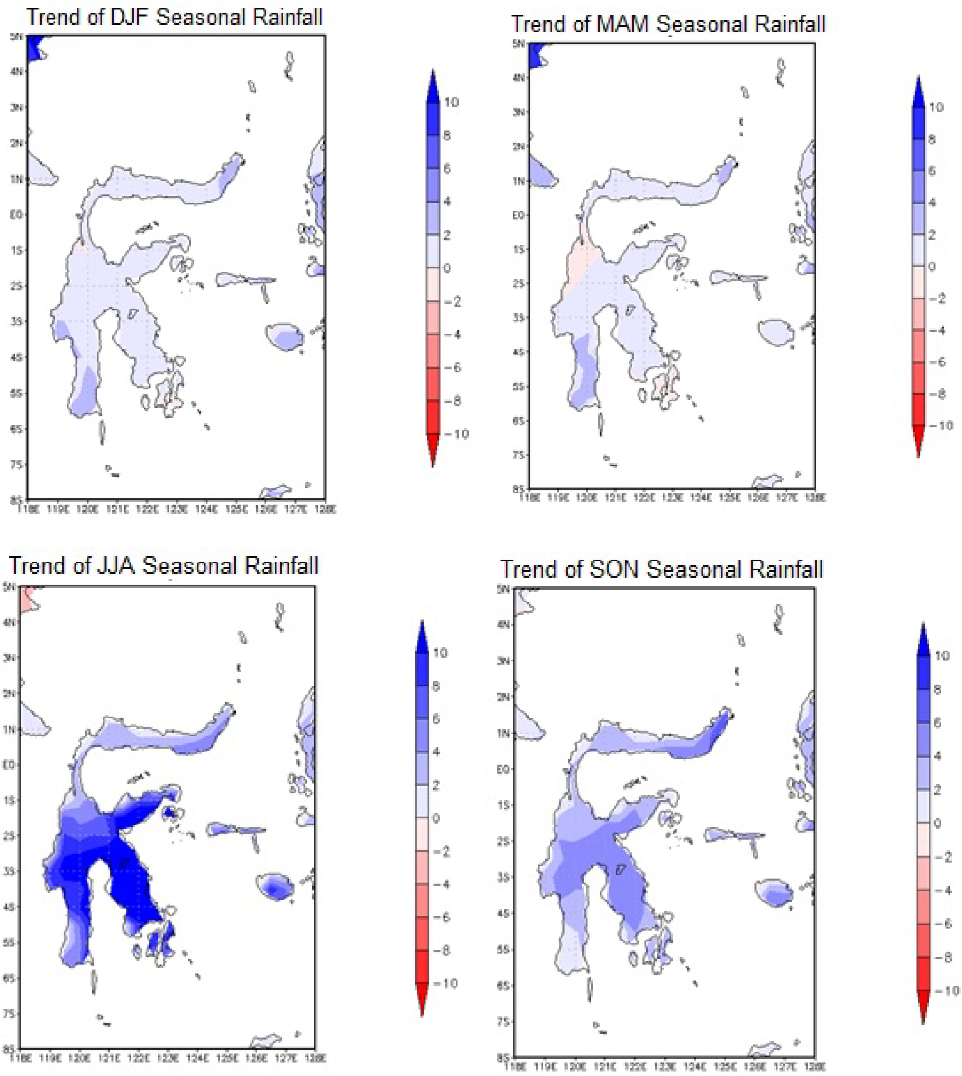


Figure 23. Trends in Seasonal Rainfall Based on CRU Data

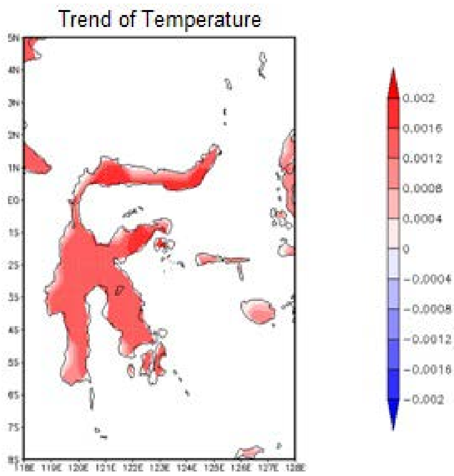
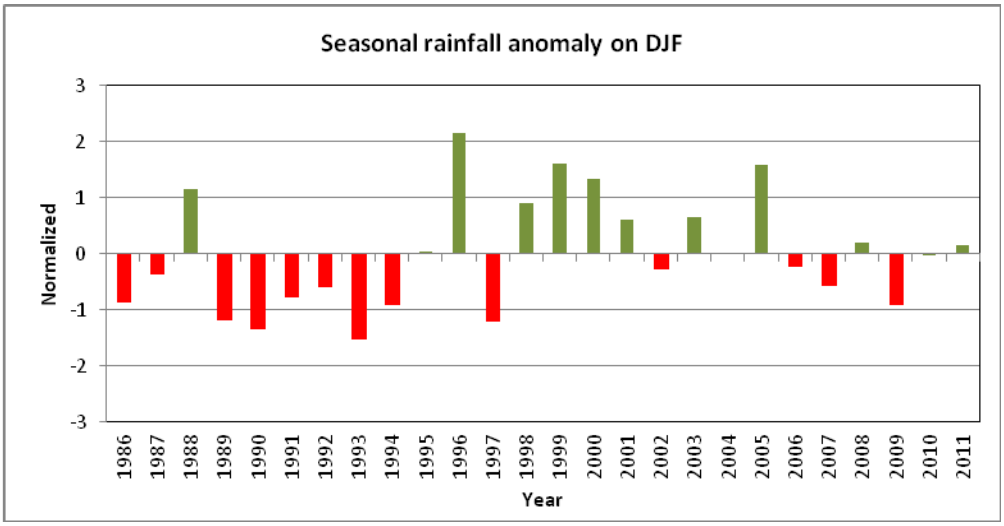
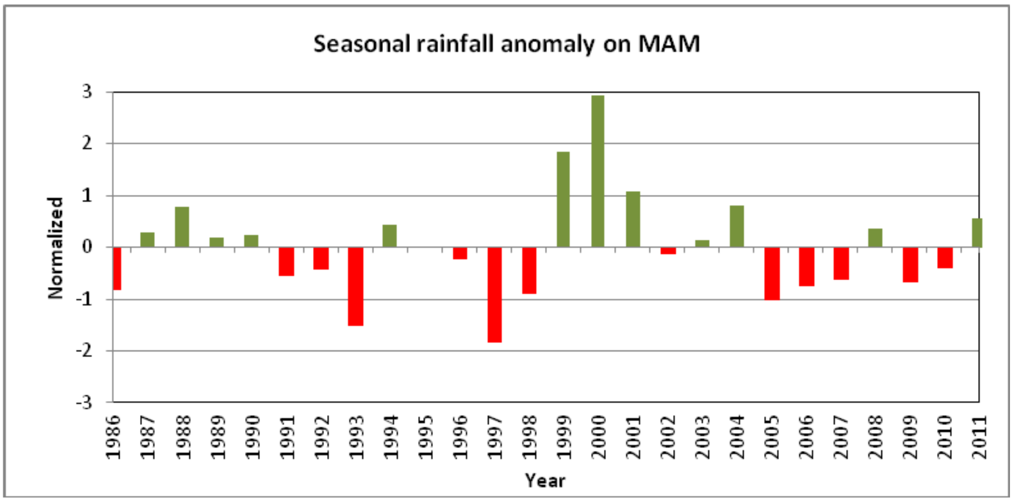


Figure 24. Trends in Temperature Based on CRU Data

Extreme Climate Analysis

Based on the above explanation, seasonal rainfall in South Minahasa is influenced by global climate phenomena and variability of ENSO and IOD as well as the regional monsoon climate phenomenon. The sharp difference in variability of ENSO and IOD between one period and another period is known as climate anomaly or extreme climate. One way to indicate climate anomaly, based on rainfall data, is by using a normalization index. If the normalization index value is 1, there is a positive climate anomaly (relatively wetter), whereas if the normalization index value is -1, there is a negative climate anomaly (relatively dryer) during the period. The anomaly values of rainfall by season, based on measured rainfall data from 1986 to 2010 in South Minahasa, are shown in Figure 25.





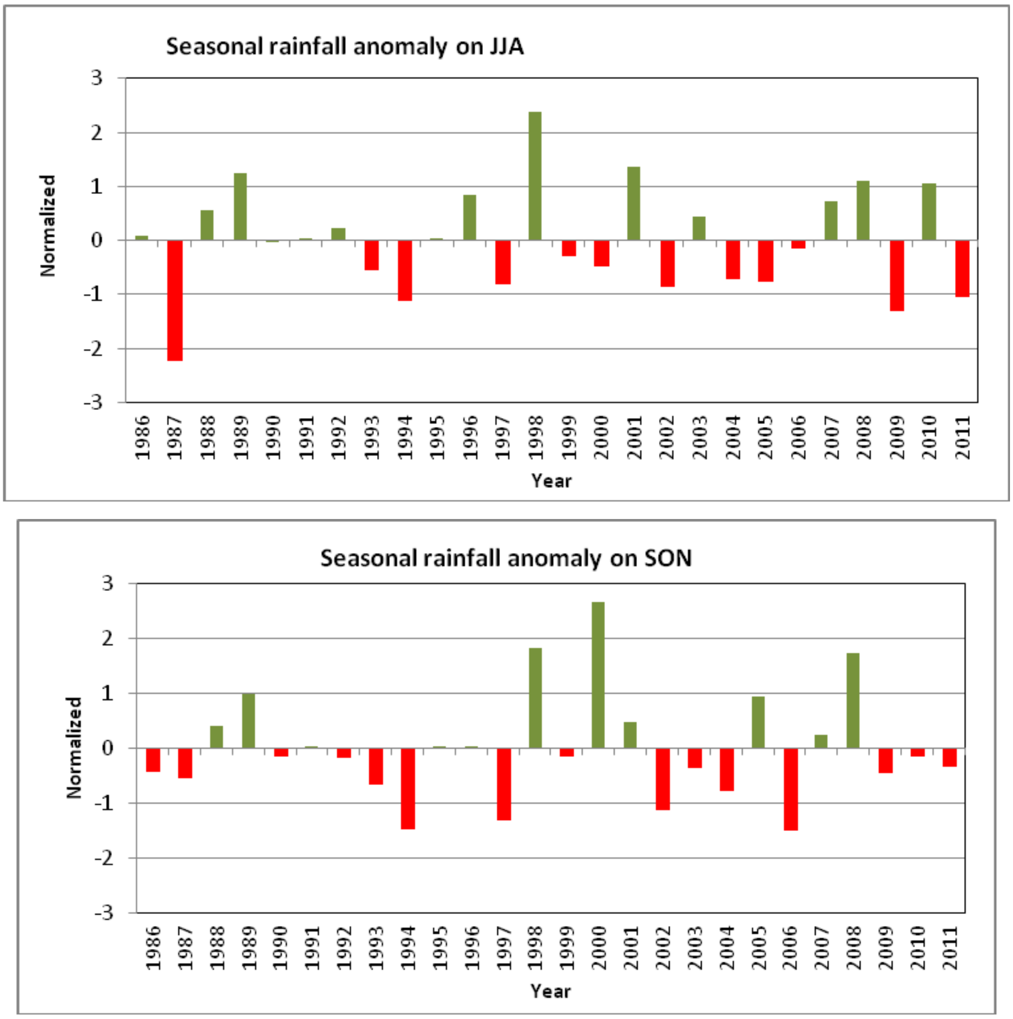


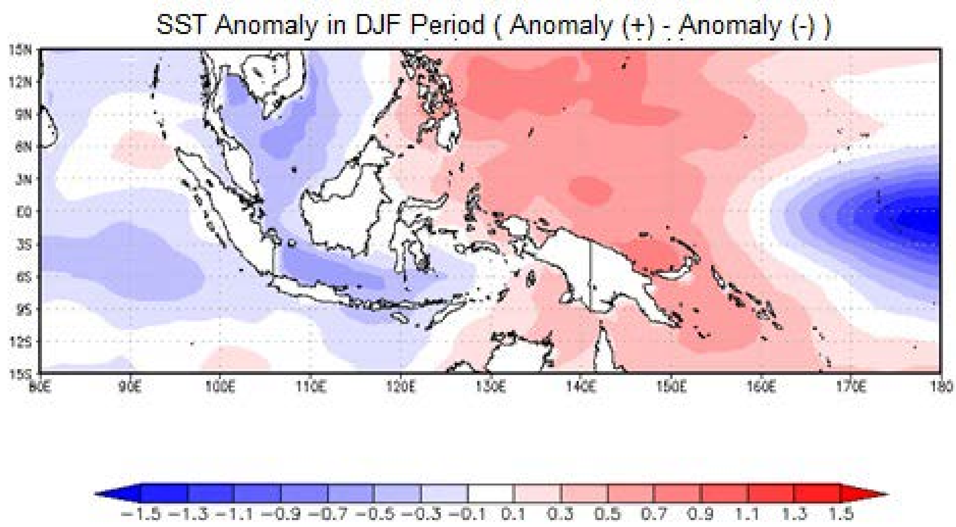
Figure 25. Seasonal Rainfall Anomaly in South Minahasa

Figure 25 shows that the rainfall anomaly in each season differs in different time periods, which means that rainfall variability is different from one season to another. As shown in Table 6, in the DJF period, wet anomaly occurred in 1988, 1996, 1999, 2000, and 2005; dry anomaly occurred in 1989, 1990, 1993, 1997. In the MAM period, wet anomaly occurred in 1999, 2000, and 2001; dry anomaly occurred in 1993 and 1997. In the JJA period, wet anomaly occurred in 1989, 1998, 2001, 2008, and 2010; dry anomaly occurred in 1998, 2000, and 2008. In the SON period, wet anomaly occurred in 1998, 2000, and 2008; dry anomaly occurred in 1994, 1997, 2002, and 2006.

Table 6. Incidence of Wet and Dry Anomalies in Each Seasonal Period

DJF		MAM		JJA		SON	
Wetter	Dryer	Wetter	Dryer	Wetter	Dryer	Wetter	Dryer
1988	1989	1999	1993	1989	1987	1998	1994
1996	1990	2000	1997	1998	1994	2000	1997
1999	1993	2001		2001	2009	2008	2002
2000	1997			2008	2011		2006
2005				2010			

Analysis of rainfall anomaly occurrence provides factors that may influence rainfall anomaly in an area. For South Minahasa, wet anomaly (or dry) in DJF, MAM, JJA, and DJF periods is generally caused by warming (or cooling) of sea surface temperature not only in Sulawesi waters but in almost all Indonesian waters (Figure 26). As shown in Figure 26, when rainfall in South Minahasa is above (or below) normal, sea surface temperature is warming (or cooling).



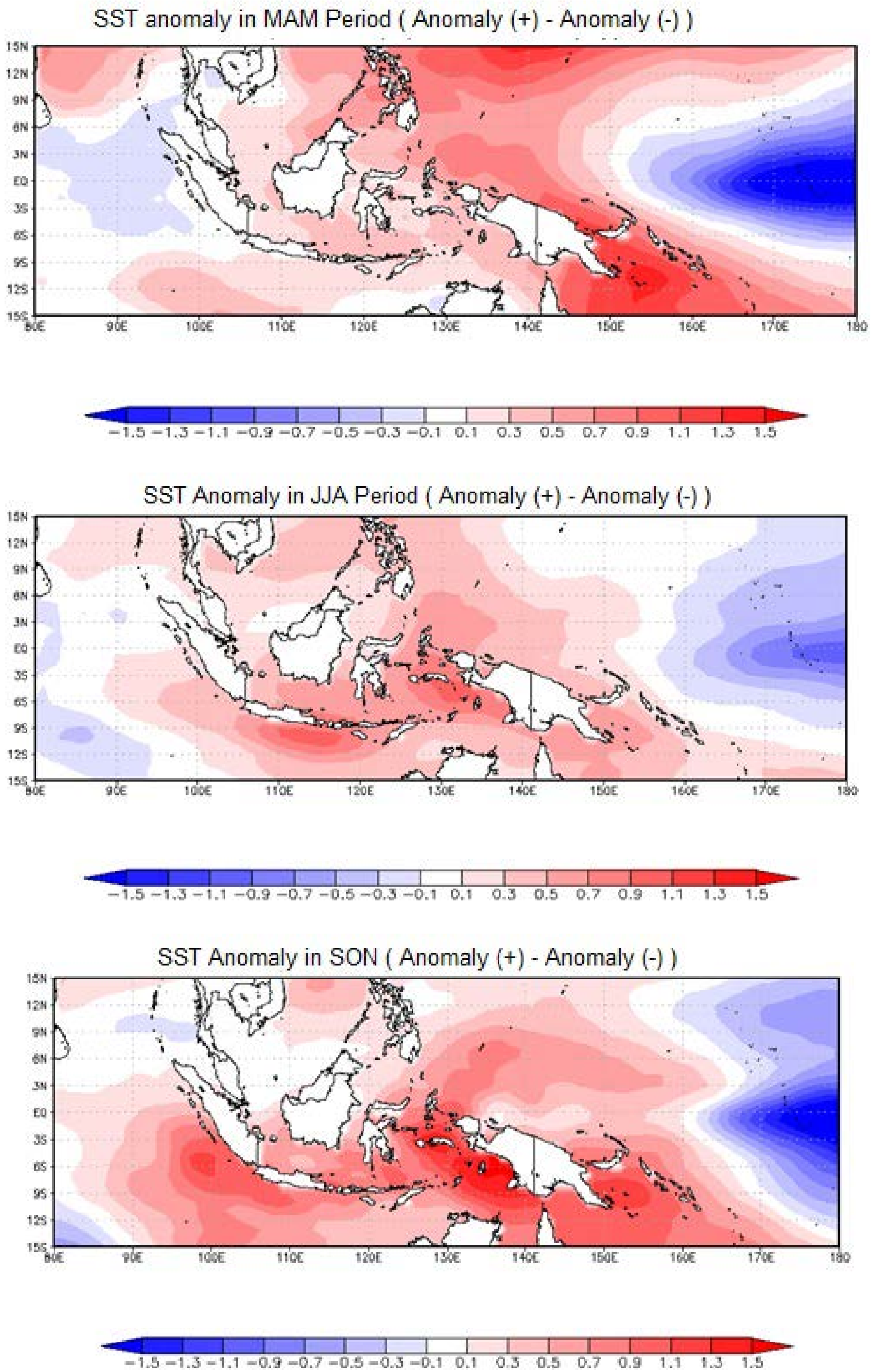
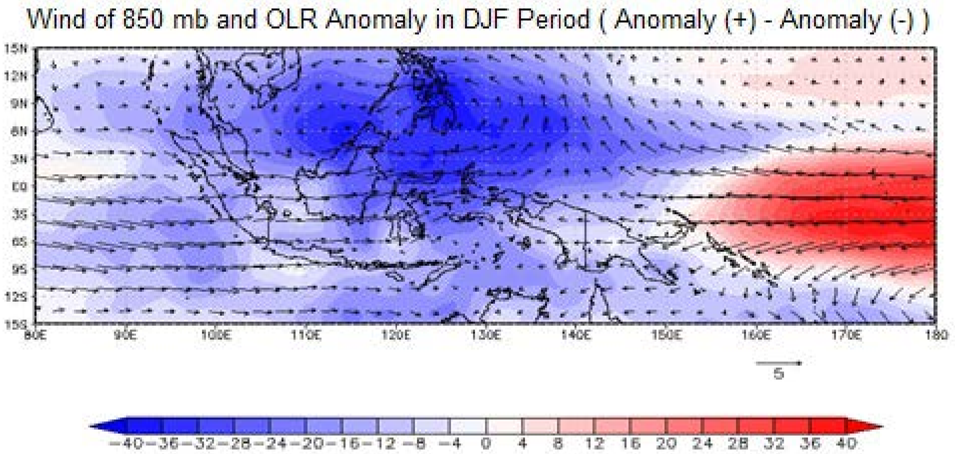


Figure 26. Composite of Water Surface Temperature Based on Rainfall Anomaly Occurrence in South Minahasa

Besides water surface temperature, rainfall anomaly in Indonesia may also be influenced by wind movement of 850 mb (Prabowo, 2010), which is caused by the global phenomena of ENSO and IOD. Composite result of wind anomaly of 850 mb and Outgoing Longwave Radiation (OLR) shows that wet anomaly (or dry) in South Minahasa in the DJF period is caused by the strengthening (or weakening) of the west wind from the Indian Ocean towards Indonesia and the strengthening (or weakening) of the easterly trade wind from the Pacific Ocean towards Indonesia. A cyclonic circulation (or anticyclone) formed in Philippine waters towards Indonesia is consistent with research results of Prabowo (2005). The wet anomaly (dry) in the MAM and SON periods is also caused by the strengthening (or weakening) of the west wind and the east trade wind. This triggers increasing (or decreasing) cloud development in Indonesia, including North Sulawesi, which is characterized by the presence of OLR negative (or positive) anomaly. On the other hand, in the JJA period, wet (or dry) anomaly is mainly due to the strengthening (or weakening) of the easterly trade wind that reaches Indonesia and experiences convergence (or divergence) around North Sulawesi, triggering an increase (or decrease) in cloud development around Sulawesi, Java, Bali, and Nusa Tenggara (Figure 27).



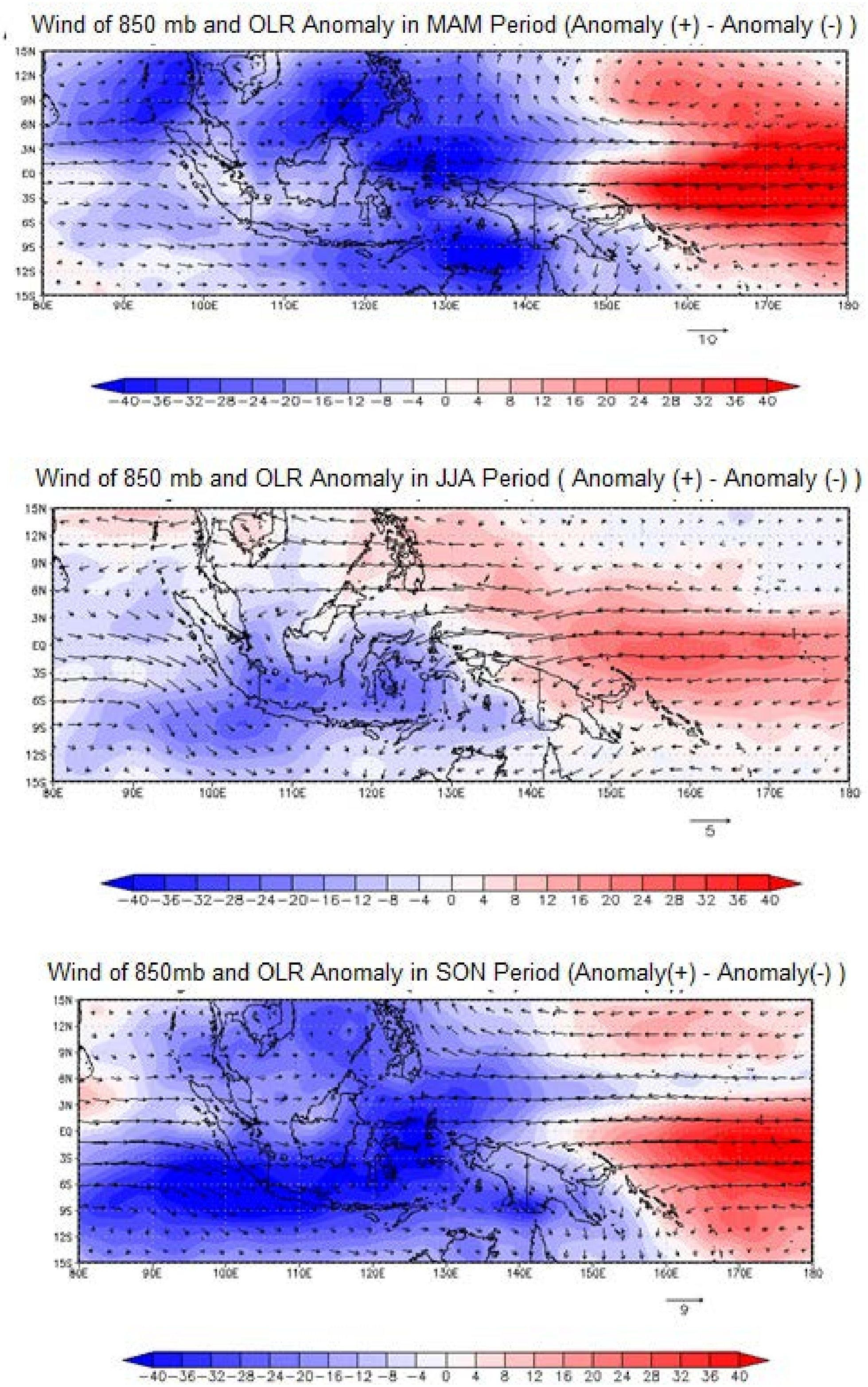


Figure 27. Wind Composite of 850 Millibars (Mb) and Outgoing Longwave Radiation (OLR) Based on Rainfall Anomaly Occurrence in South Minahasa

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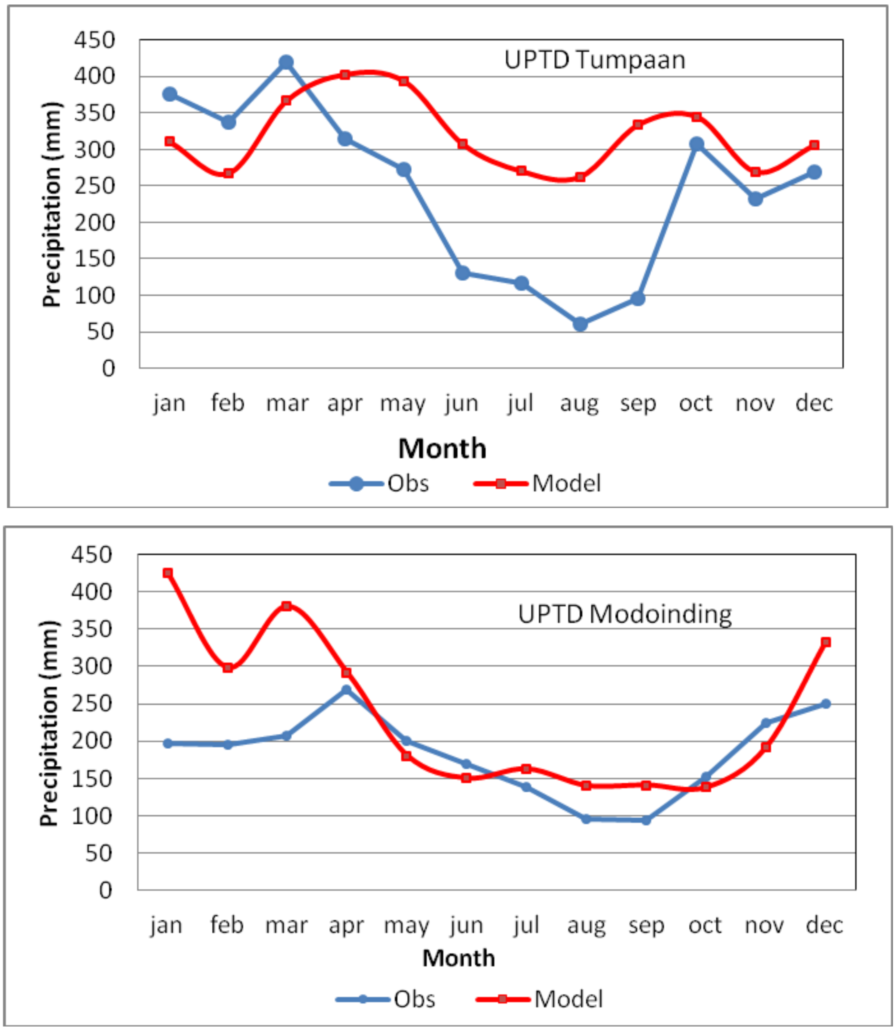
Climate Projections

Model MRI for Future Climate Projection

Comparison of monthly rainfall between observation data and model (MRI) data in South Minahasa shows that the two sets of data have similar patterns (Figure 28).



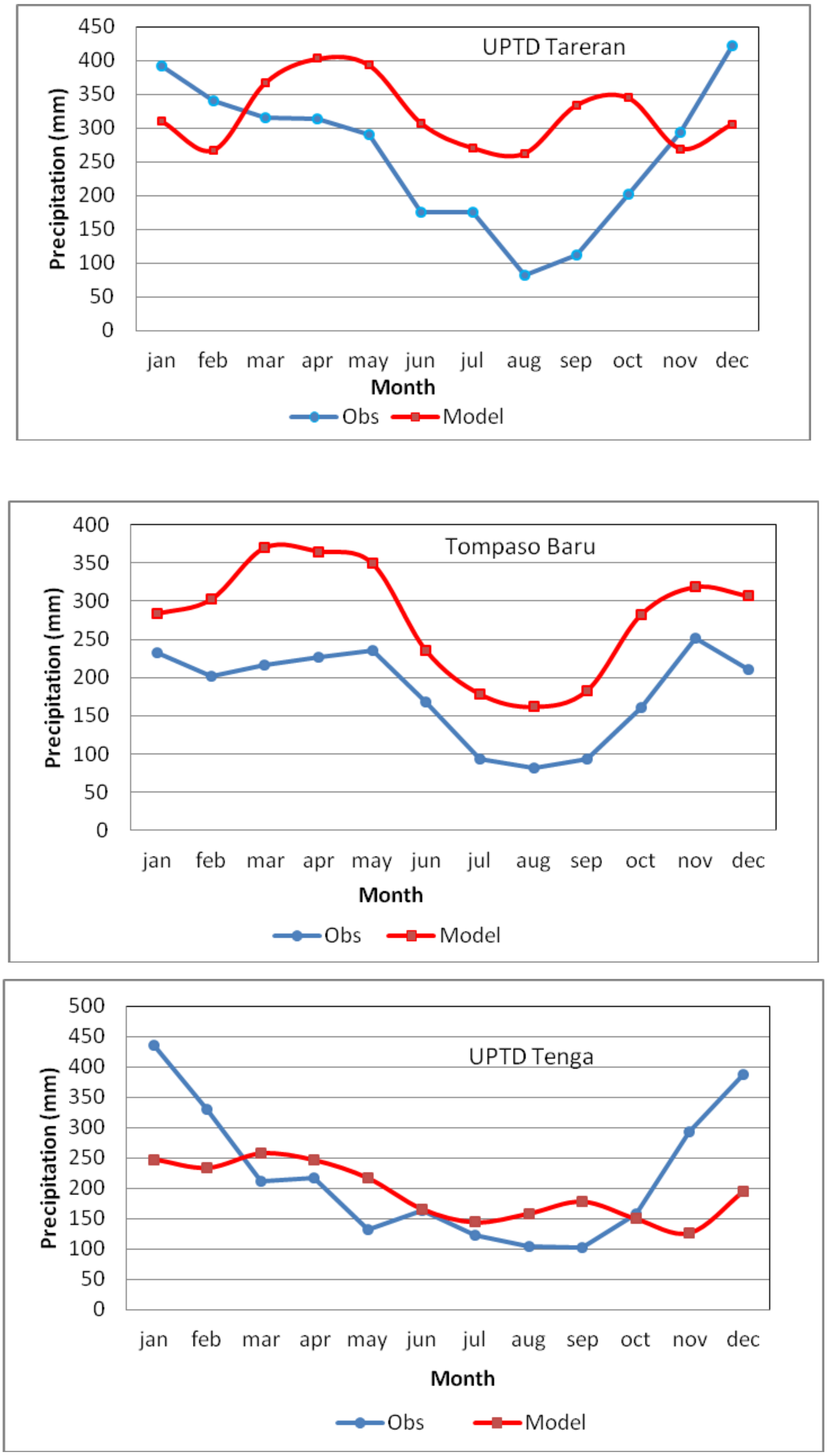


Figure 28. Comparison between Observation Data and Meteorological Research Institute (MRI) Model Data

Analysis and Projection of Future Climate

The analysis of future climate is conducted using MRI projection data that has been corrected with the observation data from rainfall stations in South Minahasa, North Sulawesi. The correction method uses bias correction, in which the model data is compared with the observation data to determine the correction factor for each month. This correction factor is used to correct the model data so that the corrected model data will be relevant to the observation data. The baseline period is determined for 1983-2007, while the near period is determined for 2014-2038.

Rainfall Projection

Results of the annual average rainfall comparison between baseline period (1983-2007) and near period (2014-2038) in South Minahasa (124.4◦ BT - 124.8◦ BT; 1.2◦ LU -1.4◦ LU) show that there is no significant change in the annual average rainfall pattern (Figure 29). As shown in Figure 29, rainfall pattern in the near period shows a similar pattern (monsoon pattern) with the baseline period (current condition). Figure 29 also shows that in the future (near period), the peak of rainfall in South Minahasa is predicted to occur in the period from December to February, while the peak of the dry season is predicted to occur in the period from July to September.

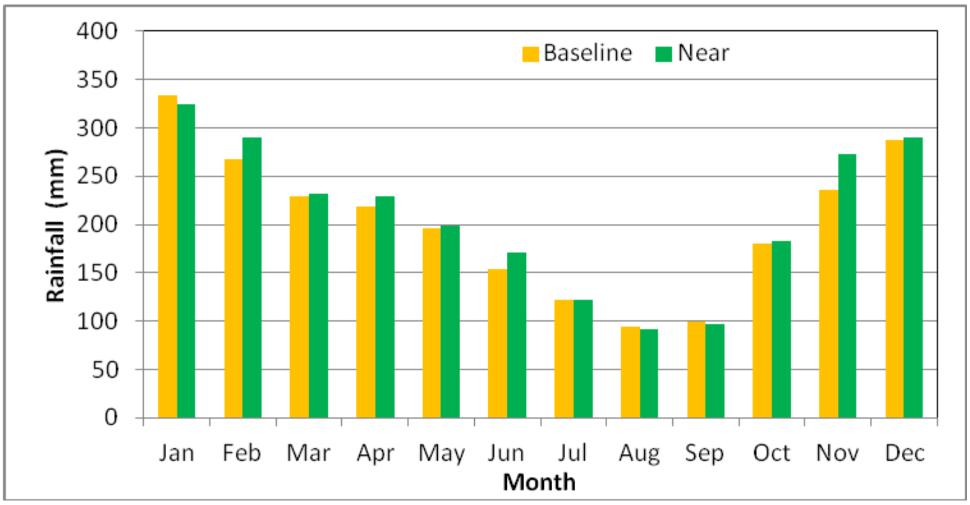


Figure 29. Comparison of Annual Average Rainfall Patterns between Baseline Period and Near Period

Figure 30 shows the percentage change in the amount of annual average rainfall between the near period and the baseline period. If the percentage change is positive, the near period is wetter; if the percentage change is negative, the near period is dryer. Generally, rainfall in the near period tends to be higher than the baseline period. According to the future projection, there will be an increase in rainfall ranging from 2% to 15% compared with the baseline period, especially in the period from February to July and the period from October to December. Meanwhile, in January, August, and September, it is projected that rainfall will be lower by approximately 3% than the baseline period. The reduced level of average annual rainfall in the future, which is projected to occur during the peak of the dry season (August-September), should be of public concern in South Minahasa, especially for potential drought hazards.

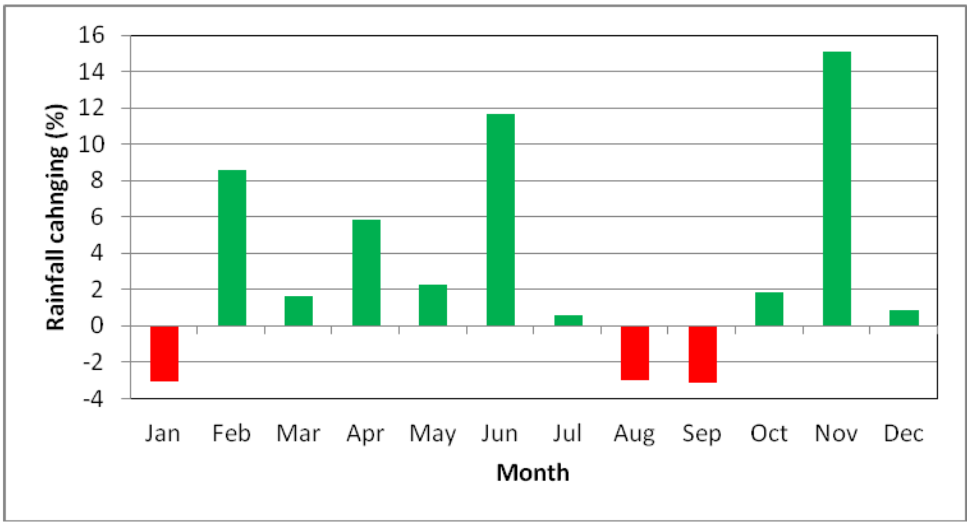


Figure 30. Percentage of Rainfall Change in Near Period Relative to Baseline Period

The IPCC reports that the impact of climate change on rainfall will not be visible when viewed from the amount of rainfall because the rainfall pattern in the future will tend to be similar to the current period. The rainfall variability in the near period compared with the baseline period is not significant (Figure 31).

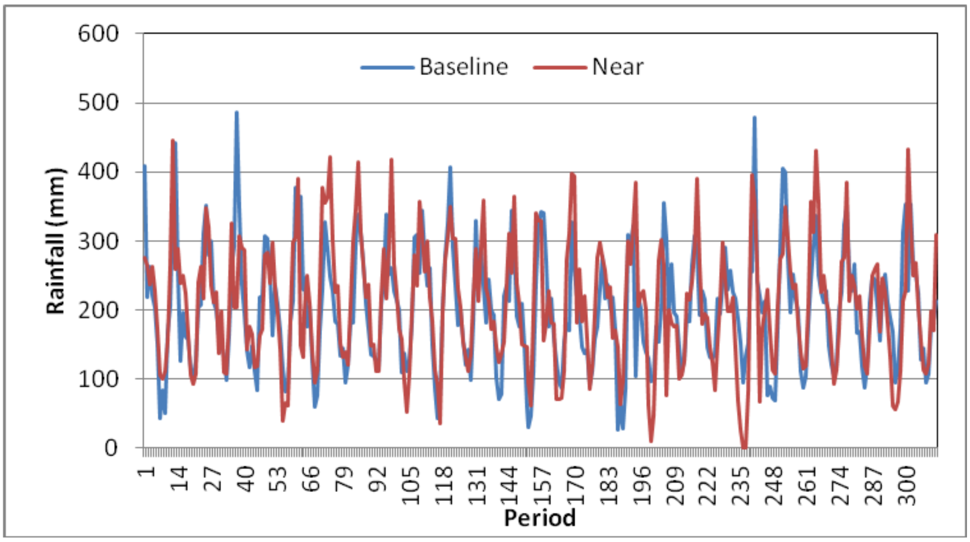


Figure 31. Comparison of Rainfall Patterns between Baseline Period and Near Period

Temperature Projection

The comparison between near period and baseline period shows that the air temperature in the future will tend to be hotter than the baseline period (Figure 32), with the highest temperature expected from July to September and the lowest temperature from November to February. The projection in temperature change shows the highest temperature increase of 0.83◦C in August and 0.81◦C in March, while the lowest temperature increase is projected at 0.66◦C in June and 0.69◦C in November (Figure 33).

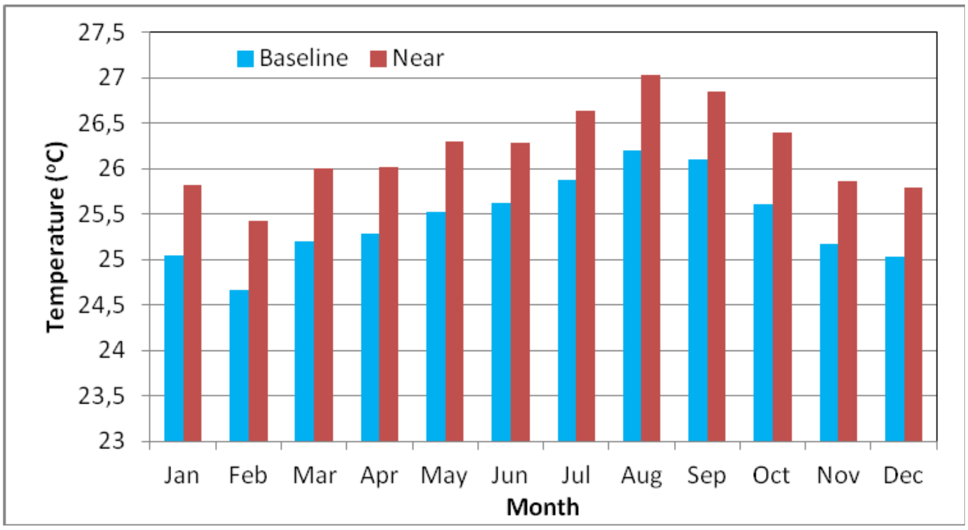


Figure 32. Comparison of Temperature Patterns between Baseline Period and Near Period

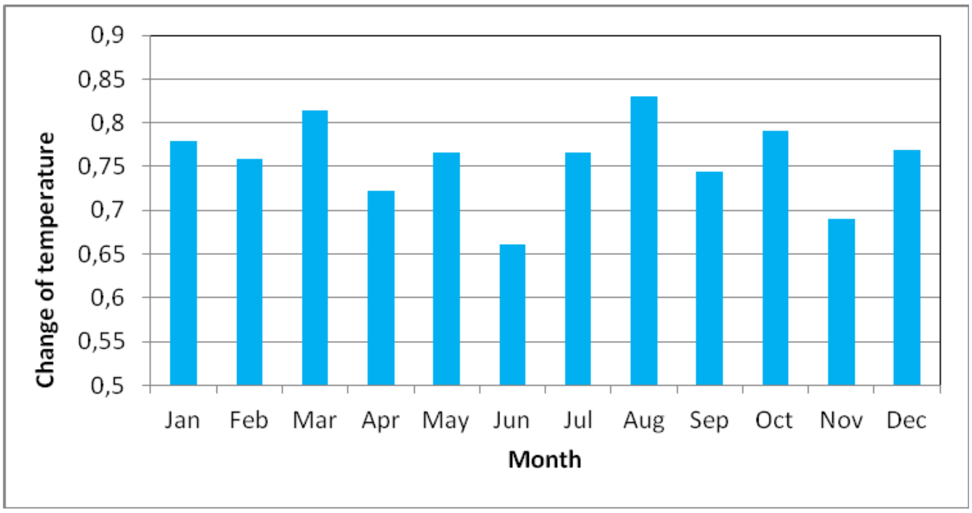


Figure 33. Change in Temperature in Near Period Relative to Baseline Period

In contrast to rainfall, air temperature increase has a linear trend. Based on the time series comparison of air temperature between the near period and the baseline period, the temperature in the near period is consistently higher than the baseline period (Figure 34). This shows that the temperature in the near period will increase faster than the baseline period. The temperature is projected to increase by 0.0028°C/month in the near period, and by 0.0011°C/month in the baseline period.

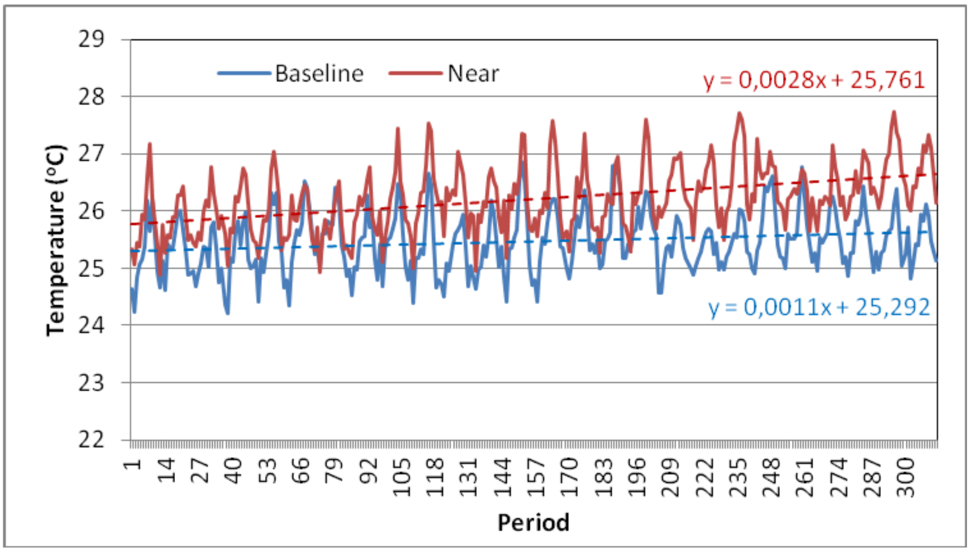


Figure 34. Comparison of Temperature Trends between Baseline Period and Near Period

Wind Projection

The comparison between the near period and the baseline period shows that wind speed in the near period tends to be higher than the baseline period in

February, March, August, September, and October. On the other hand, wind speed in the near period tends to be lower than the baseline period in January, April, May, June, July, November, and December (Figure 35). As shown in Figure 35, the fastest wind speed in the near period occurs in August and September, while the slowest wind speed occurs in April to November. It is projected that the wind speed will have the highest increase of 0.41 mm/s in March and 0.46 mm/s in September, while the lowest increase in wind speed is projected at 0.49 mm/s in May and 0.41 mm/s in June (Figure 36).

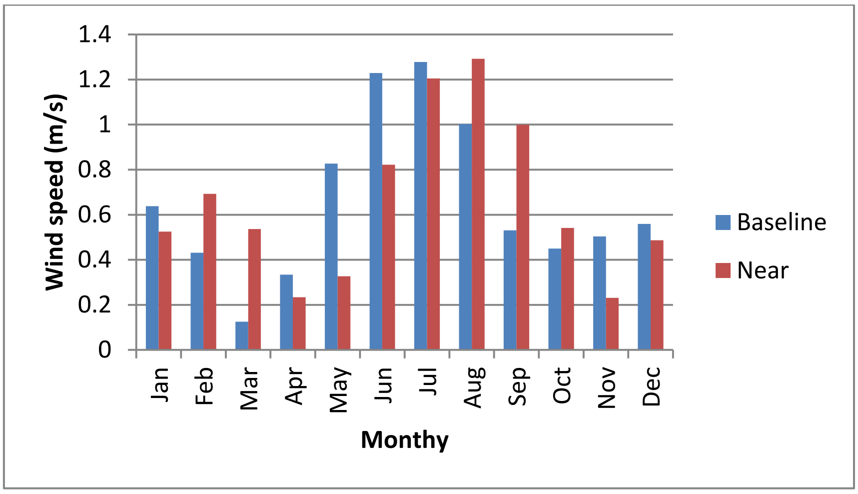


Figure 35. Comparison of Monthly Average in Wind Speed between Baseline Period and Near Period

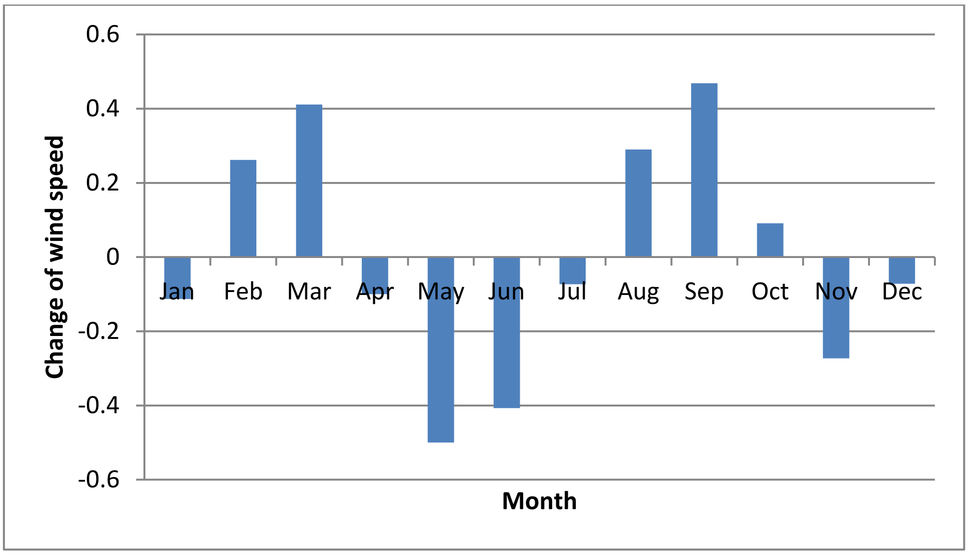


Figure 36. Change in Wind Speed in Near Period Relative to Baseline Period

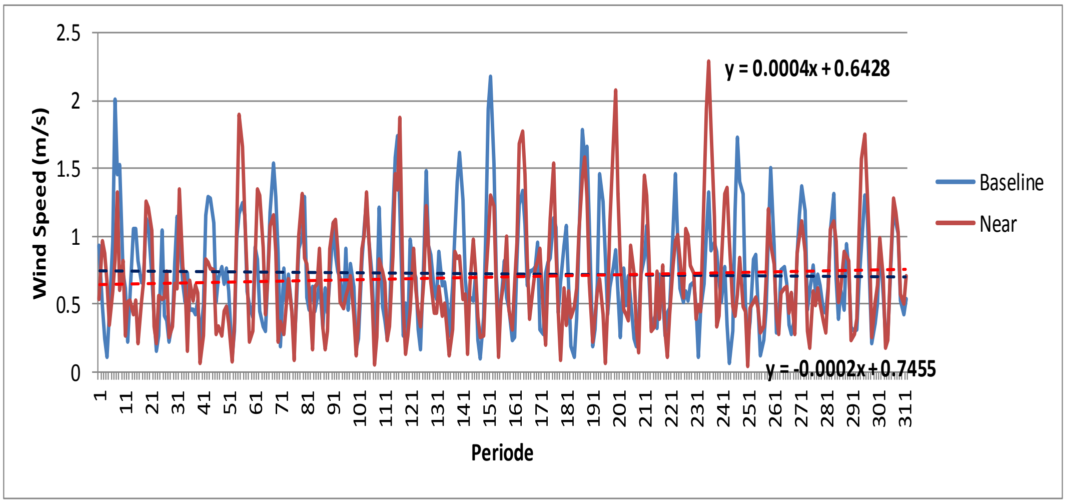


Figure 37. Trends in Wind Speed in Near Period Relative to Baseline Period

There is no significant change in the trends in wind speed between the near period and the baseline period (Figure 37).

Sea Surface Temperature Projection

To analyze the sea surface temperature (SST) in South Minahasa, seawater data was extracted around the regency (123.8◦ - 124 ◦W and 1.2◦ - 1.4◦ N). Like air temperature, sea surface temperature is projected to rise compared with the current period. Figure 38 shows that the temperature of seawater in the near period is projected to rise in all months compared with the baseline period. In the future, sea surface temperature is projected to increase from 28.95◦C to 29.60◦C from the baseline period.

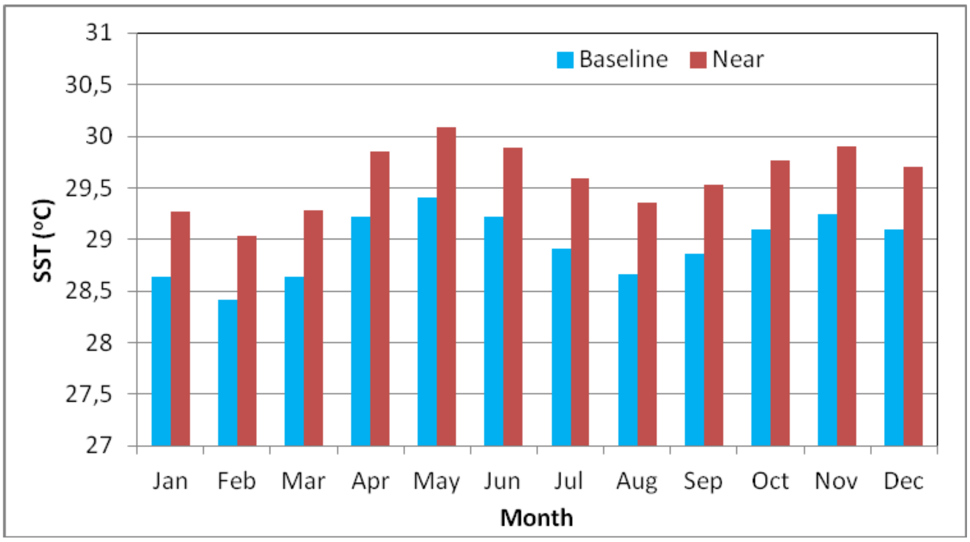


Figure 38. Comparison of Sea Surface Temperatures between Baseline Period and Near Period

The highest change in SST from the baseline period is projected to occur during the dry season from May to September (Figure 39). The increase in SST is projected to trigger the evaporation process, which could lead to the formation of more clouds that will bring more rain to South Minahasa.

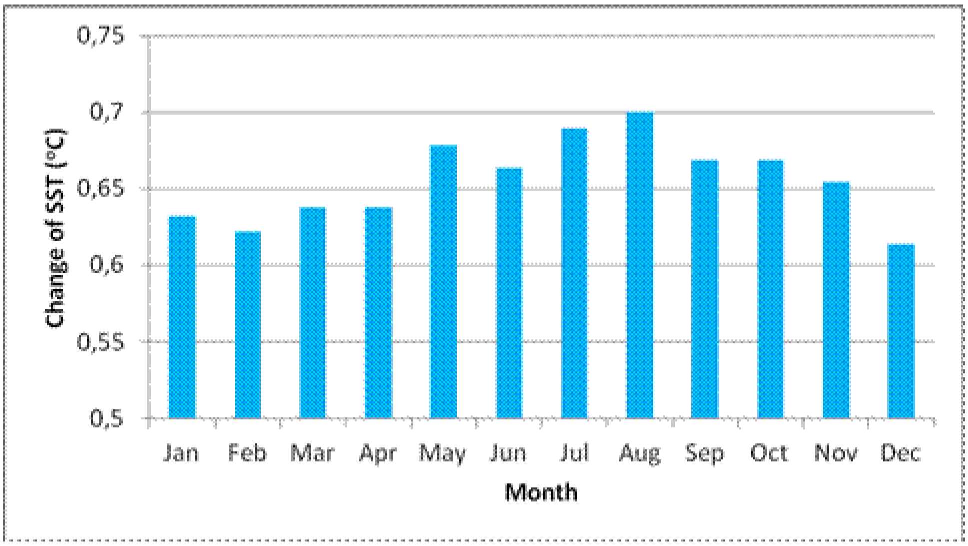


Figure 39. Changes in Sea Surface Temperature from Baseline Period to Near Period

Similar to air temperature, SST in the near period is higher than the baseline period and the rate of its increase in the near period is faster compared with the baseline period (Figure 40). It is projected that the highest increase in SST in the near period will be 0.0022°C/month, while the baseline period is projected to have an SST increase of 0.0007°C/month. The higher SST and the rapid rate of SST increase are projected to have an impact not only on the weather but on the marine life in the waters of South Minahasa. Negative impacts on marine life of rising SST include coral bleaching and a decline in fish harvest as fish will tend to swim into deeper waters and be difficult to catch.

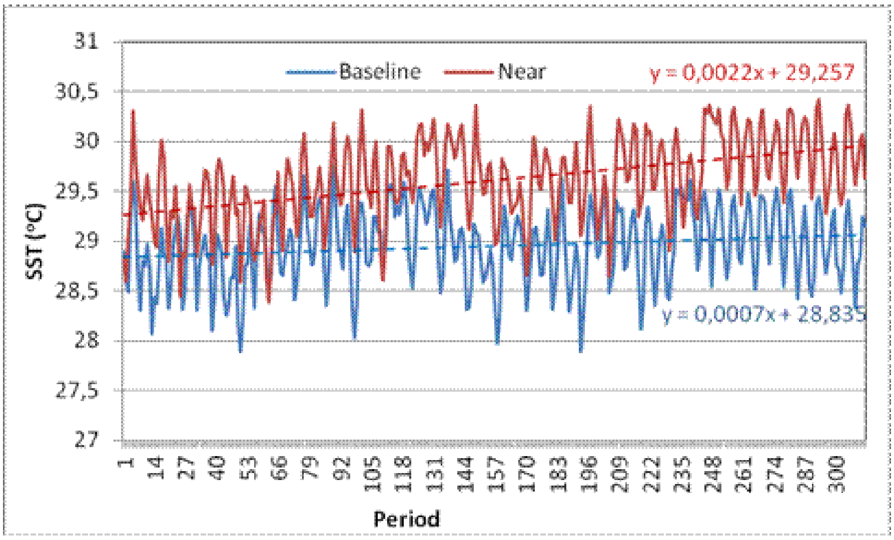


Figure 40. Comparison of Sea Surface Temperature Trends between Near Period and Baseline Period

Sea Level Rise Scenario

The sea level rise (SLR) scenario analysis was conducted using the Shuttle Radar Topography Mission (SRTM) 90+ model with a 3m scenario. This analysis was limited because the resolution of data used was about 90 m. It would have been better if higher resolution data were used in the analysis. Figure 41 shows that sea level rise is projected to reach the coastal area of Arakan village and the western part of Rap Rap village, Tatapaan district.

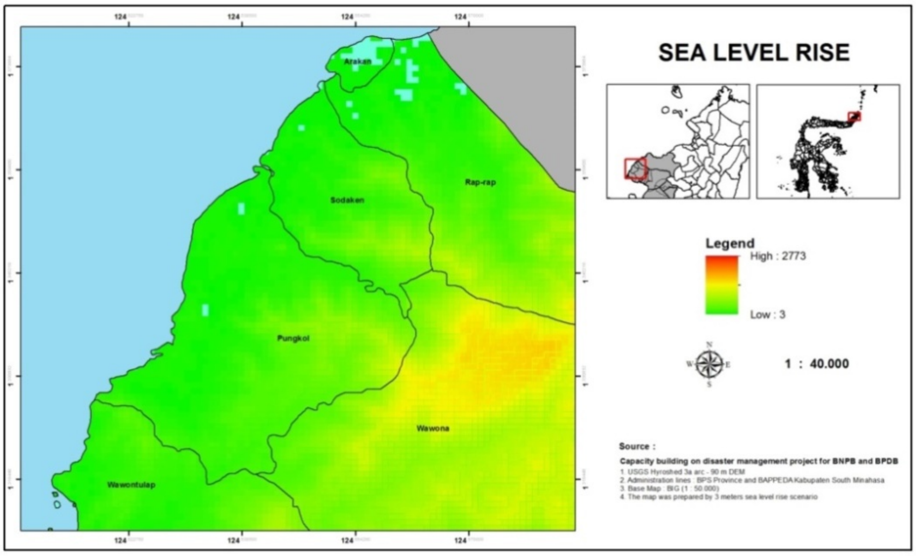


Figure 41. Sea Level Rise Scenario in South Minahasa Using Shuttle Radar Topography Mission (SRTM) 90+ Model

VULNERABILITY ASSESSMENT IN AMURANG BAY

Exposure to Extreme Events

Climate Trend Analysis for Baseline and Near Periods

The trend in climate exposure is calculated as the change between the near period and the baseline period for consecutive dry days (CDD), consecutive wet days (CWD), and rainfall over 50 mm/day (R50) and presented as an index: *(near period value minus baseline period value)/baseline period value.*

The change in CDD in Amurang Bay has an index greater than 0.4-0.5, some with a value <0.4, or less than 40% increase in CDD, especially in the northeast part of South Minahasa. The highest CDD change in South Minahasa, with a value of 0.8-0.9, was found in the western part of Tumpaan district. This shows that in the near period, the district has an 80% to 90% likelihood of consecutive dry days than the baseline period (Figures 42 to 44).

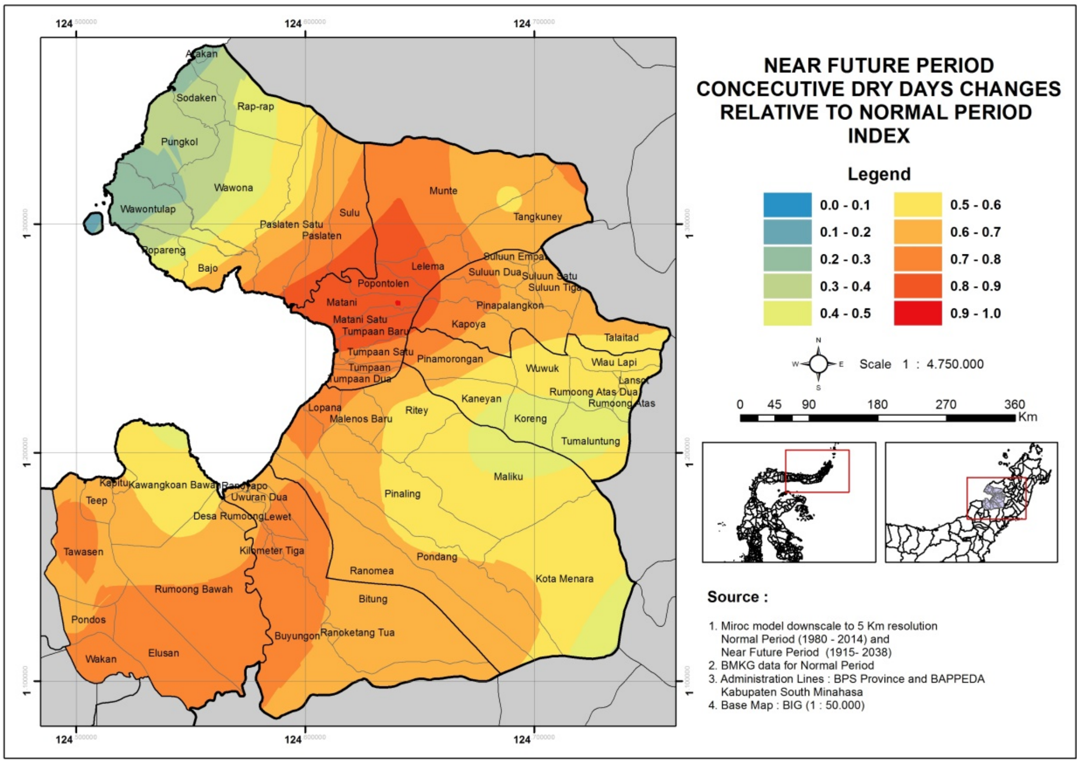


Figure 42. Map of Near Period for Consecutive Dry Days (CDD) Changes Relative to Baseline Period

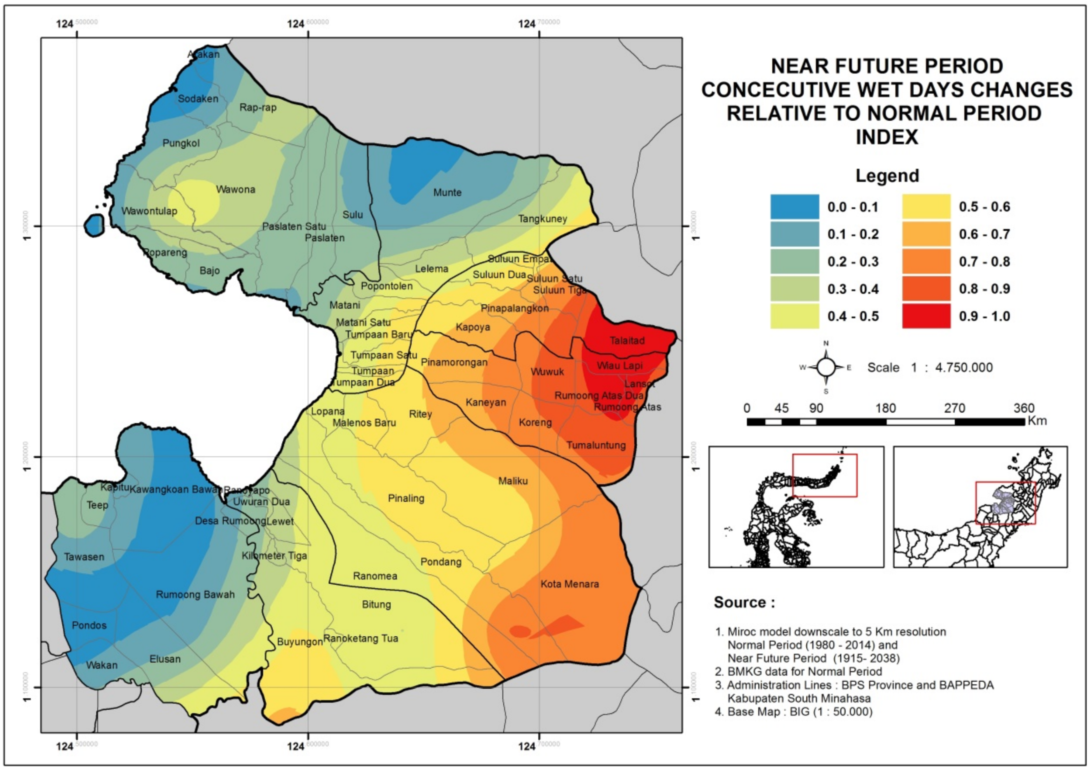


Figure 43. Map of Near Period for Consecutive Wet Days (CWD) Changes Relative to Baseline Period

The changes in consecutive wet days (CWD) between the near period and the baseline period show that the highest score is in the western part of South Minahasa, particularly Tareran and Sulta districts (Figure 43). On the other hand, the lowest score of 0.0–0.1, less than 10% likelihood of increased number of wet days, is in the northeast part of Tatapaan district, northern part of Tumpaan district, and western part of West Amurang district. The highest CWD shows that there is a higher likelihood of a wetter climate in the near period than the baseline period.

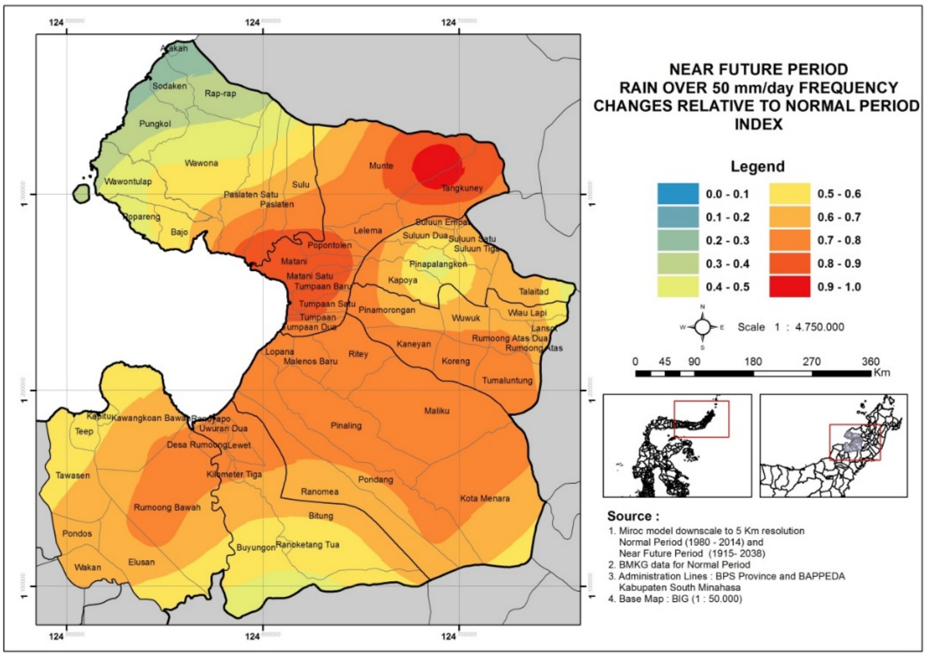


Figure 44. Map of Near Period for Rain over 50 Millimeters per Day (mm/day) Frequency Changes Relative to Baseline Period

Figure 44 shows the change in daily rainfall over 50 mm in the near period relative to the baseline period in Amurang Bay, South Minahasa. The highest score for daily rainfall over 50 mm is projected for the western part of Tumpaan district compared with the other districts in South Minahasa (Figure 44).

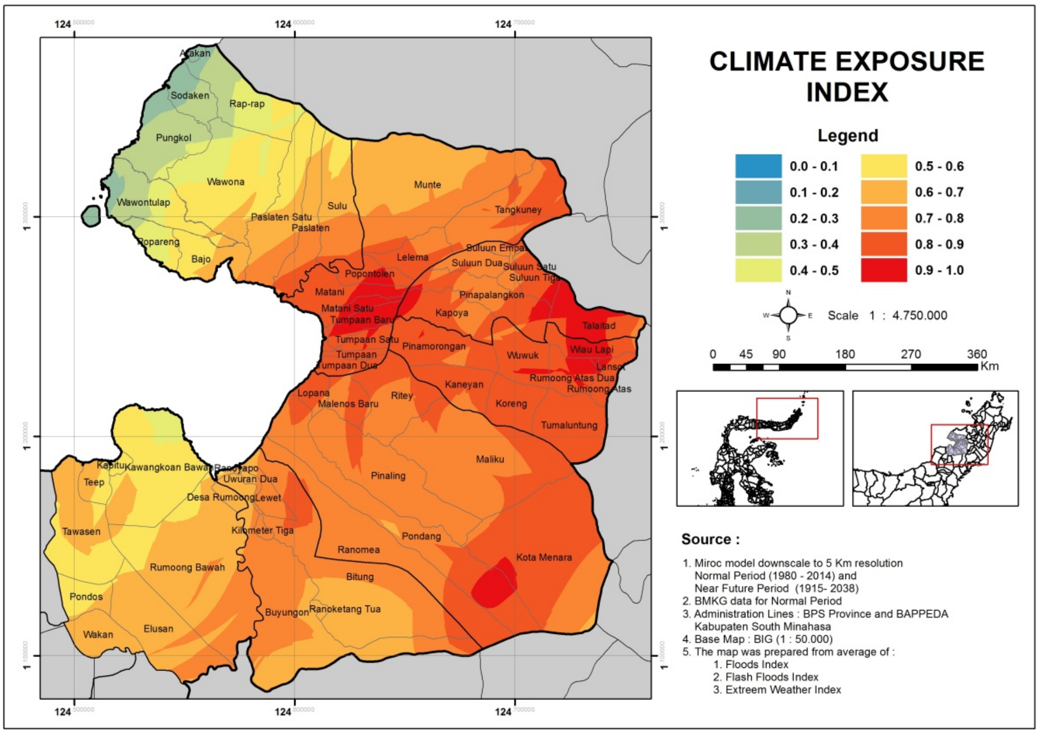


Figure 45. Map of Climate Exposure Index in South Minahasa

The climate exposure index is a function of change in CDD, CWD, and rain over 50 mm (Figure 45). Districts with an index of 0.7 to 1.0 include the northern part of Tumpaan district, most of Tareran and Sulta districts, and the western part of East Amurang district.

Current Exposure to Climate Hazards

The current exposure to climate hazards was analyzed based on the natural hazards caused by climate or weather. The analysis of climate hazards was based on floods risk map, flash floods map, and extreme weather map (Figures 46 to 49). Figure 46 shows the spatial distribution of floods index, with the higher risk of floods hazard found in the southeast and northeast parts of Tatapaan district, with an index of 0.6–0.7. The areas with the highest risk of flash floods are parts of Tumpaan district, the western part of East Amurang Timur district, and the northern part of Amurang and West Amurang districts (Figure 47). Areas of extreme weather, with an index of 0.7–0.8, are found in most parts of Sulta district, Tareran district, Amurang district, and west Amurang district (Figure 48).

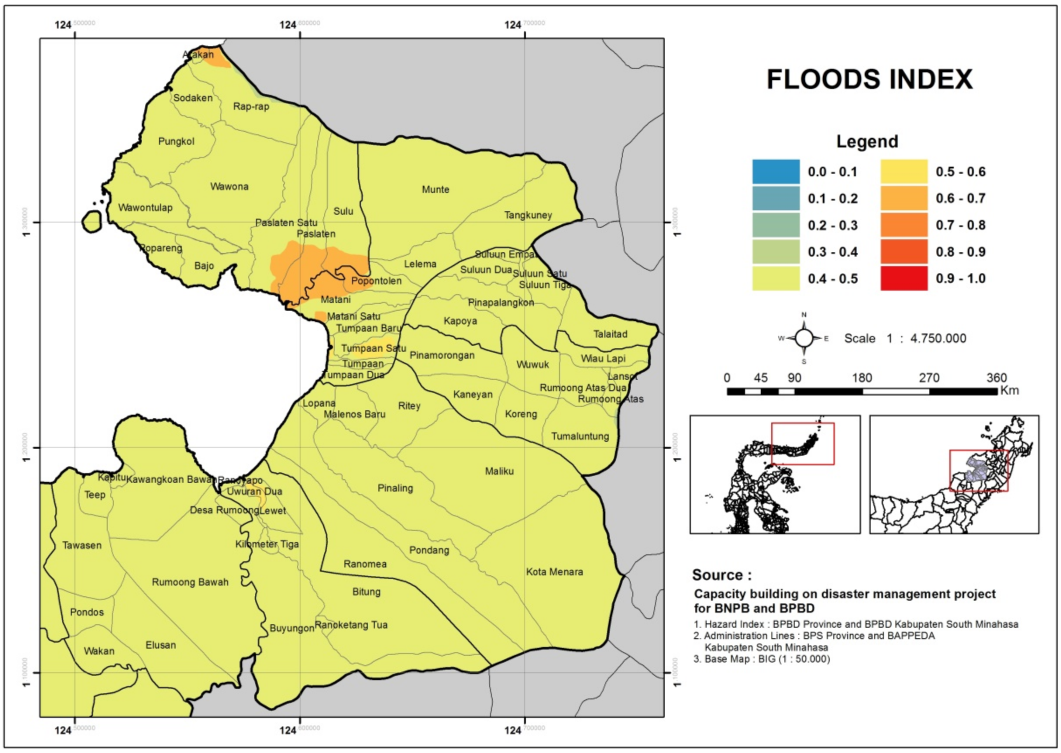


Figure 46. Map of Floods Index in South Minahasa

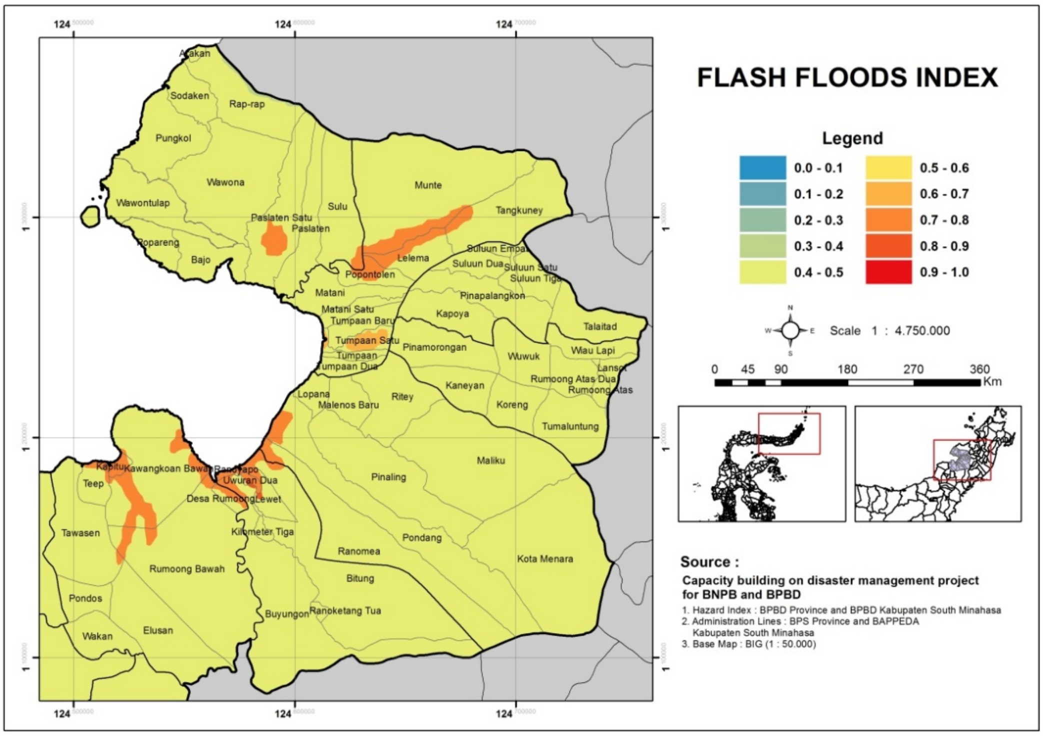


Figure 47. Map of Flash Floods Index in South Minahasa

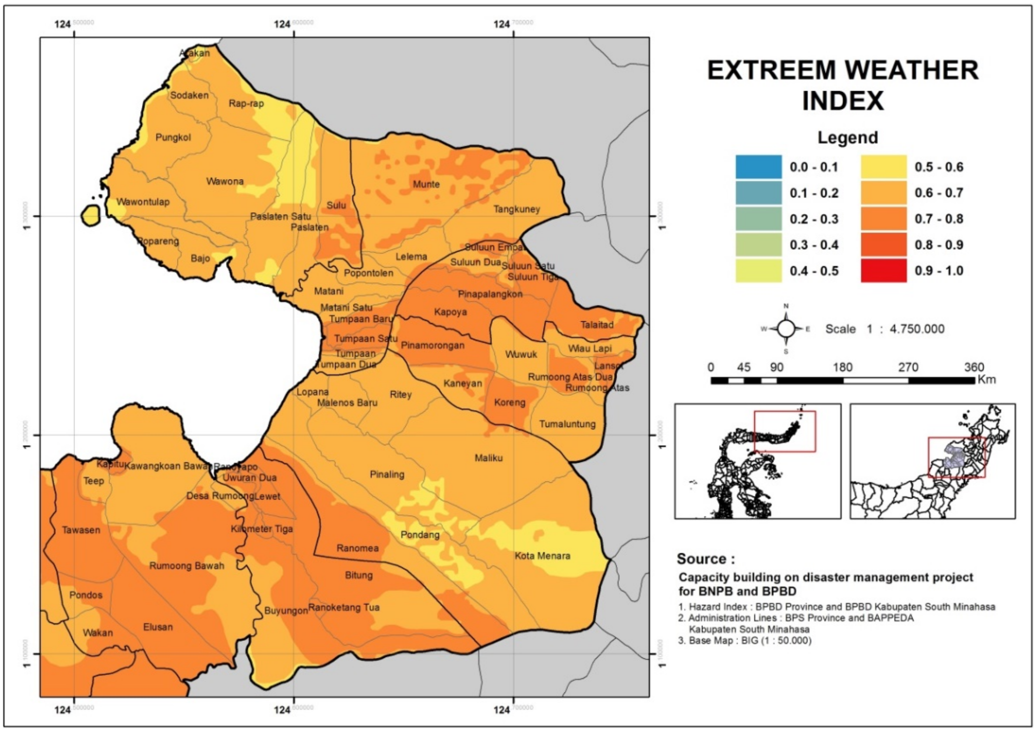


Figure 48. Map of Extreme Weather Index in South Minahasa

The climate hazard index is a function of floods, flash floods, and extreme weather hazards in Amurang Bay, South Minahasa. The map in Figure 49 shows that some areas in Amurang Bay, South Minahasa, have a climate hazard index that is higher than other areas. The highest climate hazard index is found in Tumpaan district, Tatapaan district, northern part of Amurang district, and northern part of West Amurang district.

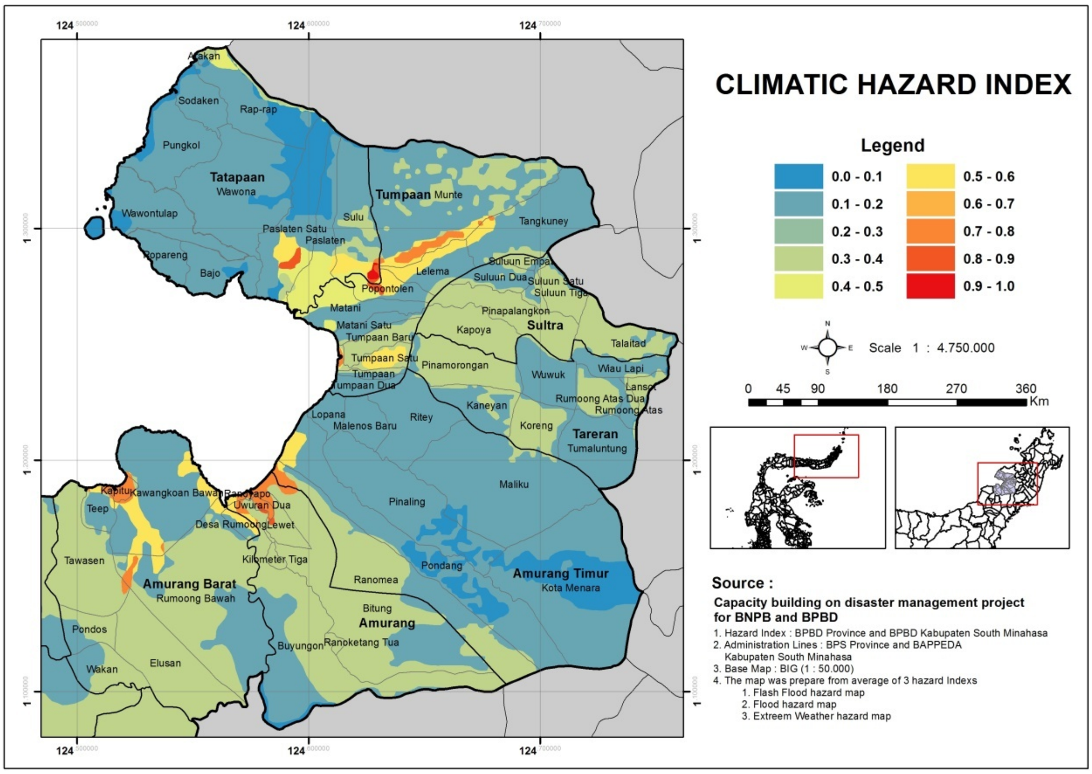


Figure 49. Map of Climate Hazard Index in South Minahasa

Sensitivity to Impacts of Climate Change

The sensitivity to the impacts of climate change in Amurang Bay, South Minahasa, was analyzed based on the elevation (height above sea level) and population density of different areas. Areas with low elevation are more sensitive to climate change impacts, such as sea level rise, floods, etc., than areas with high elevation. Furthermore, areas with high population density are more sensitive to climate change impacts than areas with low population density. In South Minahasa, the climate change sensitivity index is higher in Arakan village in Tatapaan district and Kapitu village in West Amurang district compared with other areas. The villages of Arakan and Kapitu have a high population density and are thus projected to be more sensitive to climate change impacts.

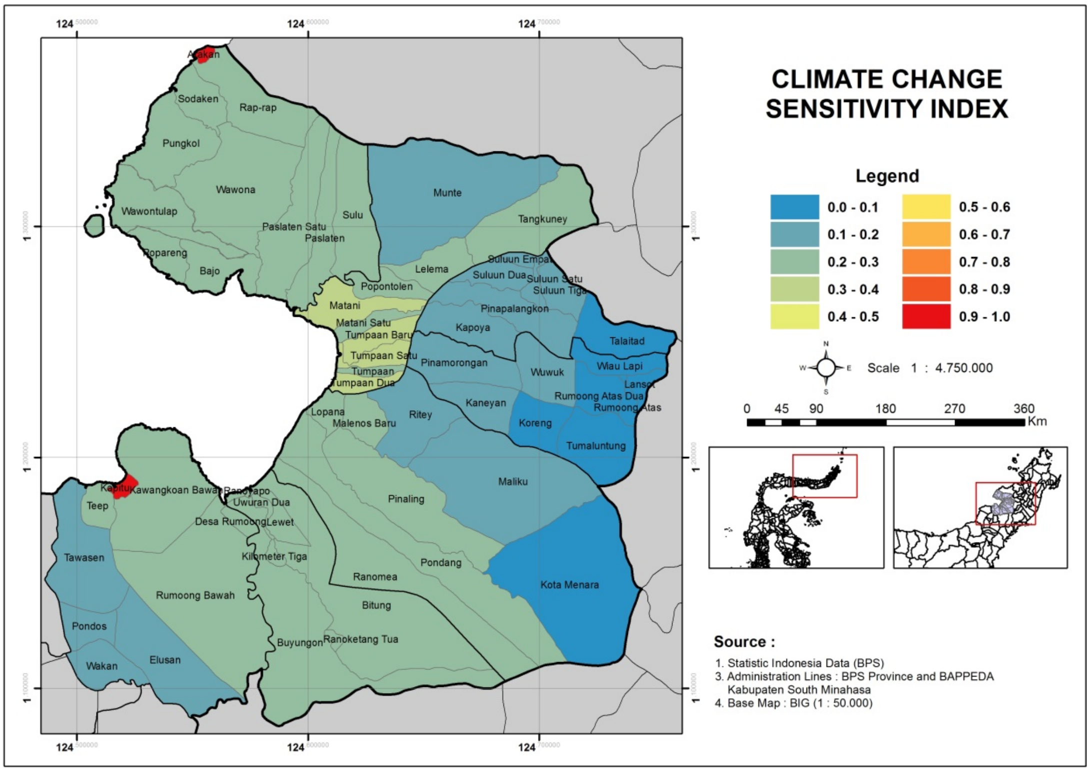


Figure 50. Map of Climate Change Sensitivity Index in South Minahasa

Adaptive Capacity of Community to Climate Change

Data used to determine the adaptive capacity of a community to climate change include the number of schools (elementary to university), distance from village to main district, number of health officers, and number of health facilities (Appendix 32). The adaptive capacity index in South Minahasa shows that the higher the index, the lower the adaptive capacity of a community to cope with the impacts of climate change (Figure 51). Areas with a higher index or lower adaptive capacity include most of the villages in Tatapaan district, most of the villages in Tumpaan district, Kota Menara village in East Amurang district, and Wakan village in West Amurang district. On the other hand, areas with a lower index and a higher adaptive capacity are Bitung, Buyongan, and Ranoiapu in Amurang district, and Pinamorongan village in Tareran District.

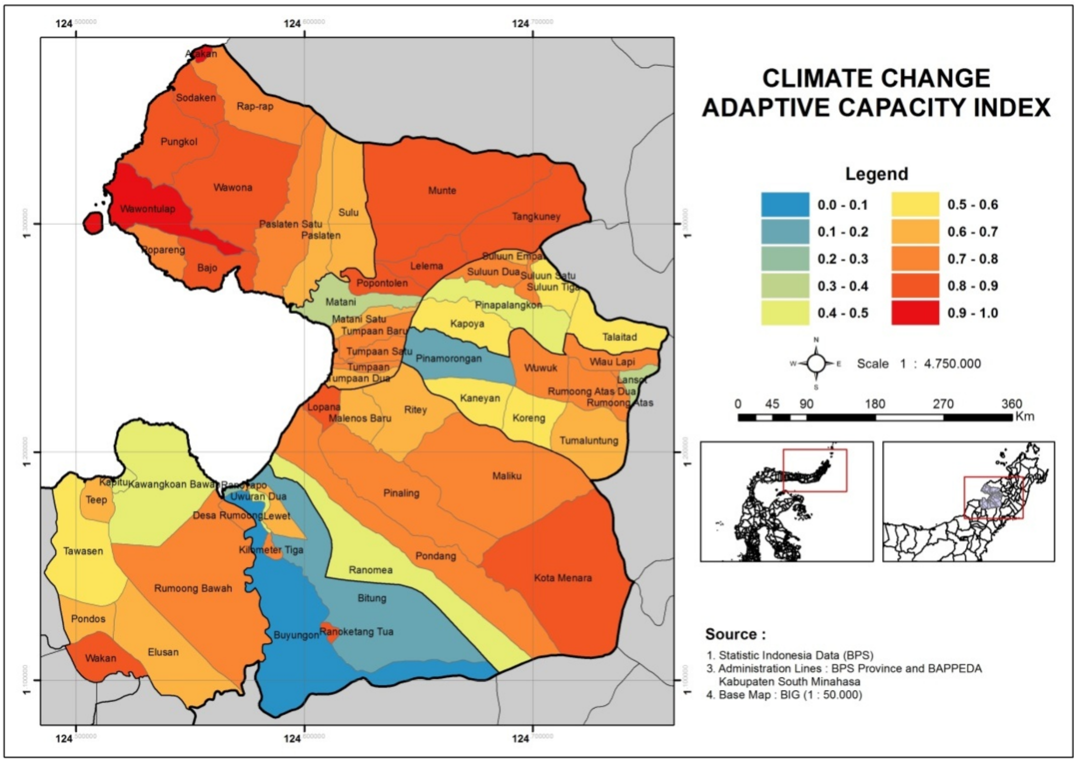


Figure 51. Map of Climate Change Adaptive Capacity Index in South Minahasa

Analysis of Social Vulnerability to Climate Change

The vulnerability to climate change is determined by combining four components: climate exposure, climate hazards, sensitivity, and adaptive capacity. The map of vulnerability to climate change in Amurang Bay, South Minahasa, shows that some districts have higher vulnerability to climate change than the others (Figure 52). Arakan village is vulnerable because of its high sensitivity index. Meanwhile, parts of Munte village, Lelema village, Tangkuney village, Popontolen village, and Tumpaan Satu village in Tumpaan district, and parts of Pondang, West Amurang district (upper-middle portion of Amurang Bay) are vulnerable because of climate hazard from flash floods. On the other hand, Kapitu village in West Amurang is vulnerable because of its high sensitivity to the impacts of climate change.

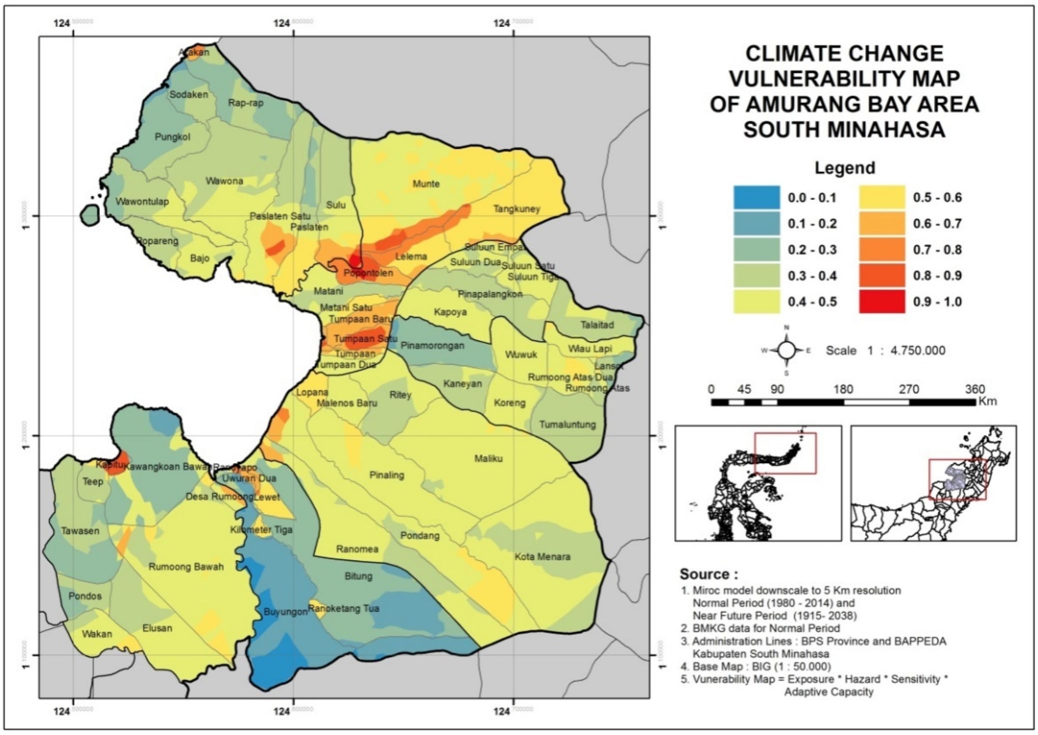


Figure 52. Map of Climate Change Vulnerability in Amurang Bay, South Minahasa

VULNERABILITY ASSESSMENT IN ARAKAN VILLAGE

Social and Economic Vulnerability Assessment in Arakan

Exposure

Floods and extreme weather are the natural hazards that frequently occur and have a high exposure index in Arakan village (Figures 46 to 48). As shown on the map of climate hazard index (Figure 49), Arakan has an index of 0.5–0.6, which means that natural hazards have a moderate likelihood of occurring in the village. On the other hand, based on the survey of the community in Arakan, the problems brought about by climate change in the village are real. Weather that can be predicted previously by fishermen in various ways cannot be presently forecast. The unpredictable weather directly affects the fishermen's livelihood. During a storm, for instance, the fishermen need to set the correct time for safe fishing activities. Based on these conditions, it can be stated that the exposure level of Arakan village to climate hazards is moderate.

Social Sensitivity to Impacts of Climate Change

Based on the survey, Arakan village has a total population of 1,238, with 363 households (2014). There are 400 fishermen, 66 farmers, 30 artisans, 30 merchants, and 5 civil employees. The Arakan community is predominantly Muslim (1,208 people), with some Christians (30 people). The density of population and number of fishermen (>75%) in Arakan are high. Population density has a score of 3, while the number of fishermen has a score of 3 (Table 7).

Table 1**.** Score of Arakan Village in Social Sensitivity Component

No.	Parameter	Score
1	High density of population	3
2	High number of fishermen (>75%)	3
	AVERAGE	3

Adaptive Capacity of the Community

For health problems, sick community members are usually cared for by paramedics in the village. In serious cases, the patients are usually taken to the hospital in Manado, rather than in Amurang because Manado is nearer than the regency capital. Moreover, the relatively narrow road could be a constraint for the fast evacuation of patients to the hospital in Manado or Amurang.

From the survey data, Arakan villagers can be categorized into five groups based on level of education: (i) no formal education (2% of villagers); (ii) elementary school (69%); (iii) secondary school (24%;) (iv) high school (5%); and (v) university (1%) (Figure 53).

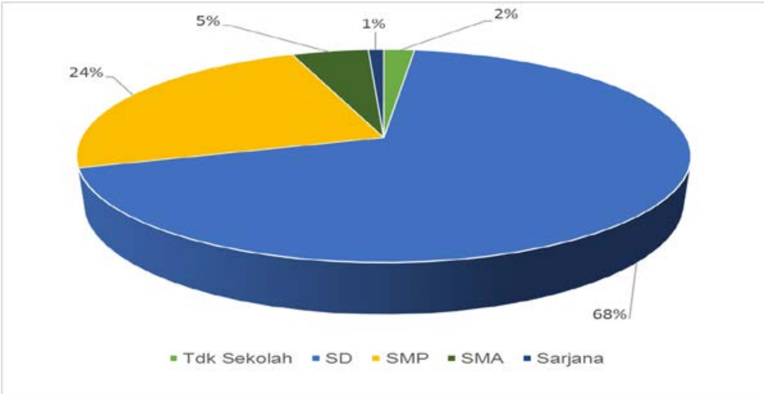


Figure 1. Composition of Arakan Villagers Based on Educational Level

The educational level of Arakan villagers is low. This could be a result of the low number of educational facilities available, as Arakan has only one elementery school and one secondary school, and no tertiary school.

Several parameters were used to observe the prosperity level of the fishermen, including gain from fishing activities, gain from non-fishing activities, and family expenditure.These parameters were used in a descriptive tool called exchange rate (ER). The fishermen's exchange rate used in this study measured the fishermen's community prosperity level. Since the indicator is also a measure of fishermen's household ability to meet their basic subsistence needs, the fishermen's exchange rate is also called subsistence terms of trade (STT).

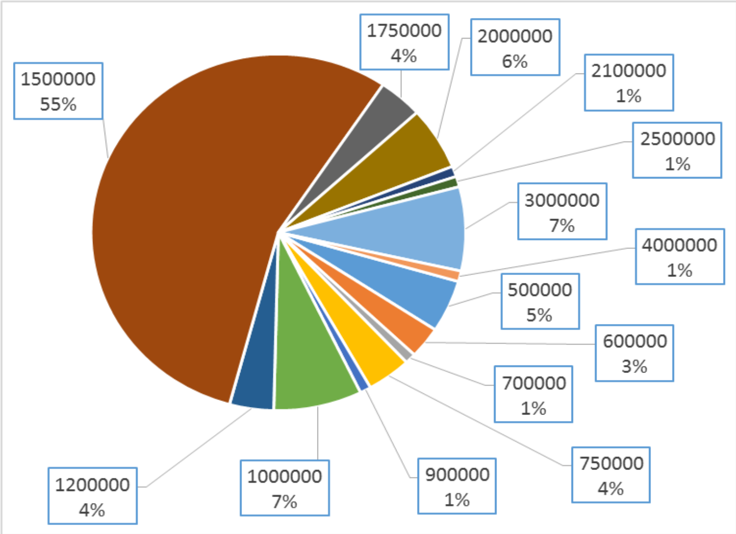


Figure 2. Composition of Fishermen's Monthly Income in Arakan

ER<1 means that the fishermen's families have low spending power to meet their needs, with a potential to have a budget deficit; ER=1 means that the fishermen's families can meet only their basic life needs; and ER>1 means that the fishermen's families can meet their subsistence needs as well as their other needs, or even have savings or investments. The ER of Arakan fishermen is 0.86. This means that the families of fishermen in Arakan have low buying power and can only meet their basic needs for subsistence, health, and education up to secondary school. Secondary and tertiary needs are not usually met.

Regarding extreme weather in Arakan based on interviews with villagers, it was found that fishermen have not yet faced significant difficulties as a result of climate change. However, this does not mean that Arakan villagers are free of the threats of climate change.

According to Adger *et al*. (2004), at the individual level, adaptive capacity to climate change could be taken as a function of human ability to get access to many types of resources. Individuals with more access to resources possess higher adaptive capacity than those with less access or no access to resources. A different approach should be used to look into the adaptive capacity at the community level. The adaptive capacity at the community level highly impacts on the collective readiness to respond to the threats of climate change. Thus, the adaptive capacity of the community can be described by looking at the resource management performance of all stakeholders**,** including the efficiency level of governance.

Good institutional performance at the village level is based on social capital characteristics (such as relationships, norms, customs, and belief systems) that enable the villagers to work together in more effective ways to reach common objectives. Thus, to understand the community stakeholders' performance, the way social capital is working in each village should be looked into. In Arakan, the mosque is an institution that is involved with the local fishermen, because the village has an agreement to give part of its fish catch to the mosque.

From the definition of social capital or adaptive capacity, resource management is the key to adaptive capacity development. It has been found that the budget collected and managed through the mosque has not been used for resources management. The budget has only been utilized for daily mosque management. It could be concluded that social capital invested through the mosque in Arakan has not been optimally functional, and the village head and other community leaders should have more active roles in resources management. Coastal ecosystem protection is a very important issue in relation to resources sustainability. Recognizing this, the village head and the communities have agreed to pursue coastal ecosystem protection for mangroves, coral reefs, and seagrasses. Mangrove planting activities and the use of garbage cans have been undertaken.

The survey of community adaptive capacity in Arakan village showed that the village has a low average adaptive capacity of 1.4 (Table 8).

Table 2. Score of Arakan Village in Adaptive Capacity Component

No.	**Parameter**	**Score**
1	Educational level (low)	1
2	Income (low, with fishermen's exchange rate <1)	1
3	Community activities (centered around the mosque)	2
4	Side jobs (very limited)	2
5	Public awareness about climate change, ecosystem, and socioeconomic benefits (low)	1
	AVERAGE	1.4

Analysis of Socioeconomic Vulnerability to Climate Change

The socioeconomic vulnerability analysis in Arakan village was based on the analysis of exposure, sensitivity, and adaptive capacity components, shown as a matrix of exposure sensitivity (Table 9).

Table 3. Matrix of Potential Impact of Climate Change in Arakan Village

		Sensitivity		
		Low	Moderate	High
Exposure	Low	Low	Low	Moderate
	Moderate	Low	Moderate	High
	High	Moderate	High	High

Based on the analysis, Arakan village has a high potential impact and low adaptive capacity. This means that Arakan's vulnerability to climate change is high (Table 10).

Table 4. Matrix of Vulnerability to Climate Change in Arakan Village

		Adaptive Capacity		
		Low	Moderate	High
PotentialImpact	High	High	Moderate	Moderate
	Moderate	Moderate	Moderate	Low
	Low	Low	Low	Low

Ecosystem Vulnerability Assessment in Arakan

Ecosystem Survey Results

a. Water Quality

The results of water quality parameter measurements in the coastal waters of Arakan are presented in Table 11. Water temperature ranged from 28^{0}C to 30^{0}C in three sampling locations, reflecting normal conditions for marine life and tourism activities. As presented in the official seawater quality standard (Living Environmental Minister's Decree no. 51, 2004), good natural seawater for organic life has a temperature range of 28.00^{0}C to 30.00^{0}C.

Water acidity is based on the concentration of hydrogen ions in the water. Water pH of 7.0 is neutral, <7 is acidic, and >7 is alkaline. Acidic or high alkaline water condition is hazardous for plankton life since it can disturb the metabolism and respiration of planktons (Barus, 2004), which will eventually affect marine productivity. The optimal pH for aquatic organisms ranges from 7.0 to 8.5. Field measurements showed that water pH ranged from 8.2 to 8.4 in Arakan. This means that the water condition in the village is normal, but close to the alkaline range, because of no organic material inputs from the land, and if there is any, is small and undetected.

Figure 3. Horiba Water Quality Measurement

Table 5. Water Quality Data of Coral Reef Waters in Arakan Coral Fishing Zone

Parameters	Location								
	1	2	3	4	5	6	7	8	9
Temperature (^oC)	28.5	28.5	28.3	30.2	29.55	29.33	30	27.84	28.58
pH	8.34	8.34	8.26	8.41	8.38	8.39	8.4	8.24	8.41
DHL (mS/cm)	49.7	49.7	49.5	50.6	51.4	51.2	51.2	51.1	51.5
Turbidity (NTU)	1	1	1	1	0.246	0.989	1	1	1
DO (mg/ltr)	8.67	8.71	8.51	8.75	9.9	8.3	8.88	8.36	8.05
Salinity (ppt)	33.4	33.4	34.1	33.3	33.8	33.7	33.7	33.7	33.8
TDS (g/ltr)	30.3	30.3	30.1	30.4	30.8	30.8	30.89	30.8	30.9
Visibility (m)	9		21					18	17

Source: 2014 Survey Data

Water salinity in the study sites ranged from 33.3 ppm to 34.1 ppm. These values did not show large variations since these are natural salinity concentrations for seawater. It is related to the dynamic characteristics of the coastal waters affected by tides. The seawater quality in Arakan is in the natural range. Nybakken (1992) states that a coastal area (littoral zone) is dynamic with low salinity variation.The organisms living in the coastal area tend to tolerate salinity fluctuations of up to 15 percent.

Dissolved oxygen is needed by all living creatures for respiration, metabolism, and growth, and for oxidation in an aerobic process. Dissolved oxygen (DO) in the water is produced through the photosynthetic process of aquatic plants (such as seagrass, algae, and phytoplankton), and surface water atmospheric interactions. The presence of DO in the coral reefs of Arakan at the coral fishing zone (8.5 mg/l to 8.7 mg/l) is within the normal range for aquatic life.

Water visibility of 9 m to 21 m means that some areas, Station 1 in particular, have low water visibility so that sunlight absorption for photosynthesis may be low. This condition could result from sampling time, when the water visibility test is done during rainy and wavy conditions that cause high seawater mass agitation and turbidity. The more turbid the water and the suspended solid, the lower the water visibility. All sampling sites have a turbidity of 1 NTU and suspended solid of 30.3 g/l. This condition does not significantly influence sunlight absorption.

From the physical and chemical parameter measurements in the coral reefs of Arakan, in relation to the living feasibility of aquatic organisms, it is apparent that all physical and chemical parameters, except for visibility, are in optimal condition for living marine biota.

b. Coral Reefs

Manta Tow

Coral reef condition in Arakan was observed through the manta tow technique. The location chosen for this activity was the reef edge fronting Arakan village. The observation results, found in Appendix 1, indicate that the average cover of live corals is 24%, while dead corals cover approximately 31% of the reef. Based on the total coverage of hard corals, it can be said that the coral reef condition in Arakan is poor (category level of <25%).

Line Intercept Transect

The coral condition data were collected using the line intercept transect (LIT) method. Four locations were established for this purpose. Two depths were sampled in each location. All objects intercepted by the line transect were recorded. Photos and video recordings were taken for more accurate figures of the bottom condition of these four locations. The reef condition, based on hard coral coverage in each location, is presented in the following eight transects.

<u>Transect 1: Arakan 1 (3 m)</u>

The total coverage of hard corals at this site was 26%, which means that the reef was in fair condition. Dead corals only covered 7% of the area. The other dominant category of live organisms at this depth was Other Fauna, which consisted of soft corals, sponge zoanthid, and others. Algae covered 8% and were dominated by Algae Assemblage (AA). The diversity index (H') was 1.22, with the abiotic category dominated by rubble (33%). 'Dead coral' and 'dead coral with algae' are the terms used for recently dead coral, while ''rubble' means that the coral has become a ruin. The average length of a hard coral colony was 1.1 m for Acropora and 21.6 cm for non-Acropora. Nineteen hard coral species were found at this depth.

The above figures indicate that the coral reef at the 3m depth in Arakan 1 has suffered from continuous destructive fishing practices such as bombing and bottom netting in previous years.

Transect 2: Arakan 1 (10 m)

At this site, Coral Submassive was the dominant live organism. It covered 11% of the substrate. Overall, live coral percentage cover was 30% at the 10m depth of Arakan 1. Twenty-seven species of hard corals were found at this depth, with the mean length of hard corals at 226 cm. Acropora Branching (ACB) had the longest mean length (80 cm). Recent dead corals covered 3%, while coral rubble covered 19%. Based on live coral coverage, this site can be categorized in fair condition. Soft coral, with 15% coverage, was the second most dominant live organism. Algae Assemblage (AA) coverage was 7%.

Transect 3: Arakan 2 (3 m)

At this site, the total coverage of hard corals was 33%, which means that the coral reef was in fair condition. Recent dead corals had only 4% coverage, Alga Assemblage (AA) had 9%, and Other Fauna dominated by soft coral had 19%. The abiotic category covered 36% of the substrate and dominated by rubble. The number of species at this site was 29. The diversity index (H') was 1.37. ACT had the largest average mean length (66 cm).

Transect 4: Arakan 2 (10 m)

At this site, Coral Foliose (CF) was the dominant live organism, with coverage of 11%. The total coverage of hard corals was 35%, which means that the reef was in fair condition. Algae Assemblage was the only algae category, with 3% coverage. Soft Corals was the other dominant fauna, with 27% coverage. Compared with the 3m depth, sand was found more than rubble (27%) at this site.

Non-Acropora had 49 colonies, while Acropora had only 6 colonies. The average mean length of a CF colony was the lowest (54 cm). Thirty-two species of live corals, including *Porites nigrecens*, were found at this site.

Transect 5: Arakan 3 (3 m)

At this site, hard corals covered 49% of the bottom contour. This means that the reef was in fair condition and almost reached good condition. Coral Branching

(CB) was the dominant live organism, with 26% coverage. The total coverage of Acroporids was 12%, with ACT (5%) being dominant. AA covered 11% of the bottom, while soft corals had 14% coverage. The diversity index (H') was 1.06. Recent coverage of dead corals was only 2%. Rubble was dominant (24% coverage) compared to other abiotic organisms. Non-Acropora had the highest number of colonies (44).

The longest mean lengths of hard corals were 65 cm for CB, 62 cm for ACS, and 60 cm for CMR. Twenty-five species of hard corals were found at this site.

Transect 6: Arakan 3 (10m)

At this site, Coral Encrusting (CE) was the most dominant hard coral, with 13% coverage. The total coverage of all hard corals was 40%, which means that the reef was in fair condition. ACB (3% coverage) occurred more than the other Acroporids. Dead corals only covered 2%, algae covered 3%, and sand covered 27% of the site. Other Fauna was dominated by soft corals (21%). The diversity index was 0.89, which means that the site could be considered productive.

There were 32 colonies of non-Acropora corals, while there were only four colonies of Acropora. Coral Encrusting had the longest mean length of colony (106 cm), and 19 species of hard corals were found at this site.

Transect 7: Arakan 4 (3 m)

The total coverage of hard corals at this site was 56%, which means that the reef was in good condition. ACB (16% coverage) and CB (37%) were the most dominant types of corals. AA covered 13% of the bottom area. Sponge (4%) was the most dominant of Other Fauna. Rubble was the predominant abiotic organism and covered 14% of the bottom. The diversity index of all categories was 0.95.

Acropora Branching had the longest mean length of colony (195 cm), followed by Coral Branching (125 cm). Sixteen species of hard corals were found at this site, with *Porites cylindrica* occurring 14 times.

Transect 8: Arakan 4 (10 m)

At this site, 56% of the bottom was covered by hard corals, which means that the reef was in good condition. Acropora Branching (16% coverage) and Coral Branching (37%) were most dominant. Dead corals covered 8% of the bottom area, while Alga Assemblage covered 13%. Coral rubble (14%) was the most dominant abiotic organism.

The diversity index was calculated at 0.95. Acropora Branching (195 cm) and Coral Branching (125 cm) were the corals with the longest mean length. Sixteen species of hard corals were recorded, with *Porites cylyndrica* occurring 14 times.

General Discussion

The results of the Arakan hard coral analysis are presented in Appendices 2 to 9. These results show that hard coral conditions varied from fair (25% to 49%) to good (50% to 75%) (Dartnall and Jones, 1986). These conditions may be due to several factors. The number of rubble occurrences show that, in previous years, a series of fish bombing and bottom netting activities were conducted in the reef areas. Only one location (Arakan 4 at 10 m) could be categorized in good condition (56%), while another location (Arakan 3 at 3 m) was one percent short of being categorized in good condition.

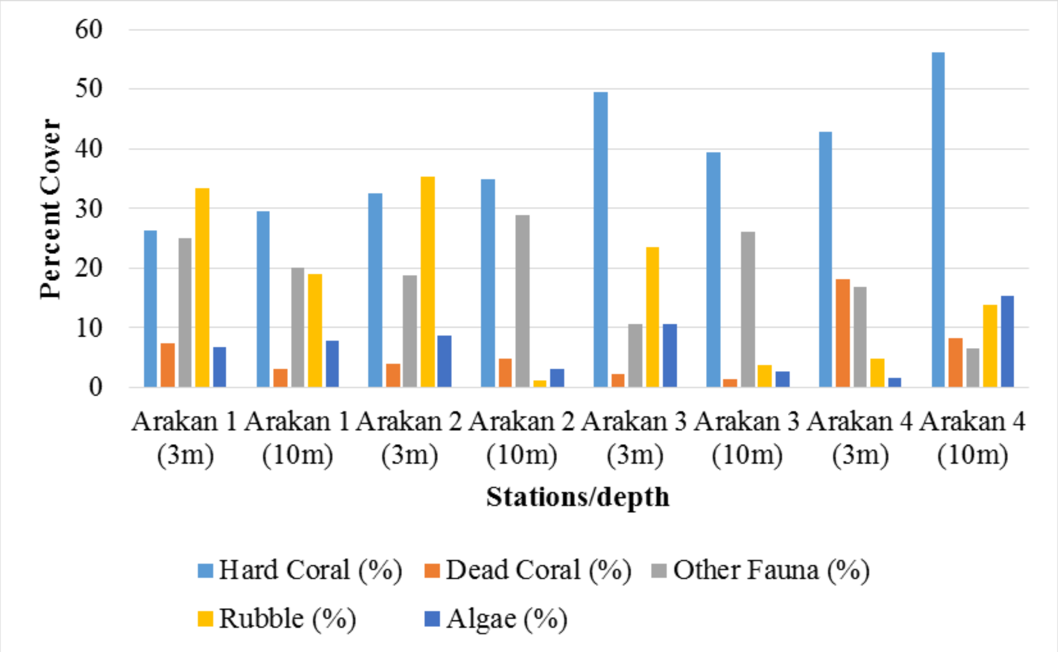


Figure 4. Coral Reef Conditions in Arakan

Although no coral reef was in poor condition, almost all of the reef bottoms were dominated by rubble. Only Arakan 2 (10 m), Arakan 3 (10m), and Arakan 4 (3 m) were not dominated by rubble. Other Fauna, such as soft corals, also occurred predominantly in the Arakan reef areas. Algae were found in all sites and covered 15% of Arakan 4 (10 m). Algae proliferation could have been triggered by a "no competitor situation," where hard coral destruction could have provided more space for algae to grow rapidly. The diversity indices (H') of the reef sites were varied and could be categorized from productive (0.75 to 1.00) to highly productive (>1) (Stoddart and Johnson). A total of 32 species of hard corals were found in this study.

c. Coral Reef Fishes

General Description

Coral reef fish communities are part of a coral reef ecosytem. Coral reef fish occurrence in a coral reef ecosystem is very important ecologically and economically. From an ecological standpoint, coral reef fishes play an important role in maintaining the ecosytem equilibrium. From an economic standpoint, they function as sources of animal food and human livelihood.

The sustainable management and utilization of coral reef fishes are needed to maintain their abundance in the coral reef areas. Several management trials have helped establish conservation/protection areas within the coral reef ecosystem, the main objective of which is to keep coral reef habitats and fisheries stocks sustainable for human prosperity.

The distribution, richness, and abundance of coral reef fish communities in the coral reef ecosystem of Arakan village were analyzed by dividing the coral reef fishes into three categories: (i) Indicator Species, (ii) Target Species, and (iii) Major Species. In general, coral reef fish condition varies in different locations, either in number of species, number of individuals, or dominant species.

The coral reef fishes recorded in the coral reefs of Arakan totalled 35 families, 99 genera, 231 species, and 7,814 individuals (Figure 57 and Appendices 10 to 12). The highest numbers of species were found in Station 4 at the 3m depth (119 species) and Station 3 at the 10m depth (102 species) (Figure 58). The coral reef fish communities in the coral reefs of Arakan, based on number of species and number of individuals, showed that Stations 1 and 4, both located closest to Arakan village, tended to have the worst conditions.

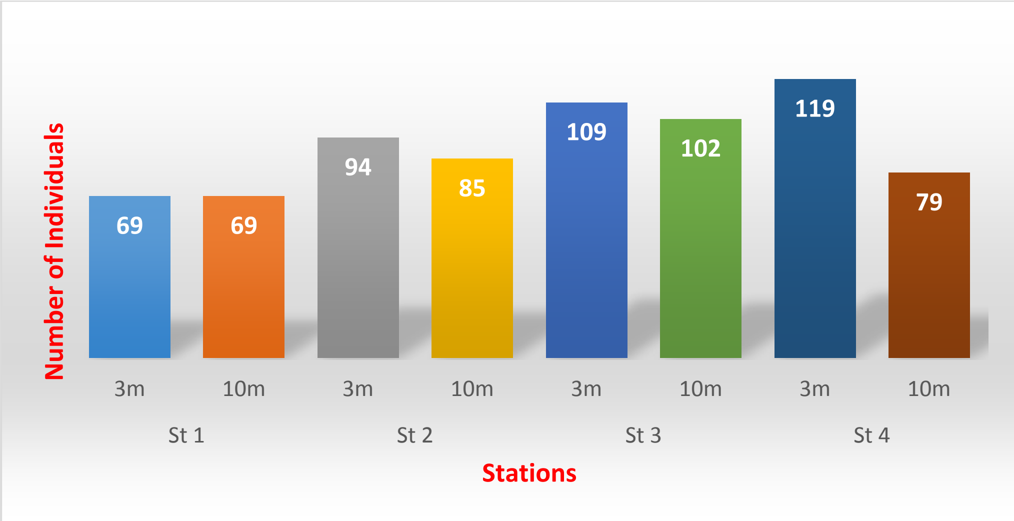


Figure 5. Coral Reef Fish Species Richness in the Coral Reefs of Arakan

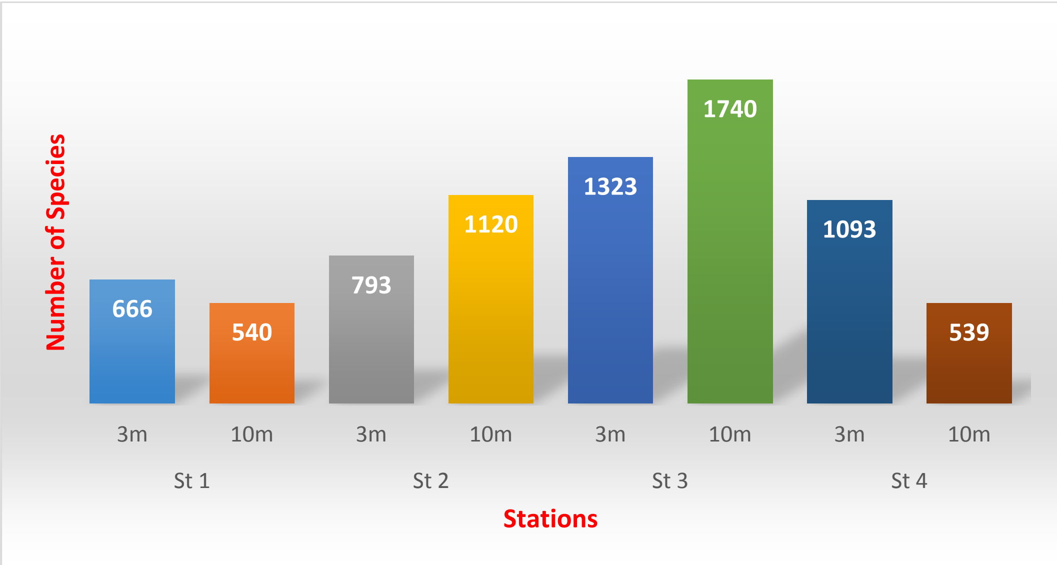


Figure 6.Coral Reef Fish Individual Abundance in the Coral Reefs of Arakan

Coral Fish Communities of Indicator Species (Family *Chaetodontidae*)

Malikusworo (1986) states that *Chaetodontidae* (buterflyfish) is a good example of a coral reef resident, since its life is always in association with coral reefs, either as habitat or feeding ground, and most of its life is probably spent in the area. Nybakken (1988) agrees that the relationship of *Chaetodontidae* with coral reefs is very strong. This fish is generally omnivore, with coral polyps as its major food.

Meanwhile, Reese (1981, in Manthachitra *et al*. 1991) says that the abundance level of colivorous *Chaetodontidae* communities could be used as a sensitive indicator of coral reef health. Changes in their distribution and abundance could serve as an initial indication that coral communities have changed.

Field observations (Appendix 10) found 21 species of *Chaetodontidae*. Four genera were recorded: *Chaetodon*, *Forcipiger*, *Heniochus*, and *Hemithaurichthys*. The highest number of species was found at the 3m depth, especially in Stations 3 and 4. Four of the 21 species (*Chaetodonkleinii*, *C. punctatofasciatus, C. lunulatus,* and *Heniochus varius*) were found in all stations and depths. This means that the four species are general indicator species in the coral reefs of Arakan.

The criterion for species diversity classification is as follows: if H' <1 (low diversity), the community stability is low; if 1< H' <3 (moderate diversity), the community stability is moderate; and if H' >3 (high diversity), the community stability is high**.** Based on the community index analysis (Appendix 10), the species diversity at the two depths (3 m and 10 m) is categorized as moderate (H' = 1.61 to 2.52), a range that reflects a moderate coral fish community stability of family *Chaetodontidae*. A key indicator of species diversity is the proportion of fish species and individual numbers in the coral reefs of Arakan at the 3m depth, which is higher than at the 10m depth.

Diversity index (H') is inversely proportional to the dominance index, where the dominance index at the two depths (3 m and 10 m) is very low (0.097 to 0.251). This means that no species of *Chaetodontidae* is dominant, as shown by the high eveness index approaching 1.

Coral Reef Fish Communities of Target Species

The coral reef fish populations of target species such as grouper, snapper, goatfish, and others are important for food security and livelihood. This fish group is big-sized (>30 cm to 1 m) and different from small-sized indicator and major species (average of 10 cm to 15 cm). Malikusworo and Adrim (1986) found that there is a positive linear relationship between percent cover of live corals and coral fish presence. In addition, Risk (1972) found that coral fish diversity and abundance is higher with increased coral habitat complexity.

Field observations found 104 species and 2,369 individuals of target species belonging to 18 families of 41 genera. The number of species varied with location. The highest number of species was recorded in Station 3 at the 10m depth (46 species), while the lowest species number was recorded in Station 1 at the 3m depth (26 species).

The species diversity index at the two depths (3 m and 10 m) was moderate to high (H'= 2.79 -2.34), as shown in Appendix 11. In this H' range, the community stability of the target species group is categorized as moderate to high. The species diversity in the coral reefs of Arakan seems to be higher at the 3m depth than at the 10m depth. Similar conditions were recorded for the indicator species (*Chaetodontidae*).

The dominance index of the target species at the 3m depth and 10m depth is very low (0.001 to 0.007), meaning that no target species is dominant in the coral reefs of Arakan. This condition is supported by a high eveness index approaching 1.

Field observations (Appendix 11) found that five of the 104 target species recorded (*Acanthurus pyroferus*, *Ctenochaetus striatus, Scolopsis bilineatus, Siganus puellus,* and *Zanclus canescen*) occurred in all stations and depths. This means that these five species are generally encountered in the coral reefs of Arakan. Unfortunately, their size is relatively small (15 cm to 25 cm) and their economic value is relatively lower than some other species, such as *Ephinephelus*, *Lutjanus*, and *Plectorhinchus*.

The tendency to low numbers of large-sized coral reef fish populations and species at depths <20 m is largely brought about by coral reef destruction, overfishing that neglects the growth rate and natural reproduction of coral fishes, and fish bombing. If this situation occurs continuously, the coral fish potential in Arakan will be increasingly threatened.

Hence, an appropriate form of sustainable coastal resources management and utilization, particularly for coral reef fish, should be implemented. An ecosystem approach to fisheries management (EAFM) should consider the following:

1. banning fishing activities using bombs and poison;
2. establishment of a marine protected area, marine sanctuary, or fisheries reserve for sustainability of coral fish stocks and habitat conservation;
3. Selectivity in the use of fishing gear to avoid catching small or juvenile fish;
4. regulation of exploitation of ornamental fish in the coral reefs, especially with regards to the use of illegal fishing practices; and
5. implementation of habitat protection and rehabilitation measures.

Figure 7.*Odonus niger* are abundant in the coral reefs of Arakan.

Coral Reef Fish Communities of Major Species

Major species groups are abundant in the coral reefs, particularly *Pomacentridae*, *Labridae*, and *Serranidae* of subfamily *Anthiinae*. Aside from being ecologically valuable, this fish group has an important economic value as ornamental fish.

In this group, 107 species in 16 families and 34 genera (Appendix 12) were recorded in the coral reefs of Arakan. The highest number of major species was found in Station 4 at the 3m depth (54) and Station 3 at the 3m depth (49). While species diversity was high in Stations 3 and 4, particularly at the 3m depth, there was a lower number of individuals at the 10m depth, especially in Station 3. This could be the result of one species having a very high population, *Odonus niger* (800 individuals, 66% of total population), at the 10m depth in Station 3.

Based on the community index analysis (Appendix 12), the major species diversity at the two depths (3 m and 10 m) are categorized as moderate to high (H' = 2.17 to 3.35). In this H' range, the coral reef fish community stability of the major species group ranges from moderate to high. As to the proportion of individual and species numbers, the species diversity at the 3m depth is higher than at the 10m depth. This condition is similar to that of indicator and target species. The dominance index at the two depths (3 m and 10 m) is relatively low (0.05 to 0.43), except at the 10m depth in Stations 2 and 3, where *Odonus niger* is dominant. This means that only one species occurs in high numbers.This condition is indicated by a very high eveness index value. Based on the distribution and diversity of major species in the coral reef ecosystem of Arakan, only three of 107 species (*Aulostomus chinensis, Chromis analis,* and*Dascyllus trimaculatus*) are found in all stations and depths (Appendix 12). This means that these three species are the major species generally encountered in the coral reefs of Arakan. Also, *Centropyge* *bicolor*, *Centropige vroliki, Pomacanthus navarchus, P. imperator, and Pomacanthus semicirculatus* have potential as ornamental fish.

d. Mangrove Ecosystem

Mangroves can either be individual plants or plant communities living in intertidal areas, as defined by the Food and Agriculture Organization (FAO 1982). According to Snedaker (1978), a mangrove is a group of plants living along the coastal line in the tropics and subtropics, and possessing special functions in a salty environment. Based on the Directorate General of Forestry Decree No. 60/Kpts/Dj/I/1978, a mangrove forest is a type of forest occurring along the coast or river mouth that is affected by seawater tides, seawater flooding in high tide, and dry in low tide.

A mangrove ecosystem consists of interacting organisms (flora and fauna). In Indonesia, the term “mangrove forest” is often associated with mangle forest, although a mangle forest only includes genus *Rhizophora*, while a mangrove forest is structured and planted with many plant genera and other types of plants.

South Minahasa regency possesses extensive mangrove forest areas. These areas are found in several village locations, including the study site in Arakan village.

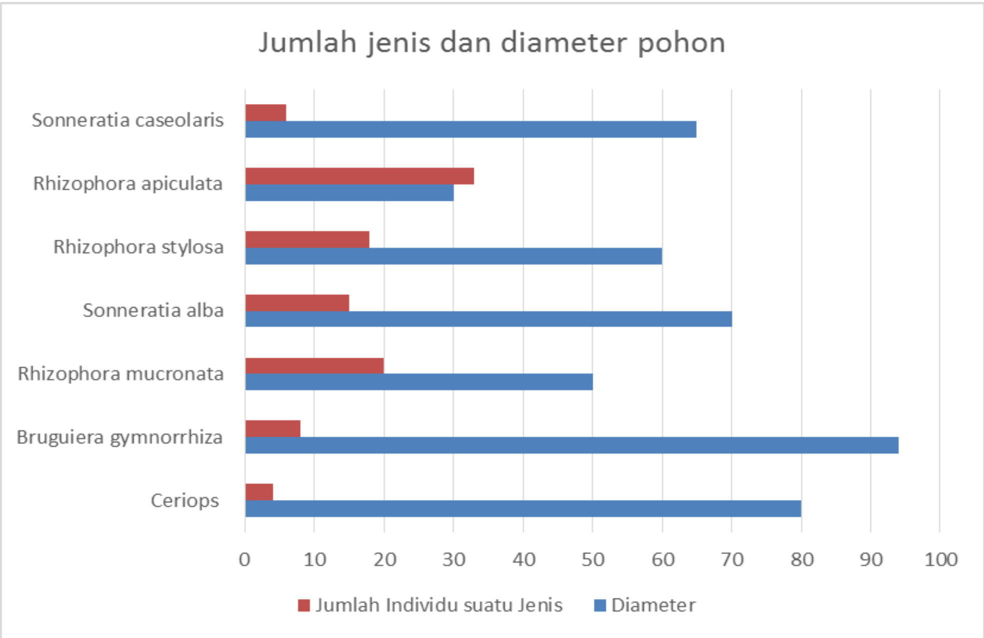


Figure 8. Species, Number, and Tree Diameter in Transect I (Right Front)

There were three sampling locations used in the study: Transect I (right front), Transect II (inside), and Transect III (left front). Mangrove vegetation in Arakan is sufficiently diverse, particularly in Transect I or the right front of the mangrove ecosystem. Seven species are dominant in this transect, led by *Rhizophora apiculata* (33 individuals), *Rhizophora mucronata* (20 individuals), *Rhizophora stylosa* (18 individuals), and *Sonneratia alba* (15 individuals).

On the other hand, the species with the largest tree diameter in the Transect I is *Bruguiera* (Figure 60). There were also other genera with low numbers recorded, such as *Ceriop spp*, *Sonneratia caseolaris*, and *Bruguiera gymnorrhiza*.

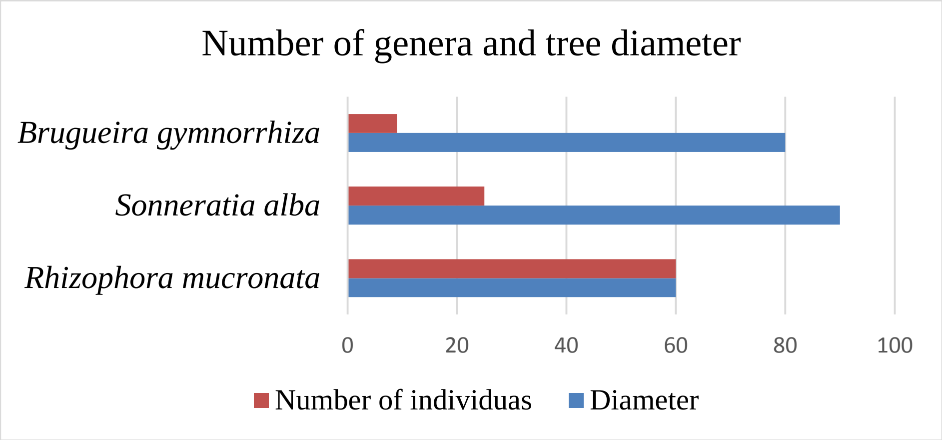


Figure 9. Species, Number, and Tree Diameter in Transect II (Inside)

Figure 10. Mangrove in Arakan Village

In Transect II or the inside of the mangrove ecosystem, only three true mangrove species were recorded. The transect is dominated by *Rhizophora mucronata* (60 individuals), *Sonneratia alba* (25 individuals), and *Bruguiera gymorrhiza* (9 individuals). On the other hand, the species representing both the smallest and the largest tree diameter in Transect II is*Sonneratia alba* (90 cm) (Figure 61).

In Transect III or left front of the mangrove ecosystem, four species were found: *Rhizophora apiculata*, *Rhizophora mucronata*, *Rhizophora stylosa*, and *Sonneratia alba*. The dominant species is *Rhizophora apiculata*, followed by *Rhizophora stylosa* and then *Sonneratia alba.* The species with the largest tree diameter is *Rhizophora mucronata*, followed by *Sonneratia alba* (Figure 63).

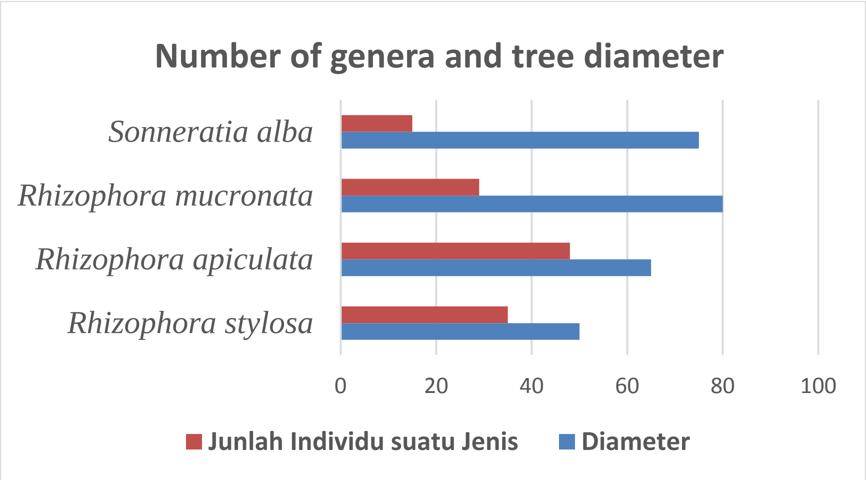


Figure 11. Species, Number, and Tree Diameter in Transect III (Left Front)

Relative Density of Mangrove Ecosystem

A species or individual mangrove has a high relative density if it possesses extensive adaptation and distribution patterns in the ecosystem. Density is highly influenced by the number of individuals of a species in the study site. The higher the number of individuals of a species, the higher the relative density level. The relative density value ranges from 4% to 64%. *Rhizophora mucronata* (64%) has the highest relative density, while *Ceriop*s (4%) has the lowest relative density (Figures 64 to 66).

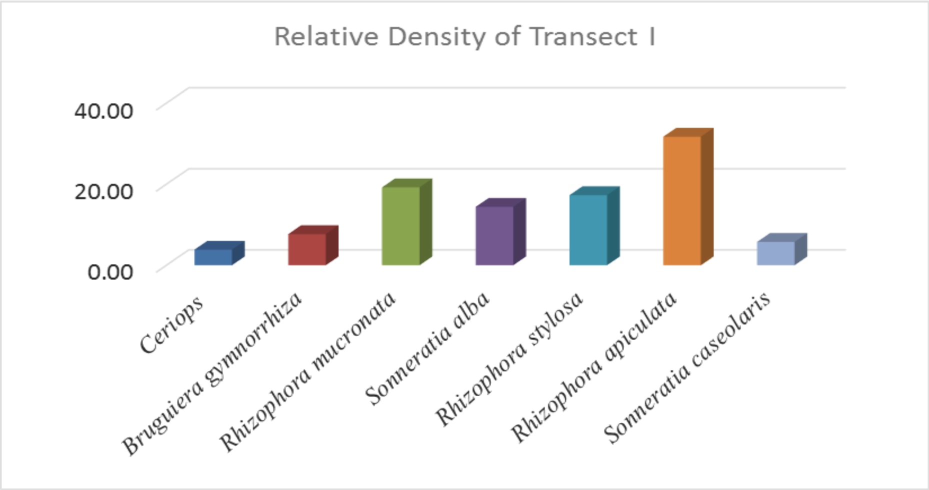


Figure 12. Relative Density in Transect I (Right Front)

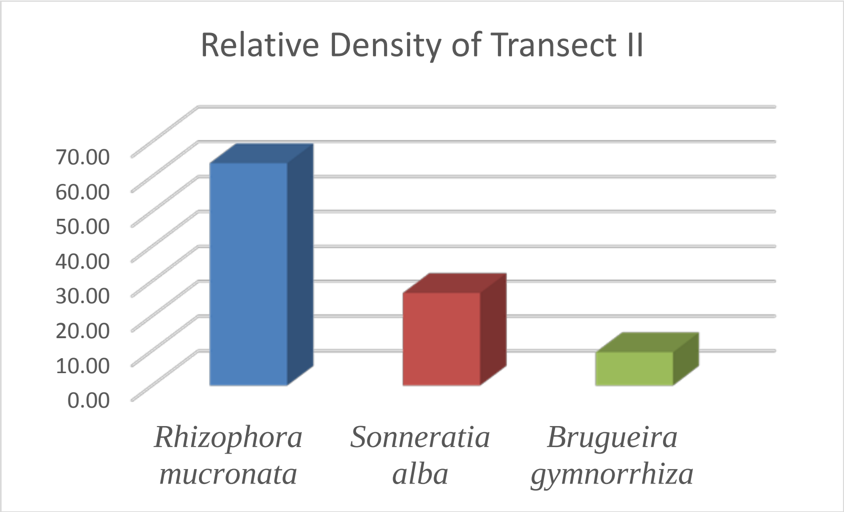


Figure 13. Relative Density in Transect II (Inside)

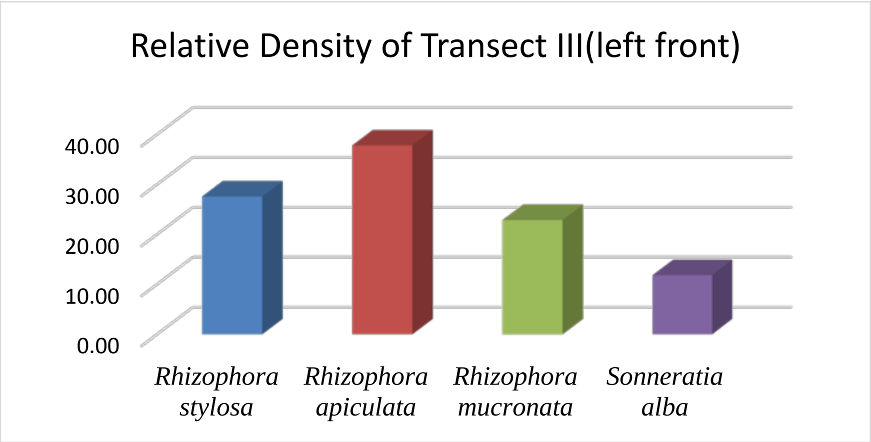


Figure 14. Relative Density in Transect III (Left Front)

The relative density of the mangrove ecosystem affects the animal biota associated with it. Skilter and Warren (1999) found that the mangrove ecosystem is used as shelter for fish and molluscs. Mangrove ecosystem relative density plays a very important role for living biota by providing protection from predatory animals. It is also related to heavy metal absorption in the mangrove ecosystem. According to Nasli and Hashim (2010, *in* Hastuti et.al. 2013), heavy metals contained in mangrove vegetation could be higher than those in sediments.

Figure 15. Transect Line and Mangrove Seedlings

Mangrove Species Dominance

Mangrove species dominance reflects the percentage level of dominance of a species in the mangrove ecosystem. The dominance value indicates the major plant species affecting and controlling the mangrove community through numbers, size, and optimal growth. In Transect I, *Bruguiera gymnorrhiza* is the most dominant (28%), while *Rhizophora apiculata* is the least dominant (3%). In Transect II, *Sonneratia alba* is the most dominant (45%), while *Rhizophora mucronata* (20%) is the least dominant. The relative dominance in Transects I, II, and III are presented in Figures 68 to 70.

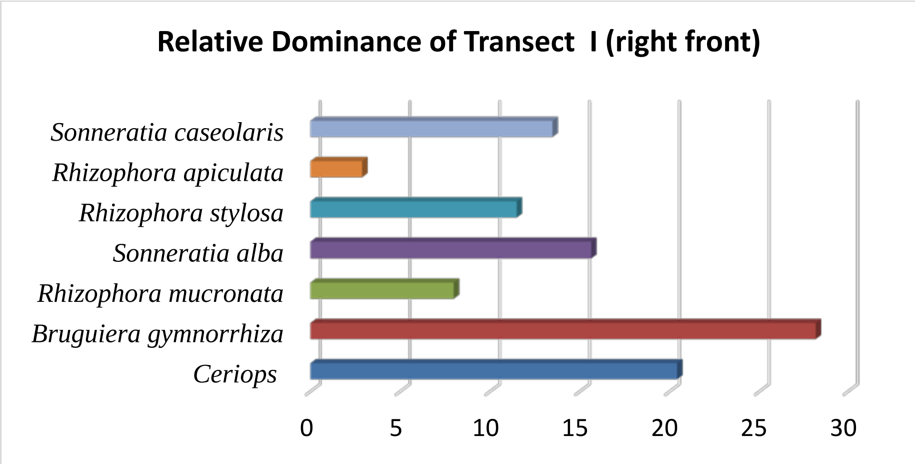


Figure 16. Relative Dominance in Transect I (Right Front)

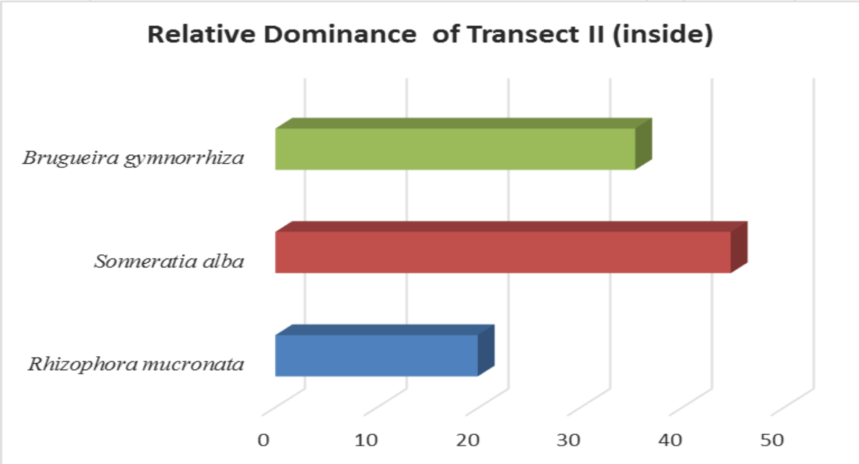


Figure 17. Relative Dominance in Transect II (Inside)

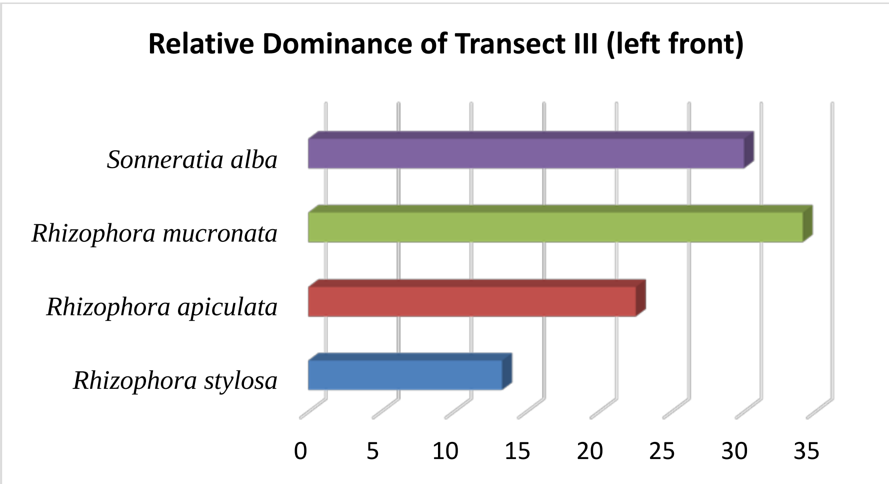


Figure 18. Relative Dominance in Transect III (Left Front)

Relative Frequency of Mangrove Species

The frequency of species within a mangrove ecosystem is affected by the number of quadrates where a mangrove genus is recorded.

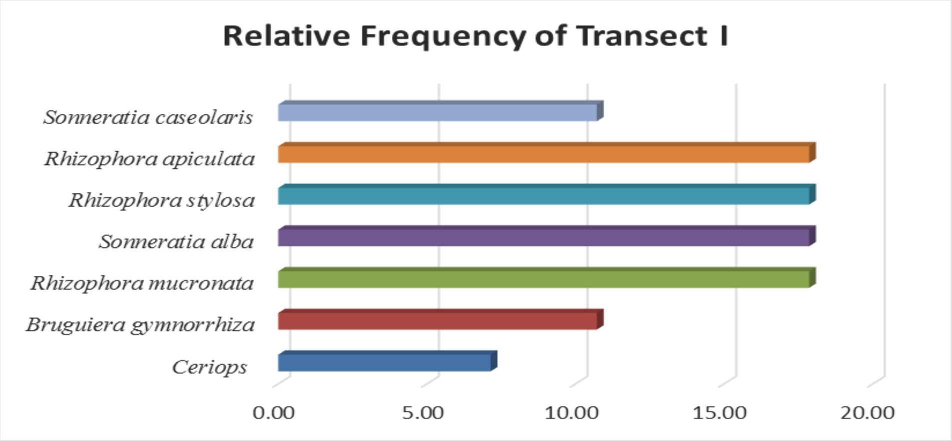


Figure 19. Relative Frequency in Transect I (Right Front)

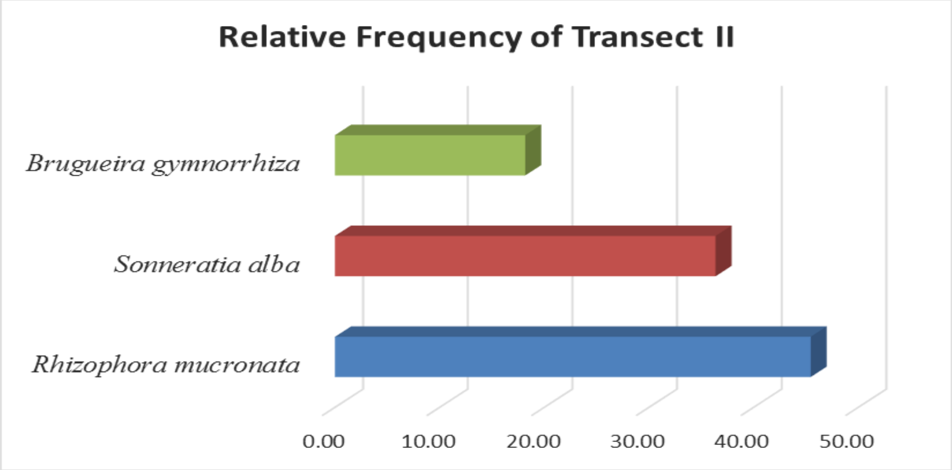


Figure 20. Relative Frequency in Transect II (Inside)

The relative frequency in Transect I (right front) is dominated by four species: *Rhizophora apiculata, Rhizophora stylosa, Sonneratia alba*, and *Rhizophora mucronata.* In Transect II (inside), *Rhizophora mucronata* has the highest relative frequency over other two species (*Sonneratia alba* and *Brugueira gymnorrhiza*), which means *Rhizhophora mucronata* is most often encountered in Transect II.

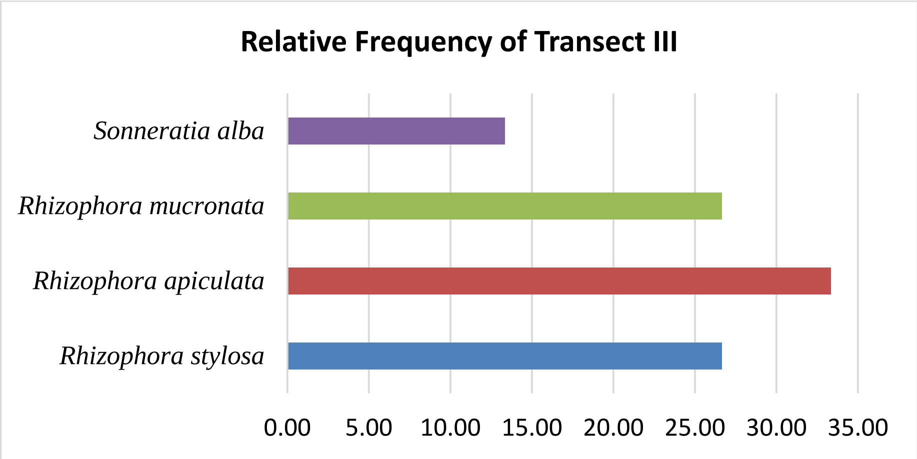


Figure 21. Relative Frequency in Transect III (Left Front)

In the three transects, *Rhizophora* spp and *Sonneratia* spp have high relative frequency, indicating that members of family *Rhizophoraceae* and some *Sonneratiaceae* possess the ability to grow better in the area.

Figure 22. Samples of *Rhizophora sp* and *Sonneratia sp*

Importance Value Index

Importance value index (IVI) is an ecological index of the importance of a plant species in a community and ecosystem. The higher the IVI value, the larger the role of the genus in the ecosystem. The mangrove IVI analytical outcomes in Arakan are given in Figures 75 to 77.

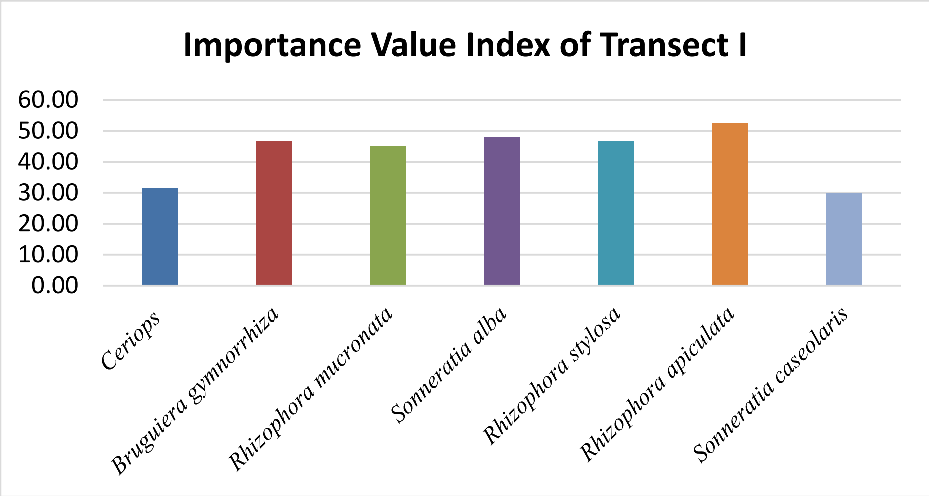


Figure 23. Importance Value Index in Transect I (Right Front)

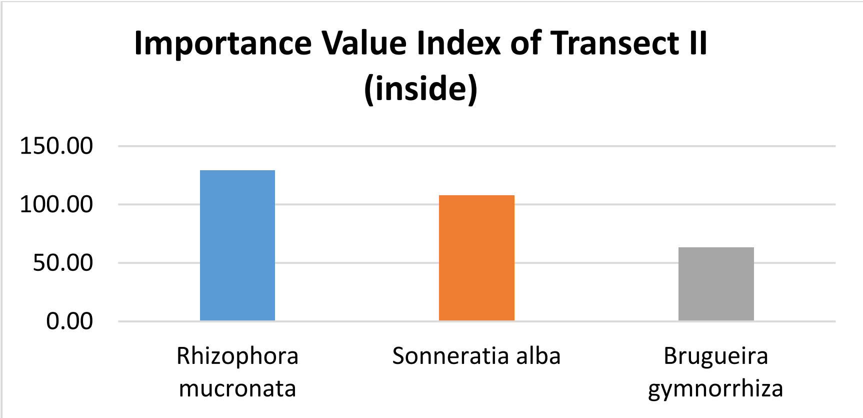


Figure 24. Importance Value Index in Transect II (Inside)

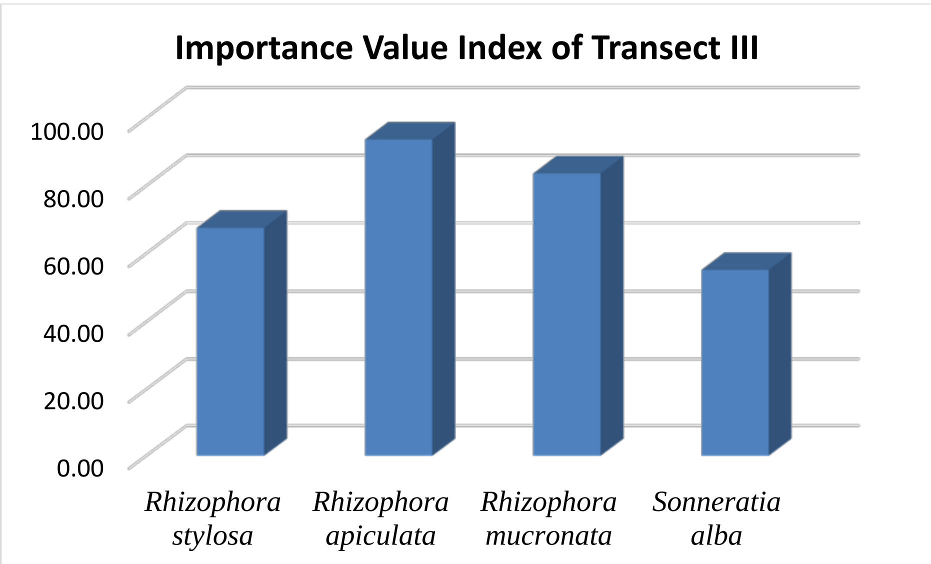


Figure 25. Importance Value Index in Transect III (Left Front)

Figures 75 to 77 show that *Rhizophora sp* has the highest importance value index in the three transects. The importance value index of *Rhizophora sp.* ranges from 46% to 92%. Other mangrove species have a lower IVI than 92%. Based on the transect data for mangroves in Arakan, genus *Rhizophora* has the largest or most dominant role over the other genera.

Mangrove Ecosystem Diversity Index

The diversity index of the mangrove ecosystem in Transect I (right front) is 1.75; Transect II (inside), 0.86; and Transect III (left front), 1.31. This means that Transect I has the highest mangrove ecosystem diversity, while Transect II (inside) has the lowest diversity. The species found in Transect I (right front) are more diverse, and therefore supports diversity condition. On the other hand, only three species were found in Transect II (inside), and four species in Transect III (left front).

With higher species diversity in Transect I, no species absolutely dominates the area since the relative frequency values of the six species in the transect are not significantly different. Hence, the importance value index of the six species is not significantly different as well. The substrate condition in Transect I is fine sandy clay or mud. On the other hand, Transect II (inside) has a denser substrate, but still muddy. The substrate condition also determines the mangrove species diversity.

e. Seagrass and Algae

Alga identification was recorded in three sites. The study found 30 species comprising 21 genera and 3 classes: *Chlorophyceae*, with 11 species; *Phaeophyceae*, 6 species; and *Rhodophyceae*, 13 species. Abundance of individuals was found in the range of 31 ind/m^2 to 45 ind/m^2. The highest number of species was found in Site 3 (27 species). Based on the results of the analysis using the community index, diversity index, dominant index, and similarity index, the seagrass in Arakan is in good condition. This indicates that the condition of aquatic environments that support seagrass growth are stable/good in Arakan (Table 12).

Table 6. Number of Individuals, Species, and Community Index Parameters of Algae

No.	Parameter	Site		
		1	2	3
1	Number of Individuals/m2	37.91944	44.625	30.86429

2	Number of Species	13	20	27
3	Diversity Index (H')	2.470471	2.192578	2.524731
4	Dominant Index (D)	0.093828	0.060586	0.083382
5	Similarity Index (e)	0.963165	0.790805	0.98432

The seaweeds collected were dominated by genera *Halimeda*, *Gracillaria*, and *Amphiroa*, each of which had two to three species. These three genera were recorded in all study sites and almost all plots had a high tolerance to drought at the lowest tide. This agrees with KADI (2004), which says that in the substrate of reef exposure relatively close to drought at the lowest tide, the growing seaweeds show high tolerance to drought, especially *Halimeda* and *Gracillaria*.

The seaweed species recorded in just one site were *Chondroccocus hornemanii, Hydroclathrus clatratus, Galaxaura rugusa, Udotea argentea, Amansia glomerata, Boergesenia forbesii,* and *Eucheuma denticulatum*. On the other hand, the seaweeds found in all sites were *Gracillaria, Amphiroa, Halimeda, Padina, Acanthophora, Turbinaria, Velonia* and *Actinotrichia*. The seaweeds dominating the coastal margin were *Halimeda, Caulerpa, Amphiroa*, and *Gracillaria*.

Seagrass communities on the sandy substrate can inhibit wave surges. On the other hand, only a few seaweeds can grow in a stony substrate area. Those able to survive the large swells were *Sargassum, Turbinaria, Padina*, and *Acanthophora* (ATMADJA & SUBAGDJA 1995).

Thallasia hemprichii

Enhallus acoroides

Cymodocea rotundata

Figure 26. Dominant Species of Seagrass on Arakan Beach

Arakan waters are part of the Bunaken National Park of Arakan–Wawontulap, with a seagrass bed area of about 1,943 ha. Data were collected using line transects with the quadrat method. Six seagrass species were identified: *Halophila ovalis, H. minor, Thalassia hemprichii, Enhalus acoroides, Cymodocea rotundata*, *and Syringodium isoetifolium*. The highest number of individuals found in one site adjacent to the coastline was 46 individuals/m2.

Based on community index analysis (Table 13), the community structure of seagrass communities on the Arakan coast is stable as characterized by a relatively high diversity index and evenness index. Meanwhile, the relatively low seagrass dominance index has a value below 0.50.

The analysis showed a tendency of each species to grow well in seagrass habitats. Two species, *Enhallus acaroides* and *Thallasia hemprichii*, dominate the area.

Based on coverage in each location, the condition of seagrass in Arakan is high, especially at Site 3, which is adjacent to the mangrove ecosystem. This means that the growth of seagrass in Arakan waters is naturally going well.

Figure 27. Measurement for Percent Cover of Seagrass

Table 7. Number of Individuals, Species, and Community Index Parameters of Seagrass

No.	Parameter	Site		
		1	2	3
1	Number of Individuals/M2	45.767	28.000	29.000
2	Number of Species	5.000	4.000	5.000
3	Diversity Index (H')	1.579	1.127	1.183
4	Dominant Index (D)	0.211	0.089	0.255
5	Similarity Index (e)	0.981	0.813	0.853

6	Percent Cover (%)	60.500	53.000	80.000

Analysis of Marine Ecosystem Exposure

Climate change can alter the geographical composition and distribution of an ecosystem. Individual plants and animals should thus adapt to climate change as their habitats face degradation. Species that cannot adapt will decline or become extinct. Climate change also triggers the death of hard corals because of temperature increasing by 1 ^{o}C to 2^{o}C and higher rainfall. Increasing temperature could also kill the algae that grow within coral tissue. The death of the symbiotic algae, which provides food for corals and influences coral color, may kill hard corals through bleaching (corals turning white). Furthermore, the increasing heavy rainfall will reduce the level of water salinity, which in turn will affect the metabolism of marine organisms. Both of these parameters show a trend of increasing in the future, and are projected to cause the death of corals.

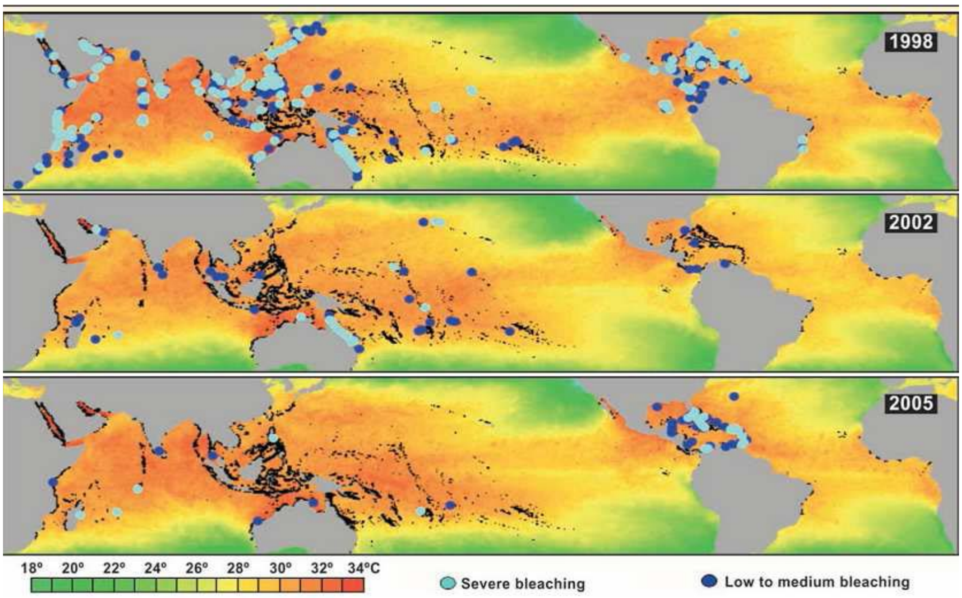


Figure 28. Satellite images in 1998, 2002, and 2005 show the mean monthly maximum temperature and coral bleaching in different locations around the world. (Source: NOAA Coral Reef Watch and IPCC, 2007)

Coral bleaching is a phenomenon where part of the coral or the whole coral turns white. It is caused by the disappearance of symbiotic algae or coral pigment. Coral bleaching can cause the extinction of some coral fishes that have high economic value, such as the tiger grouper, sun grouper, and napoleon wrasse.

Indonesian coral reef ecosystems cover approximately 51,875 km^2, which is equal to one third of Java Island. These reefs are under serious threat and could be destroyed permanently if global warming continues. This means that various marine biota that live and depend on the reef ecosystems are also in danger. Coral reef destruction could also cause the disappearance of a coastal barrier and result in beach erosion or abrasion. Nowadays, only 6% of Indonesian reefs are in excellent condition. It is projected that some of these reefs will disappear in the next 10-20 years, while other reefs will suffer in the next 20-40 years. Coral reef destruction can influence the income level of coastal communities, especially small fishermen.

Increasing sea surface temperature can also disturb the growth and development of mangroves. Mangrove leaf growth is affected at temperatures above 25^0C. Increasing temperature above 25^0C can affect the structure of mangrove roots and the stability of mangrove growth. Coral reefs function as a barrier to protect mangrove ecosystems from big waves and storm surges. Low rainfall in one area can affect the growth of mangroves as well as some marine species and biota that do not have high tolerance to changes in seawater salinity. In other words, low rainfall can cause the loss of mangrove and natural biodiversity.

More warming events can cause the death of the seabed, which is very susceptible to stress due to increasing temperature. Increasing sea surface temperature usually changes the growth rate, biological function, and reproduction patterns of marine biota.

The sensitivity of coastal area ecosystems, as affected by global climate change, has been recorded in the Arakan coastal area. An Arakan coastal ecosystem that is now in critical condition are the coral reefs. There are two main factors that can cause coral reef destruction: (i) human activities such as coral mining, blast fishing, and cyanide fishing; and (ii) global warming, which causes increasing sea surface temperature, which in turn causes coral bleaching. Both of these factors have occurred in the Arakan coral reef ecosystem.

Based on the simulation results of climate projection in South Minahasa, the sea surface temperature around Arakan and South Minahasa in the near period is projected to increase by about 0.65^oC compared with the baseline period. According to climate change literature, the increase of sea surface temperature by 1^oC to 2^oC will trigger bleaching, cause the death of hard corals, and kill the algae that grow within coral tissue. For now, the exposure of the ecosystem to increasing sea surface temperature in Arakan is at a moderate level.

Analysis of Sensitivity/Adaptive Capacity

The sensitivity of the ecosystem in Arakan was determined based on the criteria standards for the determination of coral reef damage from Kepmen LH No. 4/2001, and Yap & Gomez (1984) (Table 14); criteria standards and guidelines for the determination of mangrove destruction (Table 15) from Kepmen LH No. 201 Tahun 2004; and criteria standards and guidelines for the determination of seagrass destruction (Table 16) from Kepmen LH No. 200 Tahun 2004.

Table 8. Criteria Standards for the Determination of Coral Reef Damage

Kepmen LH No. 4 Tahun 2001			Yap & Gomez (1984)	
Category	Sub Category	Coral cover (%)	Category	Coral Cover (%)
Damage	Bad	0 – 24.9	Poor	0 – 24.9
	Moderate	25 – 49.9	Enough	25 – 49.9
Good	Good	50 – 74.9	Good	50 – 74.9
	Very good	75 - 100	Excellent	75 - 100

Table 9. Criteria Standards for the Determination of Mangrove Destruction

Criteria		Coverage (%)	Density (Tree/Ha)
Good	Very Density	≥ 75	≥ 1500
	Moderate	≥ 50 - <75	≥ 1000 - < 1500
Poor	Thin	< 75	< 1000

Table 10. Criteria Standards for the Determination of Seagrass Destruction

Damage Levels	The area of damage (%)
High	≥ 50
Moderate	30 - 49.9
Low	≤ 29.9

Corals are sensitive to changes in sea surface temperature and rainfall to a depth of 0-3 m. A summary of the coral reef survey results is presented in Table 17, while a summary of mangrove and seagrass survey results is presented in Table 18.

Table 11. Summary of Coral Reef Survey Results in Arakan

Survey Site	Arakan 1		Arakan 2		Arakan 3		Arakan 4	
Depth (m)	3	10	3	10	3	10	3	10
Hard Coral (%)	26.24	29.5	32.6	34.8	49.42	39.5	42.9	56.28

Table 12. Summary of Mangrove and Seagrass Survey Results in Arakan

Site	Mangrove	Seagrass
No.	Density (Ha)	% Cover
1	2080	60.5
2	2540	53
3	1880	80

Coral reefs, mangroves, and seagrass ecosystems are influenced by changes in sea surface temperature and rainfall. The increase in sea surface temperature will definitely affect the growth of mangroves and seagrass, while high rainfall will increase sedimentation from land and, at high levels, will kill seagrass and mangrove saplings. The results of data collection on mangrove (>1500 trees/ha) and seagrass (cover >50%) were categorized according to quality standards KLH (Tables 14, 15, and 16). Based on the percentage of hard coral cover, high density of mangrove, and percentage of seagrass cover, Arakan has an ecosystem sensitivity index of 1.7, which means that the ecosystem sensitivity is at a moderate level in the village (Table 19).

Table 13. Ecosystem Sensitivity Score of Arakan

No.	Parameter	Score
1	Percent cover of hard corals (25-49.9%)	3
2	High density of mangrove trees (>1500 ind/ha)	1
3	Percent cover of seagrass (>50%)	1
	AVERAGE	1.7

Adaptive capacity can be determined by some ecosystem parameters, such as coral colony diameter, size of target fish, mangrove condition, number and density of seagrass and seaweed species, and water quality. It can also be influenced by the development of infrastructure (housing and roads) in the mangrove area.

The average size of coral colonies was found to be relatively small (<50 cm). Target fish length (15 cm to 25 cm) was likewise small. This indicated a low adaptation rate (ability to live), especially in the face of environmental changes. Thus, in the face of increasing sea surface temperatures and rainfall, there is low adaptive capacity, with a score of 1.

Good mangrove condition, along with the dominance of old mangrove trees and the high number and density of seagrass and seaweed species, indicated a good level of adaptive capacity to environmental changes, with a score of 3. On the other hand, based on the results of water quality measurements for several parameters, a score of 3 was given for adaptive capacity of aquatic organisms.

Rural development in Arakan, particularly for housing and road infrastructure, began in mangrove areas due to the narrowness of the land. This caused the conversion and modification of mangrove land and indicated an adaptive capacity score of 1.

The adaptive capacity component also depends on the condition of the community in Arakan with regards to educational level, income, livelihood activities, and public awareness about climate change, ecosystems, and socioeconomic benefits. Based on the scores for ecosystem and socioeconomic component parameters, an average score of 1.7 was given for adaptive capacity (Table 20).

Table 14. Ecosystem Adaptive Capacity Score of Arakan

No.	Parameter	Score
1	Average diameter of coral colony is small (<50 cm)	1
2	Average size of economic fishes is small (15-25 cm)	1
3	Mangal is dominated by mature trees	3
4	Number and density of seagrass and seaweed species are high	3
5	Water quality condition is good	3
6	Infrastructure development affects the size of mangrove areas	1
7	Low educational level	1
8	Low income (fishermen exchange rate <1)	1
9	Community activities are focused on mosque activities	2
10	Low public awareness about climate change, ecosystems, and socioeconomic benefits	1
	AVERAGE	1.7

Analysis of Ecosystem Vulnerability in Arakan

The level of ecosystem vulnerability to climate change in Arakan village was based on the ecosystem survey results of the analysis of exposure, sensitivity, and adaptive capacity components. It was found that Arakan has a moderate level of ecosystem exposure and a moderate level of ecosystem sensitivity. This indicates that the potential impact of climate change to the ecosystem in Arakan is at a moderate level (Table 21).

Table 15. Potential Impact of Climate Change to Ecosystem in Arakan Village

		Sensitivity		
		Low	Moderate	High
Exposure	Low	Low	Low	Moderate
	Moderate	Low	Moderate	High
	High	Moderate	High	High

Based on the analysis of ecosystem potential impact and adaptive capacity, both of which were found to be on a moderate level, the vulnerability of the ecosystem to climate change in Arakan is moderate (Table 22).

Table 16. Ecosystem Vulnerability to Climate Change in Arakan Village

		Adaptive Capacity		
		Low	Moderate	High
PotentialImpact	High	High	Moderate	Moderate
	Moderate	Moderate	Moderate	Low
	Low	Low	Low	Low

DEVELOPING AN ADAPTATION OPTION

Vulnerability Assessment

The above historical climate analysis, using observation data, shows the conditions, trends, and patterns of climate (rainfall, temperature, wind speed) over the last twenty years, known as the baseline period. These climate conditions can be used to understand how historical climate patterns developed in South Minahasa. On the other hand, the climate projections in the near period (20-40 years) were analyzed to predict the impacts of climate change.

It is likewise necessary to know the changes in climate parameters in the near period compared with the baseline period using the following key indexes in a vulnerability map:

(i) exposure index and climate hazard index (likelihood of potential disasters);
(ii) sensitivity index (existence of exposure units); and
(iii) adaptive capacity index (where abilities to handle potential disasters are weak).

From the results of the climate change vulnerability assessment, the most important factors from each index in the vulnerability map were determined, such as:

(i) exposure index (rainfall over 50 mm/day);
(ii) climate hazard index (flash floods);
(iii) sensitivity index (density of population); and
(iv) adaptive capacity index (number of schools, health officers, and health facilities).

An area is highly vulnerable if it has high levels of climate exposure, climate hazard, and sensitivity, and low levels of adaptive capacity.

For the project site in Arakan village, Tatapaan district, the vulnerability map indicates high vulnerability because of high sensitivity and low adaptive capacity. The high sensitivity in Arakan is due to the very high population density of the village. Its low adaptive capacity is based on a low number of schools, health officers, and health facilities. The village has high exposure and climate hazard indices because of high levels of rainfall and floods.

The availability of data for all four indices is important for a detailed assessment. However, because of limited socioeconomic data, livelihood was not included in the adaptive capacity component.

Based on the analysis of climate change parameters, increases are projected for rainfall, temperature, and wind speed. On the other hand, the sensitivity and adaptive capacity components are projected to remain constant, while climate exposure and climate hazard trends are projected to increase. The key factor influencing sensitivity and adaptative capacity needs to be determined. The determination of key influences on climate exposure, climate hazard, sensitivity, and adaptive capacity will be used to support adaptation planning. However, this assessment of climate change vulnerability does not include sectors such as agriculture and health.

Determining an Adaptation Plan

The plan for climate change adaptation in Amurang Bay, South Minahasa, is determined from the results of the climate change vulnerability assessment. Generally, with regards to the climate exposure component, rain over 50 mm is the most important factor. For the climate hazard component, some areas have floods/flash floods while other areas have extreme weather. Furthermore, the key factor for adaptive capacity are the number of schools, health officers, and health facilities.

For Arakan village, the most important factors for developing an adaptation plan are the following:

i) rainfall over 50 mm for climate exposure;
ii) floods hazard for climate hazard;
iii) population density for sensitivity; and
iv) number of schools, health officers, and health facilities.

Community Action Strategy

As previously mentioned, the adaptive capacity on the individual level is determined by access to resources affecting adaptive capacity to climate change. In Arakan village, there are some adaptation activities, including:

(i) temporary jobs during the storm season; and
(ii) seaweed culture.

Moving to another job is normally done in Arakan, particularly during the storm season, with fishermen taking on other jobs such as driving motorbike taxis, farming, and construction building. These types of alternative jobs are generally not conducted in the long term, since most fishermen continue to rely on fishing as their major source of income. In fact, not all fishermen take on other jobs during the storm season; instead, they continue to fish knowing the risks of fishing during this period.

Most fishermen also practice seaweed farming. But in 2014, there was no seaweed farming activity due to disease infection as a result of the bad quality of seaweed seedlings used. In this regard, an adaptive activity would be for fishing families to use good quality seaweed seedlings.

Adaptive Capacity Development Constraint

This study presents adaptive capacity at the collective level as well as the individual level in Arakan. Beyond the present adaptive capacity weakness, there are two major problems inhibiting adaptive capacity development in the village.

The first problem is low awareness of the threat of climate change. Based on interviews, it was found that even though climate change has directly affected Arakan, its residents still do not consider it as an emergent problem.This can raise the susceptibility level of the community to climate change impacts, because it is not possible to have adaptive capacity building if people are unaware of the severity of problems brought about by climate change.

The second problem is the economic imbalance between the merchant middlemen and the fishermen in Arakan. Aside from determining fish prices, merchant middlemen in the village also act as money lenders for the fishermen as they accumulate more income than those who are actually engaged in fishing. This inequitable patron-client relationship can make certain individuals have more access to resources at the expense of other individuals. It can also affect the adaptive capacity at the collective level.

The two problems need to be understood and resolved for Arakan to raise its adaptive capacity in facing the impacts of climate change.

From the analysis of climate change vulnerability, adaptation planning requires the following:

(i) information dissemination about the results of the vulnerability assessment in Amurang Bay and Arakan village, South Minahasa, to local governments, elders and other members of the community, educational institutions, and other stakeholders through radio and television, as well as local community meetings;

(ii) selection of Arakan village as a priority area for the implementation of a pilot project to improve climate change adaptation in South Minahasa;

(iii) formation of a working group consisting of relevant government agencies, local governments, and other community stakeholders to support the implementation of a climate change adaptation program in Arakan;

(iv) community activities for the environment, such as waste management, mangrove planting, and livestock management;

(v) livelihood improvement through capacity building based on the use of better seaweed seedlings and the establishment of a fishermen's cooperative to buy high quality seaweed seedlings;

(vi) capacity building to promote and enhance public awareness through the transfer of knowledge and technology (training, seminars, etc.), and the creation of a module and other educational materials on climate change, which should be included in the school curricula; and

(vii) natural resources management and infrastructure building, especially for education and health.

CONCLUSION

The vulnerability assessment and climate change adaptation analysis in Amurang Bay and Arakan village, South Minahasa regency, were conducted using climate observation data, climate projections, natural hazards observation data, and socioeconomic statistics.

Climate Projections

In South Minahasa, long-term increasing trends are projected for rainfall, temperature, and wind.

Increasing trends include the following:

(i) yearly total rainfall in three stations in North Sulawesi (11.3 mm/year at Sam Ratulangi station, 23.6 mm/year at Kayuwatu station, and 6.6 mm/year at Bitung station);

(ii) temperature parameter in three stations in North Sulawesi (0.0026^{o}C/year at Sam Ratulangi station, 0.0157^{o}C/year at Kayuwatu station, and 0.0082^{o}C/year at Bitung station); and

(iii) wind speed (0.0157mm/s/year at Kayuwatu station, and 0.0172 mm/s/year at Bitung station).

The seasonally observed rainfall in South Minahasa shows a positive trend, but its value is insignificant. Rainfall tends to show an increase of 10 mm/year in the December to February (DJF) period; 1.4 mm/year in the March to May (MAM) period; 0.025 mm/year in the June to August (JJA) period; and 1.65 mm/year in the September to November (SON) period. Wet anomaly in DJF, MAM, JJA, and DJF periods is generally caused by the warming of the sea surface temperature, while dry anomaly in these periods is generally caused by the cooling of the sea surface temperature not only in the Sulawesi Sea but in almost all Indonesian waters. Also in South Minahasa, the sea surface temperature experiences warming when rainfall is above normal, while it experiences cooling when rainfall is below normal. The changes in rainfall, temperature, wind speed, and sea surface temperature in the near period is generally projected to increase compared with the baseline period (last 20 years).

Vulnerability Assessment

The exposure index and climate hazard index show potential disasters, the sensitivity index shows the existence of exposure units, and the adaptive capacity index shows where abilities to handle potential disasters are weak.

In Amurang Bay, the results of the climate change vulnerability assessment indicate the most important factors for different indices:

(i) rainfall over 50 mm/day for the exposure index;
(ii) flash floods for the climate hazard index;
(iii) density of population for the sensitivity index; and
(iv) low number of schools, health officers, and health facilities for the adaptive capacity index.

An area is projected to have high vulnerability if it has high levels of climate exposure, climate hazard, and sensitivity, and low adaptative capacity. The vulnerability map indicates the most vulnerable areas: Arakan village, Tatapaan district; Kapitu village,West Amurang district; and the upper-middle area of Amurang Bay.

In Arakan village, the socioeconomic vulnerability map indicates high vulnerability to climate change because of high sensitivity and low adaptive capacity. The most important factors are rainfall over 50 mm for climate exposure, floods hazard for climatic hazard, huge density for sensitivity, and low of number of schools, health officers, and health facilities for adaptive capacity.

Ecosystem Vulnerability

To determine the ecosystem vulnerability to climate change in Arakan, an ecosystem survey was conducted. Field measurements gave the following results:

(i) PH ranges from 8.24 to 8.41.
(ii) Water salinity ranges from 33.3 ppm to 34.1 ppm, indicating natural salinity concentrations for seawater.
(iii) Dissolved oxygen (DO) in the coral reefs within the coral reef fishing zone ranges from 8.53 mg/l to 8.70 mg/l, which is a good range for aquatic life.
(iv) All physical and chemical parameters, except visibility, are still in optimal condition for living marine biota. Arakan reefs are in fair or

good condition. The seabed is predominantly covered by algae and other fauna such as sponge.

The tendency to have a low number of large-sized coral reef fish populations and species in the 0–20M depth is largely brought about by coral reef destruction, coral reef fish overfishing, and blast fishing. If this situation continues, the coral reef fisheries potential of Arakan will be increasingly threatened and will adversely affect the lives of coastal fishers and their families who depend on marine resources for food and livelihood..

To survey the condition of mangrove ecosystems, three sampling locations were used: Transect I (right front), Transect II (inside), and Transect III (left front). Mangrove vegetation in Arakan is sufficiently diverse, particularly in Transect I (right front), where seven species dominate. The three transects show a high relative frequency occurrence of *Rhizophora* sp and *Sonneratia* sp. This indicates that members of family *Rhizophoraceae* and some *Sonneratiaceae* possess the ability to grow better in the area compared to other species.

The analysis of important value index (IVI) of mangroves show that *Rhizophora sp* has the highest IVI in the three locations. Its IVI ranges from 45.6% to 129.17%. Other mangrove species have lower IVI than 129.17 %. Thus, based on the transect data for mangroves in Arakan, genus *Rhizophora* possesses the largest or the most dominant role over the other genera. Furthermore, from the mangrove diversity analysis, the mangrove ecosystem of Transect I (right front) has the highest diversity, while Transect II (inside) has the lowest diversity. The mangrove species found in Transect I (right front) are more diverse and numerous, while only three species are found in Transect II (inside) and four species in Transect III (left front).

Based on the fact that small trees are predominant in the mangrove area, the mangove forest is not in good condition. Nevertheless, the community in Arakan has started a small-scale mangrove planting activity to enlarge the mangrove area.

Based on the analysis of the seaweed survey using the community index, diversity index, dominance index, and similarity index, it was found that the seaweeds in Arakan waters are in good condition.

Based on the community index analysis of seagrass, the structure of seagrass communities on the Arakan coast is considered stable. It is characterized by a relatively high diversity index and evenness index and a relatively small seagrass dominance index (<0.50). The analysis show a tendency of each species to grow well in seagrass habitats, although it was found that two species (*Enhallus* *acaroides* and *Thallasia hemprichii*) dominate the area. Based on percent cover in each location, the seagrass area on the Arakan coast is sizeable, especially at Site 3 adjacent to the mangrove ecosystem.

In Arakan, the ecosystem vulnerability to climate change indicates a moderate level of vulnerability because the ecosystem's exposure, sensitivity, and adaptive capacity are at moderate levels.

In summary, the keys to the ecosystem condition in Arakan are increasing sea level rise, percent cover of coral reefs, education, and community awareness of ecosystem vulnerability.

Adaptation Planning

Based on the results of the vulnerability assessment in Amurang Bay and Arakan village, South Minahasa, the key steps for adaptation planning include:

(i) information dissemination about the results of the vulnerability assessment in Amurang Bay and Arakan village to local governments, elders and other members of the community, educational institutions, and other stakeholders through radio and television, as well as local community meetings;

(ii) selection of Arakan village as a priority area for the implementation of a pilot project to improve climate change adaptation in South Minahasa;

(iii) formation of a working group consisting of relevant government agencies, local governments, and other community stakeholders to support the implementation of a climate change adaptation program in Arakan;

(iv) community activities for the environment such as waste management, mangrove planting, and livestock management;

(v) sustainable management of coral reefs and coral reef fishes through the implementation of the following measures:

  (a) banning illegal fishing activities using explosives and poison;

  (b) establishment of marine protected areas (MPAs), marine sanctuaries, and fishery reserves;

  (c) regulation of fishing gears, including banning the use of fine-meshed nets, to prevent the capture of small and juvenile fish;

(d) regulation of the exploitation of ornamental coral reef fishes to stop illegal fishing practices; and

(e) habitat protection and rehabilitation;

(vi) livelihood improvement through capacity building based on the use of better seaweed seedlings and the establishment of a fishermen's cooperative to buy high quality seaweed seedlings;

(vii) capacity building to promote and enhance public awareness through the transfer of knowledge and technology (training, seminars, etc.); the creation of a module and other educational materials on climate change, which should be included in the school curricula; and more intensive use of BMKG weather and climate information for daily activities in the community;

(viii) natural resources management, such as strengthening the capacity of Bunaken National Park, and better law enforcement for reef conservation; and

(ix) infrastructure building, especially for education and health.

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APPENDICES

Appendix 1. Manta Tow Survey Data

NO.	Data Manta Tow and Coordinate 25/09/2014					
	HC	SC	DC	OT	Notes	GPS
1	Start					N : 01° 22' 53,7" E : 124° 33' 28,7"
2	10	5	5	80	Sand and Seagrass	N : 01° 22' 57,5" E : 124 ° 33' 23,1"
3	70	20	5	5		N : 01° 22' 59,4" E : 124 ° 33' 21,6"
4	60	10	20	10		N : 01° 23' 01,1" E : 124 ° 33' 21,6"
5	30	20	40	10		N : 01° 23' 03,0" E : 124 ° 33' 21,7"
6	40	30	20	10		N : 01° 23'05,1" E : 124 ° 33' 22,2"
7	10	10	10	70	Sand and Seagrass	N : 01° 23'07,1" E : 124 ° 33'22,3"
8	30	30	10	30	Rubble	N : 01° 23'10,3" E : 124 ° 33'21,4"
9	30	50	10	10	soft coral Dominated	N : 01° 23'12,3" E : 124 ° 33'22,5"
10	30	40	20	10		N : 01° 23'15,0" E : 124 ° 33'22,0"
11	20	20	50	10	ACB Many corals (ACB) broken, traps covered with dead corals at depth of 5 meters.	N : 01° 23'16,8" E : 124 ° 33'20,4"
12	20	20	40	20	ACB many broken	N : 01° 23'18,9" E : 124 ° 33'19,3"
13	40	50	5	5		N : 01° 23'21,7" E : 124 ° 33'19,10"
14	40	30	20	10		N : 01° 23'24,6" E : 124 ° 33'16,5"
15	20	20	50	10	ACB damaged, broken	N : 01° 23'24,6" E : 124 ° 33'15,1"
16	20	20	50	10	ACB damaged, broken	N : 01° 23'24,4" E : 124 ° 33'12,9"
17	10	5	45	40	ACB damaged, broken	N : 01° 23'22,4" E : 124 ° 33'10,8"

NO	Data Manta Tow and Coordinate 25/09/2014					
	HC	SC	DC	OT	Notes	GPS
18	20	30	30	20		N : 01° 23'24,0" E : 124° 33'07,3"
19	10	10	30	50	Sand and rubble	N : 01° 23'24,9" E : 124° 33'05,3"
20	80	0	10	10	ACB dominated	N : 01° 23'26,6" E : 124° 33'05,5"
21	20	20	40	20		N : 01° 23'30,9" E : 124° 33'07,6"
22	40	30	20	10		N : 01° 23'32,5" E : 124° 33'11,4"
23	5	5	60	30	ACB damaged, broken	N : 01° 23'34,6" E : 124° 33'10.4"
24	15	15	50	20	ACB damaged, broken	N : 01° 23'36,3" E : 124° 33'06,7"
25	70	10	10	10	ACS dominated	N : 01° 23'37,5" E : 124° 33'04,0"
26	40	20	30	10		N : 01° 23'37,8" E : 124° 32'57,6"
27	40	30	20	10		N : 01° 23'37,1" E : 124° 32'53,3"
28	15	10	60	15	ACS damaged, broken	N : 01° 23'36,0" E : 124° 32'51,1"
29	10	5	50	35	ACS damaged, broken	N : 01° 23'33,7" E : 124° 32'47,8"
30	5	10	40	45	Destroyed ACS dominated by coral fragments	N : 01° 23'29,6" E : 124° 32'48,0"
31	5	5	20	70	Sandy area, dominated by red, blue, and brown algae	N : 01° 23'27,3" E : 124° 32'50,1"
32	5	5	30	60		N : 01° 23'26,2" E : 124° 32'47,6"
33	5	20	40	35	Destroyed ACS, only fragments occurred	N : 01° 23'30,8" E : 124° 32'45,0"
34	10	10	40	40		N : 01° 23'31,9" E : 124° 32'42,5"
35	15	25	30	30		N : 01° 23'31,4" E : 124° 32'37,1"
36	10	20	40	30		N : 01° 23'29,3" E : 124° 32'33,3"
37	15	15	50	20	ACS damaged, broken	N : 01° 23'27,3" E : 124° 32'29,2"
38	15	15	50	20	ACS damaged, broken	N : 01° 23'26,6" E : 124° 32'20,8"

NO	Data Manta Tow and Coordinate 25/09/2014					
	HC	SC	DC	OT	Notes	GPS
39	10	10	70	10	ACS damaged, broken	N : 01° 23'24,0" E : 124° 32'14,6"
40	10	10	70	10	ACS damaged, broken. fishing with jubi (8 people)	N : 01° 23'20,2" E : 124° 32'08,2"
41	10	10	70	10	ACS damaged, broken	N : 01° 23'16,3" E : 124° 32'00,6"
42	30	20	20	30		N : 01° 23'08,5" E : 124° 32'03,3"
43	10	5	15	70	Sand	N : 01° 23'06,0" E : 124° 32'05,2"
44	25	15	50	10		N : 01° 23'03,9" E : 124° 32'04,6"
45	30	25	35	10		N : 01° 23'00,4" E : 124° 32'07,9"
46	40	10	20	30		N : 01° 22'58,0" E : 124° 32'10,7"
47	50	20	10	20		N : 01° 22'56,7" E : 124° 32'11,8"
48	40	20	20	20		N : 01° 22'54,5" E : 124° 32'14,7"
49	40	10	20	30		N : 01° 22'52,3" E : 124° 32'10,6"
50	10	10	30	50	Sand	N : 01° 22'50,5" E : 124° 32'22,6"
51	10	10	25	55	Sand	N : 01° 22'49,2" E : 124° 32'24,6"

Appendix 2. Coral Reef Condition in Arakan 1, Depth of 3 Meters

REEF NAME :	Arakan 1	**TRANSECT DEPTH :**	3 m
SITE DESCRIPTION :	Slope	**COLLECTOR :**	Frangky Runtukahu
DATA SAMPLE :	Arakan	**DATE :**	
TRANSECT LENGTH SAMPLES :	5000 cm	**POSITION :**	0
TEMPERATURE :	0	**REMARKS :**	0

BENTHIC LIFEFORMS			CODE	OCCURRENCE	PERCENT COVER	CATEGORY TOTAL
HARD CORALS (ACROPORA)						
	Branching		ACB	6	15.80%	
	Tabulate		ACT	3	3.40%	
	Encrusting		ACE	0	0.00%	
	Submassive		ACS	0	0.00%	
	Digitate		ACD	0	0.00%	19.20%
HARD CORALS (NON-ACROPORA)						
	Branching		CB	5	1.84%	
	Massive		CM	4	2.60%	
	Encrusting		CE	0	0.00%	
	Submassive		CS	0	0.00%	
	Foliose		CF	0	0.00%	
	Mushroom		CMR	15	2.60%	
	Millepora		CME	0	0.00%	
	Heliopora		CHL	0	0.00%	7.04%
DEAD SCLERACTINIA						
	Dead Coral		DC	0	0.00%	
	Dead Coral with Alga		DCA	4	7.30%	7.30%

BENTHIC LIFEFORMS			CODE	OCCURRENCE	PERCENT COVER	CATEGORY TOTAL
ALGAE						
	Macro		MA	1	1.30%	
	Turf		TA	0	0.00%	
	Coralline		CA	0	0.00%	
	Halimeda		HA	0	0.00%	
	Alga Assemblage		AA	5	6.56%	7.86%
OTHER FAUNA						
	Soft Coral		SC	16	25.10%	
	Sponge		SP	0	0.00%	
	Zoanthids		ZO	0	0.00%	
	Other		OT	0	0.00%	25.10%
ABIOTIC						
	Sand		S	1	0.20%	
	Rubble		R	17	33.30%	
	Silt		SI	0	0.00%	
	Water		WA	0	0.00%	
	Rock		RCK	0	0.00%	33.50%
TOTAL				77		100.00%

Appendix 3. Coral Reef Condition in Arakan 1, Depth of 10 Meters

REEF NAME :	Arakan 1	**TRANSECT DEPTH :**	10 m
SITE DESCRIPTION :	Reef slope	**COLLECTOR :**	Frangky Runtukahu
DATA SAMPLE :	Arakan 1	**DATE :**	
TRANSECT LENGTH SAMPLES :	5000 cm	**POSITION :**	0
TEMPERATURE :	0	**REMARKS :**	0

BENTHIC LIFEFORMS			CODE	OCCURRENCE	PERCENT COVER	CATEGORY TOTAL
HARD CORALS (ACROPORA)						
	Branching		ACB	2	3.20%	
	Tabulate		ACT	0	0.00%	
	Encrusting		ACE	0	0.00%	
	Submassive		ACS	0	0.00%	
	Digitate		ACD	0	0.00%	3.20%
HARD CORALS (NON-ACROPORA)						
	Branching		CB	10	6.20%	
	Massive		CM	3	1.90%	
	Encrusting		CE	2	0.60%	
	Submassive		CS	18	11.40%	
	Foliose		CF	7	3.60%	
	Mushroom		CMR	12	2.60%	
	Millepora		CME	0	0.00%	
	Heliopora		CHL	0	0.00%	26.30%
DEAD SCLERACTINIA						
	Dead Coral		DC	1	1.00%	

BENTHIC LIFEFORMS			CODE	OCCURRENCE	PERCENT COVER	CATEGORY TOTAL
	Dead Coral with Alga		**DCA**	3	2.00%	**3.00%**
ALGAE						
	Macro		**MA**	1	0.20%	
	Turf		**TA**	0	0.00%	
	Coralline		**CA**	0	0.00%	
	Halimeda		**HA**	0	0.00%	
	Alga Assemblage		**AA**	12	6.60%	**6.80%**
OTHER FAUNA						
	Soft Coral		**SC**	17	15.40%	
	Sponge		**SP**	3	0.70%	
	Zoanthids		**ZO**	1	4.00%	
	Other		**OT**	0	0.00%	**20.10%**
ABIOTIC						
	Sand		**S**	9	21.50%	
	Rubble		**R**	12	19.10%	
	Silt		**SI**	0	0.00%	
	Water		**WA**	0	0.00%	
	Rock		**RCK**	0	0.00%	**40.60%**
TOTAL				113		**100.00%**

Appendix 4. Coral Reef Condition in Arakan 2, Depth of 3 Meters

REEF NAME :	Arakan 2	**TRANSECT DEPTH :**	3 m
SITE DESCRIPTION :	Slope	**COLLECTOR :**	Frangky Runtukahu
DATA SAMPLE :	Arakan	**DATE :**	
TRANSECT LENGTH SAMPLES :	5000 cm	**POSITION :**	0
TEMPERATURE :	0	**REMARKS :**	0

BENTHIC LIFEFORMS			**CODE**	**OCCURRENCE**	**PERCENT COVER**	**CATEGORY TOTAL**
HARD CORALS (ACROPORA)						
	Branching		ACB	4	2.44%	
	Tabulate		ACT	4	5.24%	
	Encrusting		ACE	0	0.00%	
	Submassive		ACS	5	5.20%	
	Digitate		ACD	0	0.00%	12.88%
HARD CORALS (NON-ACROPORA)						
	Branching		CB	15	9.00%	
	Massive		CM	8	3.58%	
	Encrusting		CE	5	1.14%	
	Submassive		CS	4	1.20%	
	Foliose		CF	2	0.60%	
	Mushroom		CMR	6	3.00%	
	Millepora		CME	1	1.20%	
	Heliopora		CHL	0	0.00%	19.72%

BENTHIC LIFEFORMS			CODE	OCCURRENCE	PERCENT COVER	CATEGORY TOTAL
DEAD SCLERACTINIA						
	Dead Coral		**DC**	1	2.00%	
	Dead Coral with Alga		**DCA**	2	2.00%	**4.00%**
ALGAE						
	Macro		**MA**	0	0.00%	
	Turf		**TA**	0	0.00%	
	Coralline		**CA**	0	0.00%	
	Halimeda		**HA**	0	0.00%	
	Alga Assemblage		**AA**	11	8.78%	**8.78%**
OTHER FAUNA						
	Soft Coral		**SC**	12	18.62%	
	Sponge		**SP**	0	0.00%	
	Zoanthids		**ZO**	0	0.00%	
	Other		**OT**	1	0.20%	**18.82%**
ABIOTIC						
	Sand		**S**	1	0.48%	
	Rubble		**R**	16	35.32%	
	Silt		**SI**	0	0.00%	
	Water		**WA**	0	0.00%	
	Rock		**RCK**	0	0.00%	**35.80%**
TOTAL				98		**100.00%**

Appendix 5. Coral Reef Condition in Arakan 2, Depth of 10 Meters

REEF NAME :	Arakan 2	**TRANSECT DEPTH :**	10 m
SITE DESCRIPTION :	Reef flat	**COLLECTOR :**	Frangky Runtukahu
DATA SAMPLE :	0	**DATE :**	
TRANSECT LENGTH SAMPLES :	5000 cm	**POSITION :**	0
TEMPERATURE :	0	**REMARKS :**	0

BENTHIC LIFEFORMS			**CODE**	**OCCURRENCE**	**PERCENT COVER**	**CATEGORY TOTAS**
HARD CORALS (ACROPORA)						
	Branching		ACB	3	1.00%	
	Tabulate		ACT	3	2.00%	
	Encrusting		ACE	0	0.00%	
	Submassive		ACS	0	0.00%	
	Digitate		ACD	0	0.00%	3.00%
HARD CORALS (NON-ACROPORA)						
	Branching		CB	12	8.00%	
	Massive		CM	6	3.40%	
	Encrusting		CE	10	4.64%	
	Submassive		CS	4	1.36%	
	Foliose		CF	10	10.80%	
	Mushroom		CMR	2	0.60%	
	Millepora		CME	5	3.00%	
	Heliopora		CHL	0	0.00%	31.80%
DEAD SCLERACTINIA						
	Dead Coral		DC	0	0.00%	
	Dead Coral with Alga		DCA	6	4.80%	4.80%

BENTHIC LIFEFORMS			CODE	OCCURRENCE	PERCENT COVER	CATEGORY TOTAL
ALGAE						
	Macro		**MA**	0	0.00%	
	Turf		**TA**	0	0.00%	
	Coralline		**CA**	0	0.00%	
	Halimeda		**HA**	0	0.00%	
	Alga Assemblage		**AA**	7	3.20%	**3.20%**
OTHER FAUNA						
	Soft Coral		**SC**	16	27.20%	
	Sponge		**SP**	2	0.70%	
	Zoanthids		**ZO**	0	0.00%	
	Other		**OT**	2	1.00%	**28.90%**
ABIOTIC						
	Sand		**S**	7	27.10%	
	Rubble		**R**	1	1.20%	
	Silt		**SI**	0	0.00%	
	Water		**WA**	0	0.00%	
	Rock		**RCK**	0	0.00%	**28.30%**
TOTAL				96		**100.00%**

Appendix 6. Coral Reef Condition in Arakan 3, Depth of 3 Meters

REEF NAME :	Arakan 3	**TRANSECT DEPTH :**	3 m
SITE DESCRIPTION :	Slope	**COLLECTOR :**	Frangky Runtukahu
DATA SAMPLE :	Arakan 3	**DATE :**	
TRANSECT LENGTH SAMPLES :	5000 cm	**POSITION :**	0
TEMPERATURE :	0	**REMARKS :**	0

BENTHIC LIFEFORMS			**CODE**	**OCCURRENCE**	**PERCENT COVER**	**CATEGORY TOTAL**
HARD CORALS (ACROPORA)						
	Branching		ACB	5	3.20%	
	Tabulate		ACT	6	5.48%	
	Encrusting		ACE	0	0.00%	
	Submassive		ACS	3	3.70%	
	Digitate		ACD	0	0.00%	12.38%
HARD CORALS (NON-ACROPORA)						
	Branching		CB	20	25.80%	
	Massive		CM	9	2.50%	
	Encrusting		CE	6	1.84%	
	Submassive		CS	3	0.70%	
	Foliose		CF	0	0.00%	
	Mushroom		CMR	3	3.60%	
	Millepora		CME	3	2.60%	
	Heliopora		CHL	0	0.00%	37.04%
DEAD SCLERACTINIA						
	Dead Coral		DC	0	0.00%	
	Dead Coral with Alga		DCA	3	2.20%	2.20%

BENTHIC LIFEFORMS			CODE	OCCURRENCE	PERCENT COVER	CATEGORY TOTAL
ALGAE						
	Macro		**MA**	0	0.00%	
	Turf		**TA**	0	0.00%	
	Coralline		**CA**	0	0.00%	
	Halimeda		**HA**	0	0.00%	
	Alga Assemblage		**AA**	14	10.70%	**10.70%**
OTHER FAUNA						
	Soft Coral		**SC**	13	14.10%	
	Sponge		**SP**	0	0.00%	
	Zoanthids		**ZO**	0	0.00%	
	Other		**OT**	0	0.00%	**14.10%**
ABIOTIC						
	Sand		**S**	0	0.00%	
	Rubble		**R**	12	23.58%	
	Silt		**SI**	0	0.00%	
	Water		**WA**	0	0.00%	
	Rock		**RCK**	0	0.00%	**23.58%**
TOTAL				100		**100.00%**

Appendix 7. Coral Reef Condition in Arakan 3, Depth of 10 Meters

REEF NAME :	Arakan 3	**TRANSECT DEPTH :**	10 m
SITE DESCRIPTION :	Reef flat	**COLLECTOR :**	Frangky Runtukahu
DATA SAMPLE :	Arakan 3	**DATE :**	
TRANSECT LENGTH SAMPLES :	5000 cm	**POSITION :**	0
TEMPERATURE :	0	**REMARKS :**	0

BENTHIC LIFEFORMS			**CODE**	**OCCURRENCE**	**PERCENT COVER**	**CATEGORY TOTAL**
HARD CORALS (ACROPORA)						
	Branching		ACB	3	2.50%	
	Tabulate		ACT	1	1.00%	
	Encrusting		ACE	0	0.00%	
	Submassive		ACS	0	0.00%	
	Digitate		ACD	0	0.00%	3.50%
HARD CORALS (NON-CROPORA)						
	Branching		CB	6	3.00%	
	Massive		CM	7	6.20%	
	Encrusting		CE	6	12.70%	
	Submassive		CS	4	3.80%	
	Foliose		CF	6	7.00%	
	Mushroom		CMR	3	3.30%	
	Millepora		CME	0	0.00%	
	Heliopora		CHL	0	0.00%	36.00%
DEAD SCLERACTINIA						
	Dead Coral		DC	1	0.80%	
	Dead Coral		DCA	1	0.60%	1.40%

	with Alga					

BENTHIC LIFEFORMS			**CODE**	**OCCURRENCE**	**PERCENT COVER**	**CATEGORY TOTAL**
ALGAE						
	Macro		**MA**	0	0.00%	
	Turf		**TA**	0	0.00%	
	Coralline		**CA**	0	0.00%	
	Halimeda		**HA**	0	0.00%	
	Alga Assemblage		**AA**	3	2.60%	**2.60%**
OTHER FAUNA						
	Soft Coral		**SC**	13	20.70%	
	Sponge		**SP**	2	1.80%	
	Zoanthids		**ZO**	0	0.00%	
	Other		**OT**	7	3.50%	**26.00%**
ABIOTIC						
	Sand		**S**	7	26.80%	
	Rubble		**R**	2	3.70%	
	Silt		**SI**	0	0.00%	
	Water		**WA**	0	0.00%	
	Rock		**RCK**	0	0.00%	**30.50%**
TOTAL				72		**100.00%**

Appendix 8. Coral Reef Condition in Arakan 4, Depth of 3 Meters

REEF NAME :	Arakan 4	**TRANSECT DEPTH :**	3 m
SITE DESCRIPTION :	Reef flat	**COLLECTOR :**	Frangky Runtukahu
DATA SAMPLE :	Arakan	**DATE :**	
TRANSECT LENGTH SAMPLES :	5000 cm	**POSITION :**	0
TEMPERATURE :	0	**REMARKS :**	0

BENTHIC LIFEFORMS			**CODE**	**OCCURRENCE**	**PERCENT COVER**	**CATEGORY TOTAL**
HARD CORALS (ACROPORA)						
	Branching		ACB	0	0.00%	
	Tabulate		ACT	0	0.00%	
	Encrusting		ACE	0	0.00%	
	Submassive		ACS	0	0.00%	
	Digitate		ACD	0	0.00%	0.00%
HARD CORALS (NON-ACROPORA)						
	Branching		CB	9	37.50%	
	Massive		CM	0	0.00%	
	Encrusting		CE	4	1.40%	
	Submassive		CS	1	1.80%	
	Foliose		CF	1	1.80%	
	Mushroom		CMR	2	0.40%	
	Millepora		CME	0	0.00%	
	Heliopora		CHL	0	0.00%	42.90%
DEAD SCLERACTINIA						
	Dead Coral		DC	0	0.00%	
	Dead Coral with Alga		DCA	7	18.20%	18.20%

BENTHIC LIFEFORMS			CODE	OCCURRENCE	PERCENT COVER	CATEGORY TOTAL
ALGAE						
	Macro		**MA**	0	0.00%	
	Turf		**TA**	0	0.00%	
	Coralline		**CA**	0	0.00%	
	Halimeda		**HA**	0	0.00%	
	Alga Assemblage		**AA**	4	1.60%	**1.60%**
OTHER FAUNA						
	Soft Coral		**SC**	7	15.80%	
	Sponge		**SP**	1	0.20%	
	Zoanthids		**ZO**	0	0.00%	
	Other		**OT**	1	0.90%	**16.90%**
ABIOTIC						
	Sand		**S**	5	15.60%	
	Rubble		**R**	2	4.80%	
	Silt		**SI**	0	0.00%	
	Water		**WA**	0	0.00%	
	Rock		**RCK**	0	0.00%	**20.40%**
TOTAL				44		**100.00%**

Appendix 9. Coral Reef Condition in Arakan 4, Depth of 10 Meters

REEF NAME :	Teluk Totok	**TRANSECT DEPTH :**	10 m
SITE DESCRIPTION :	Slope	**COLLECTOR :**	Frangky Runtukahu
DATA SAMPLE :	Ratatotok	**DATE :**	
TRANSECT LENGTH SAMPLES :	5000 cm	**POSITION :**	0
TEMPERATURE :	0	**REMARKS :**	0

BENTHIC LIFEFORMS			**CODE**	**OCCURRENCE**	**PERCENT COVER**	**CATEGORY TOTAL**
HARD CORALS (ACROPORA)						
	Branching		ACB	4	15.60%	
	Tabulate		ACT	0	0.00%	
	Encrusting		ACE	0	0.00%	
	Submassive		ACS	0	0.00%	
	Digitate		ACD	0	0.00%	15.60%
HARD CORALS (NON-ACROPORA)						
	Branching		CB	15	37.44%	
	Massive		CM	0	0.00%	
	Encrusting		CE	2	0.30%	
	Submassive		CS	6	1.70%	
	Foliose		CF	0	0.00%	
	Mushroom		CMR	7	1.14%	
	Millepora		CME	0	0.00%	
	Heliopora		CHL	0	0.00%	40.58%
DEAD SCLERACTINIA						
	Dead Coral		DC	0	0.00%	
	Dead Coral with Alga		DCA	7	8.30%	8.30%

BENTHIC LIFEFORMS			CODE	OCCURRENCE	PERCENT COVER	CATEGORY TOTAL
ALGAE						
	Macro		**MA**	1	1.80%	
	Turf		**TA**	0	0.00%	
	Coralline		**CA**	0	0.00%	
	Halimeda		**HA**	0	0.00%	
	Alga Assemblage		**AA**	8	13.46%	**15.26%**
OTHER FAUNA						
	Soft Coral		**SC**	3	2.90%	
	Sponge		**SP**	5	3.60%	
	Zoanthids		**ZO**	0	0.00%	
	Other		**OT**	0	0.00%	**6.50%**
ABIOTIC						
	Sand		**S**	0	0.00%	
	Rubble		**R**	8	13.76%	
	Silt		**SI**	0	0.00%	
	Water		**WA**	0	0.00%	
	Rock		**RCK**	0	0.00%	**13.76%**
TOTAL				66		**100.00%**

Appendix 10. Distribution and Diversity of Indicator Species (Family *Chaetodontidae*) in the Coral Reefs of Arakan

No.	Species	Station							
		St 1		St 2		St 3		St 4	
		3m	10m	3m	10m	3m	10m	3m	10m
1	*Chaetodon auriga*			3	4	2	2	2	2
2	*C. ocellicaudus*	2			2				4
3	*C. melannotus*	4						4	
4	*C. rafflesi*			4		2	2		
5	*C. lunula*					*2*		2	
6	*C. kleinii*	4	4	7	6	12	8	11	4
7	*C. unimaculatus*							4	
8	*C. punctatofasciatus*	2	2	4	2	4	4	2	2
9	*C. citrinellus*	2		2			2	4	
10	*C. lunulatus*	4	2	5	4	4	4	2	4
11	*C. trifascialis*			2			2	2	
12	*C. baronessa*	2	2	2		3	2	2	2
13	*C. vagabundus*		2	2		4	2		2
14	*C. ornatissimus*					2			
15	*C. auriga*					2		2	
16	*Chaetodon ulietensis*					2			
17	*Forcipiger flavissimus*	4		4		6	2	6	4
18	*F. longirostris*		4		3	3	2	4	4
19	*Heniochus varius*	2	2	4	3	4	2	2	2
20	*H. chrysostomus*		2			2	2	2	2
21	*Hemithaurichthys polylpeis*			5	25	11	32		
	Number of Species	**9**	**8**	**12**	**8**	**16**	**14**	**15**	**11**
	Number of Individuals	**26**	**20**	**44**	**49**	**65**	**68**	**51**	**32**
	Diversity Index	**2.138**	**2.025**	**2.404**	**1.613**	**2.552**	**1.977**	**2.524**	**2.339**
	Dominance Index	**0.124**	**0.140**	**0.097**	**0.299**	**0.097**	**0.251**	**0.099**	**0.102**
	Similarity Index	**0.973**	**0.974**	**0.967**	**0.776**	**0.921**	**0.749**	**0.932**	**0.976**

Appendix 11. Distribution and Diversity of Target (Economic) Species in the Coral Reefs of Arakan

No.	Species	Station							
		St 1		St 2		St 3		St 4	
		3m	10m	3m	10m	3m	10m	3m	10m
	Family Acanthuridae								
1	*Acanthurus pyroferus*	3	3	6	5	4	7	12	3
2	*A. nigricans*			3			2	4	
3	*A. thompsoni*				4	6	14		
4	*A. xanthopterus*			3	2				2
5	*A. nigrofuscus*	10		7	8	12	8	6	2
6	*Zebrasoma scopas*		3	6	2	6	4	12	3
7	*Naso lituratus*	3		2	4			3	
8	*Ctenochaetus striatus*	14	20	12	6	24	18	20	20
	Family Caesionidae								
9	*Pterocaesio tile*		50		60	60	50	60	
10	*P. pisang*								60
11	*P. diagramma*			30	20	60	120		
12	*Caesio cuning*		25	30	40	60		40	
13	*C. teres*	30		20	60	40	75	30	
14	*Caesio caerulaurea*							26	
	Famili Carangidae								
15	*Carangoides ferdau*	2	10	4				8	10
16	*Caranx melampygus*						12		
17	*Elagatis bipinnulatus*			9		16			
	Family Ephippidae								
18	*Platax teira*					3			
	Family Haemulidae								
19	*Plectorhynchus orientalis*					2			

No.	Species	Station							
		St 1		St 2		St 3		St 4	
		3m	10m	3m	10m	3m	10m	3m	10m
20	*P. vittatus*		2				2	2	2
21	*P. chaetodontoides*							2	2
22	*P. lineatus*							4	
23	*Plectorhincus lesson*				4				
	Family Holocentridae								
24	*Myripristis murdjan*		4			4		2	4
25	*M. adusta*		3						3
26	*M. vialocea*		2		2			2	2
27	*M. kuntee*	3	4	2				5	4
28	*Myripristis botche*		12						
29	*Sargocentron caudimaculatum*	1	2	2	2		4		2
30	*Neoniphon argenteus*		9				2		
	Famili Priacanthidae								
31	*Priacanthus hamrur*	2	5				2		5
	Family Labridae								
32	*Cheilinus fasciatus*		3		4			4	6
33	*C. trilobatus*	2		4	2			4	
34	*C. chlorourus*	2		2		5		4	
35	*Epibulus insidiator*		2						2
36	*Hemigymnus melapterus*			2	2				
37	*Hemigymnus fasciatus*				2				
38	*Helichoeres hortulanus*						3		
39	*H. solorensis*							2	
40	*H. chlorochepalus*	2		2					
41	*H. prosopeion*			2					

No.	Species	Station							
		St 1		St 2		St 3		St 4	
		3m	10m	3m	10m	3m	10m	3m	10m
42	*H. richmondi*	2			3				
43	*Chaerodon anchorago*					4	2	3	
44	*Oxycheillinus diagrammus*						3		
45	*O. celebicus*	3			4	6			7
46	*O. orientalis*				3				
	Family Lethrinidae								
47	*Letrinus lentjan*		3					4	3
48	*Lethrinus sp A*							4	
49	*Gnathodentex aurolineatus*				1	3	4	4	
50	*Monotaxis grandoculis*					2		2	
	Family Lutjanidae								
51	*Lutjanus fulvus*						4		4
52	*L. gibbus*						4		
53	*Lutjanus decussates*		2	3			2		2
54	*Macolor niger*		2		2				2
55	*M. macularis*					2	2		
	Family Mullidae								
56	*Parupeneus bifasciatus*	2		4	2		2	4	
57	*P. multifasciatus*			6	5	3	6	4	4
58	*P. barberinus*				4	2	2	2	
59	*M. flavolineatus*		3			5			3
	Family Nemipteridae								
60	*Scolopsis bilineatus*	4	5	2	3	4	4	2	5
61	*S. margaritifer*			2	3	2		4	
62	*S. ciliates*	2	2				2		2
63	*S. lineatus*					12	22		
64	*S. trilineatus*			2			20		

No.	Species	Station							
		St 1		St 2		St 3		St 4	
		3m	10m	3m	10m	3m	10m	3m	10m
	Family Acanthuridae								
65	*Pentapodus emeryii*		7						
	Family Scaridae								
66	*Scarus ghoban*			2	2	3	3	2	
67	*S. dimidiatus*	4		4			4	7	
68	*S. sordidus*	2		4		6	4	12	
69	*S. tricolor*			4		3			
70	*S. chameleon*	2	2				4	4	2
71	*S. russellii*		4			4		4	4
72	*S. globiceps*						2		
73	*S. rivulatus*							3	
74	*S. flavipectoralis*		2						2
75	*S. oviceps*	4				3		25	
76	*S. japanensis*					1			
77	*S. scaber*					2			
78	*Scarus virdifucatus*				1				
79	*Chlorurus bleekeri*		4	8		8	2	9	6
80	*C. capistratoides*						2		
81	*C. sordidus*			2				3	4
82	*Cetosscarus bicolor*					3			
	Family Serranidae								
83	*Epinephelus ongus*					2			
84	*E. merra*	2			1	2	1	4	
85	*E. sexfasciatus*				4			2	
86	*E. bontoides*					3			
87	*E. tauvina*			2			2		
88	*Ephinephelus fasciatus*						3	1	
89	*Cephalopholis argus*		2					2	2
90	*C. microprion*		2			2			2

No.	Species	Station							
		St 1		St 2		St 3		St 4	
		3m	10m	3m	10m	3m	10m	3m	10m
92	**Anyperodon leucogrammicus**							2	
93	**Plectropomus areolatus**				2				
94	**Variola louti**								
	Family Siganidae								
95	**Siganus puellus**	4	2	11	9	12	6	10	2
96	**S. canaliculatus**						7		
97	**S. doliatus**	4			6		4	9	
98	**S. vulpinus**	2	2	4		16	9	5	2
99	*S. corallines*			6	3		3		
100	*S. puntatissimus*					4			
101	*S. guttatus*							2	
	Family Synodontidae								
102	*Synodus variegates*		2				6		2
	Famili Sphyraenidae								
103	*Sphyraena forsteri*					29			
	Family Zanclidae								
104	*Zanclus canescen*	8	4	4	12	8	4	7	4
	Number of Species	**26**	**34**	**36**	**38**	**44**	**46**	**50**	**37**
	Number of Individuals	**119**	**209**	**218**	**301**	**460**	**468**	**398**	**196**
	Diversity Index	**2.794**	**2.925**	**3.157**	**2.802**	**3.082**	**2.872**	**3.343**	**2.938**
	Dominance Index	**0.007**	**0.001**	**0.004**	**0.003**	**0.006**	**0.001**	**0.002**	**0.001**
	Similarity Index	**0.858**	**0.829**	**0.881**	**0.770**	**0.815**	**0.750**	**0.855**	**0.814**

Appendix 12. Distribution and Diversity of Major Species in the Coral Reefs of Arakan.

No.	Species	Station							
		St 1		St 2		St 3		St 4	
		3m	10m	3m	10m	3m	10m	3m	10m
	Major Species Group								
	Family Fistulariidae								
1	*Aulostomus chinensis*	4	2	3	4	4	4	4	2
	Family Apogonidae								
2	*Apogon compressus*	27				4		5	
3	*A. macrodon*		2						2
4	*Ceilodipterus intermedius*	2						2	
5	*C. sostigmatus*	2	4						4
6	*Sphaeramia nematoptera*					16			
	Family Balistidae								
7	*Sufflamen bursa*	2			2	3	4	4	
8	*Balistapus undulatus*		2	3		3	4	2	2
9	*Rhinecanthus verrucosus*							4	
10	*Chatigaster Papua*		2	3		4			2
11	*Odonus niger*			100	500	150	800		
	Family Echeneidae								
12	*Echeneis naucrates*					2			
	Family Labridae								
13	*Bodianus mesothorax*				2	2		1	
14	*Diproctacanthus xanthurus*	2		26			2		
15	*Cirrhilabrus cYesnopleura*	12			22	37	23	40	
16	*Coris gaimard*						2	2	
17	*Halichoeres binotopsis*	2	2		2		4		2
18	*H. hortulanus*			2	4	4	4	3	
19	*H. prosopeion*		2						2

No.	Species	Station							
		St 1		St 2		St 3		St 4	
		3m	10m	3m	10m	3m	10m	3m	10m
20	*Helichoeres richmondi*			3					
21	*Gompphosus varius*			2		**2**	4	4	
22	*Thalassoma hardwikie*	2		4		**6**	5	8	
23	*T. lunare*	7	6	5		**10**	10	8	
24	*T. jenseni*		2	3			3	4	2
25	*Labroides pectoralis*	2		4	2				
26	*L. dimidiatus*			2	4	**3**	4	6	
27	*L. bicolor*						4		
28	*Stethojulis bandanensis*							3	
29	*Labrichthys unilineatus*					**3**			
30	*Labropsis xanthonata*			4					
31	*Anampses meleagrides*							3	
32	*Pseudocheilinops ataenia*			4					
33	*Macropharyngodon meleagris*								2
34	*Diproctacanthus xanthurus*						9		
35	*Pseudodax mollucanus*					**1**			
	Family Ostraciidae								
36	*Ostracion meleagris*			4	2				
37	*Ostracion cubicus*		1						
	Family Pempheridae								
38	*Pempheris adusta*	8					15	58	
39	*P. vanicolensis*			4		**6**		60	
	Family Pomacanthidae								
40	*Centropyge bicolor*				3	**2**	4	3	
41	*C. tibicen*				4			2	
42	*C. bispinosus*								1
43	*Centropige vroliki*					**2**		2	

No.	Species	Station							
		St 1		St 2		St 3		St 4	
		3m	10m	3m	10m	3m	10m	3m	10m
44	*Chaetodontoplus sp*					4			
45	*Pygoplites diacanthus*	2	2		2	4	3	2	2
46	*Pomacanthus navarchus*				2		2	1	
47	*P. imperator*		2	2		2		2	2
48	*Pomacanthus semicirculatus*						2		
	Family Pomacentridae								
49	*Abudefduf sexfasciatus*					29			
50	*A. vaigiensis*	14		100	12		70		
51	*Neoglyphidodon nigroris*	7	6	13	14	18		20	6
52	*N. thoracotaeniatus*			7	5	8			
53	*N. melas*	4			9		6	11	
54	*N. crossi*			4		6			
55	*N. oxyodon*				4			3	
56	*Amblyglyphidodon curacao*	20	8	10		50	30	20	8
57	*A. leucogaster*	12			4	22	12	17	12
58	*A. aureus*		12	4		6		4	3
59	*Chromis analis*	48	6	20	15	60	20	40	6
60	*C. margaritifer*			16	36				
61	*C. ternatensis*	250	150	30	25	150		50	150
62	*C. viridis*						8	6	
63	*C. amboinensis*			25		55	25	30	
64	*C. atripes*					6	2	6	
65	*C. atripectoralis*						3		
66	*C. retrofasciata*			14					
67	*chromis albomaculata*				6				
68	*Acanthochromis polYescanthus*		12	16	6	7		12	
69	*Crysiptera springeri*	2		4		19			

No.	Species	Station							
		St 1		St 2		St 3		St 4	
		3m	10m	3m	10m	3m	10m	3m	10m
70	*C. rollandi*	2			4	3		6	2
71	*C. talboti*			2			4		
72	*Dascyllus aruanus*					14			
73	*D. trimaculatus*	26	20	4	15	9	35	50	20
74	*D. reticulatus*		10			20	12	10	10
75	*Dischistodus prosopotaenia*							3	
76	*Parma oligolepis*		2	3				2	2
77	*Pomacentrus alexanderae*	5	6	10	3	3			6
78	*P. lepidogenys*			30	12		10		
79	*P.amboinensis*	7	3						3
80	*P. moluccensis*	17	5	12		6	25	40	5
81	*P. branchialis*			4			5		6
82	*P. auriventris*			4	13		10	8	
83	*P. wardi*						3		
84	*Pomacentrus philippinus*							3	
85	*Pomacentrus Sp. A*							5	
86	*Pomacentrus Sp. B*							2	
87	*Pomacentrus reidi*							4	3
88	*P. saksonoi*	4			5				
89	*Amphiprion clarkii*	4		4	4	8	2	4	
90	*A. ocellaris*	2		4	4				
91	*A. perideraion*	4		2	3				
92	*A. sandaracinos*				3				
93	*Amphiprion melanopus*	10							
94	*Macropharyngodon meleagri*								2
	Family Ptereleotridae								
95	*Nemateleotris magnifica*						4		

No.	Species	Station							
		St 1		St 2		St 3		St 4	
		3m	10m	3m	10m	3m	10m	3m	10m
	Family Scorpionidae								
96	*Pterois antennata*				2	2	3		
	Family Serranidae								
97	*Pseudanthias squamipinnis*		10						10
98	*P. tuka*	4			6			32	
99	*P. huchtii*		30					8	30
100	*Diploprion bifasciatum*				2	5		2	
	Family Tetraodontidae								
101	*Canthigaster papua*	2		2		4			
102	*C. valentini*	3							
103	*Arothron nigropunctatus*		2	2		4		2	2
	Family Bleniidae								
104	*Aspidontus dussumieri*					2			
	Family Centriscidae								
105	*Aeoliscus strigatus*			3		8		11	
	Family Cirrhitidae								
106	*Paracirrhites forsteri*			4	3		3		
107	*Cirrhitichthys falco*			4					
	Number of Species	**34**	**27**	**47**	**39**	**49**	**42**	**54**	**31**
	Number of Individuals	**521**	**311**	**535**	**770**	**798**	**1204**	**644**	**311**
	Diversity Index	**2.251**	**2.167**	**3.049**	**1.785**	**2.964**	**1.706**	**3.347**	**2.229**
	Dominance Index	**0.250**	**0.254**	**0.088**	**0.428**	**0.093**	**0.449**	**0.051**	**0.253**
	Eveness Index	**0.638**	**0.658**	**0.792**	**0.487**	**0.761**	**0.456**	**0.839**	**0.649**

Appendix 13. Individual Abundance of Algae Found on the Beach of Arakan Site 1

No.	Species	No. of Individuals in 1 m^2										Total	Rata-Rata/ m2
1	*Gracillaria salicornia*	4	3	4	6	2	3	5	4	7	5	43	**4.300**
2	*Gracillaria lichenoides*	2	3	1		1	4	2	4	2	3	22	**2.444**
3	*Amphiroa fragillisima*	3	2	2	1		3	2		4	1	18	**2.250**
4	*Halimeda opuntia* var triloba	6	8	5	6	9	7	8	5	4	7	65	**6.500**
5	*Halimeda incrasata*	2	4	2		1	2	4	1		2	18	**2.250**
6	*Halimeda makroloba*	4	6	5	8	6	7	3	2	5	2	48	**4.800**
7	*Padina australis*	2		1	3		2			1	3	12	**2.000**
8	*Acanthophora spicifera*		2	3	2		1	3	1		2	14	**2.000**
9	*Turbinaria ornata*	3	2		4	2	2	1	3		4	21	**2.625**
10	*Turbinaria decurrens*	1		3	2	3		2				11	**2.200**
11	*Valonia ventricosa*			2	1			1		3		7	**1.750**
12	*Acthinotricia fragilis*	2			3	1	2		1			9	**1.800**
13	*Eucheuma denticulatum*			3		2	4			3		12	**3.000**
		29	**30**	**31**	**36**	**27**	**37**	**31**	**21**	**29**	**29**	**300**	**37.919**

Appendix 14. Individual Abundance of Algae Found on the Beach of Arakan Site 2

No.	Species	No. Of Individuals in 1 m2, Site 2										Total
1	*Gracillaria salicornia*	6	7	8	5	6	9	3	5	8	4	61
2	*Gracillaria lichenoides*	4	2	2	3	2	2	6	3	1	4	29
3	*Amphiroa fragillisima*	2	1	4	2	3			3	1		16
4	*Halimeda opuntia* var triloba	3	4	4	2	6	3	2	4	3	4	35
6	*Halimeda incrasata*		3		2			1	2	2	3	13
7	*Halimeda makroloba*	6	5	8	5	4	2	4	3	2	6	45
8	*Padina australis*		2		1	3	1	1	3	4	2	17
9	*Acanthophora spicifera*	1		2	4	2		1		3	1	14
12	*Turbinaria decurrens*						2		3	2		7
13	*Valonia ventricosa*	1	3	1		2	1				2	10
14	*Acthinotricia fragilis*	2	4	2			3	2	4	2		19
15	*Ulva* sp.				3		2			2		7
16	*Hypnea cervicornis*		3	1				2		1		7
17	*Hypnea asperi*	2		2		1		1	3	-	2	11
18	*Dictyota cervicornis*				2		3			2		7
19	*Sargassum polycistum*		2	3	2	4	3			3		17
20	*Gelidiella acerosa*	1			1		2			1		5

Appendix 15. Individual Abundance of Algae Found on the Beach of Arakan Site 3

No.	**Species**	**No. of Individuals in 1 m2, Site 3**										**Total**
1	*Gracillaria salicornia*	3	4	2	4	5	2	3	3	2	4	32
2	*Gracillaria lichenoides*		2		3	2				4	2	13
3	*Amphiroa fragillisima*	1	3		2	1		4	2		3	16
4	*Halimeda opuntia* var triloba	3	3	4	5	3	2	3	2	4	2	31
5	*Halimeda opuntia*	1		3	2			3		2		11
6	*Halimeda incrasata*			1	3	2				3		9
7	*Halimeda makroloba*	5	3	6	4	3	4	2	3	4	6	40
8	*Padina australis*				2			3	1	2		8
9	*Acanthophora spicifera*	1				2				2		5
10	*Acanthophora muscoides*			2	3	2			1			8
11	*Turbinaria decurrens*		2	1	1		2		1		1	8
12	*Valonia ventricosa*	3	1			2			1		2	9
13	*Acthinotricia fragilis*		4	2	3	2		2		3	1	17
14	*Ulva* sp.	2	1			1		-				4
15	*Hypnea cervicornis*	3	2	3		1		2				11
16	*Hypnea asperi*			1			3		2	1		7
17	*Dictyota cervicornis*				3		1			2		6
18	*Caulerpa racemosa*		4	3		1	3		2	1	3	17
19	*Caulerpa sertularoides*	2	1				1					4
20	*Boergensia forbesii*		2		1	2		4		2		11
21	*Amansia glomerata*		1					2				3
22	*Chondrococcus hornemanii*	3	2			1		4		2	1	13
23	*Hydroclathrus clatrathus*			2		3						5
24	*Galaxaura rugusa*		1		2							3
25	*Amphiroa* sp.				3		2			2		7
26	*Udotea argentea*		1			2		1				4
27	*Eucheuma denticulatum*	2	3		2	1		3		1		12

Appendix 16. Seagrass Condition on Beach Site 1

No.	Species	No. of Individuals										Total	Rata-Rata/ m2
1	*Halophila ovalis*		4		6			6	8	4		28	**5.600**
2	*Syringodium isoetifolium*	12		10		12		7		18	12	71	**11.833**
3	*Thalassia hemprichii*	6	8	12		10	8		13	15	8	80	**10.000**
4	*Cymodocea rotundata*		6		8		10	12		4	7	47	**7.833**
5	*Enhallus acoroides*	8	9	11		12	10	16		12	6	84	**10.500**
		26	**27**	**33**	**14**	**34**	**28**	**41**	**21**	**53**	**33**	**310**	**45.767**

Number of Individuals/M^2	**45.767**
Diversity Index (H')	**1.579**
Dominant Index (D)	**0.211**
Similarity Index (e)	**0.981**

Appendix 17. Seagrass Condition on Beach Site 2

No.	Species	No. of Individuals										Total	Rata-Rata/m2
1	*Halophila ovalis*	6		6			4	6	10		7	10	**6.5**
2	*H. minor*		6			5		4		8			**5.75**
3	*Thalassia hemprichii*	10	7		8	6	9	6		2		15	**6.857**
4	*Enhalus acoroides*		8		4	6		8		10	12	159	**8**
		16	**21**	**6**	**12**	**17**	**13**	**24**	**10**	**20**	**19**	**184**	**27.10714**

Number of Individuals/M2	27.107
Diversity Index (H')	1.127
Dominant Index (D)	0.089
Similarity Index (e)	0.813

Appendix 18. Seagrass Condition on Beach Site 3

No.	Species	No. of Individuals										Total	Rata-Rata/m2
1	*Enhalus acoroides*	16	17	13	16	15	18	19	16	14	15	159	15.9
2	*Thalassia hemprichii*	8	6	9	11	6	8		12	10	14	15	9.333
3	*Halophila ovalis*					6			7	4	2	10	4.75
4	*Cymodocea rorundata*	8		4	5	2		6		10	4		5.571
5	*Syringodium isoetifolum*	12		10		12		7		18	12	71	11.833
		44	**23**	**36**	**32**	**41**	**26**	**32**	**35**	**56**	**47**	**255**	**35.555**

Number of Individuals/M2	35.555
Diversity Index (H')	1.183
Dominant Index (D)	0.255
Similarity Index (e)	0.853

Appendix 19. Socioeconomic Data Based on Questionnaires

No.	Name	Age	Status	Education	Dependent (No. of People)	Inhabitant (Native/Not Native)
1	Rustam Madji	31	Married	JHS	4	No
2	Muchsin Tabuan	44	Married	JHS	4	Yes
3	Movrie Mamesah	46	Married	Bachelor	3	No
4	Mukdir Tabuan	33	Married	PS	4	Yes
5	Lucky Saray	34	Married	HS	3	Yes
6	Sudirman Tabuan	40	Married	JHS	5	Yes
7	Mursad Sabakang	46	Married	JHS	2	Yes
8	Natip Yunus	70	Married	PS	1	No
9	RiHSn Nungan	26	Married	JHS	2	Yes
10	Hanafi Tamengge	48	Married	PS	2	Yes
11	Musli Sarai	31	Married	PS	2	Yes
12	Isam Pitola	23	Married	PS	2	Yes
13	IHSil Sumampouw	53	Married	HS	3	No
14	Robo Mahmud	63	Married	PS	1	Yes
15	Salim Libukota	47	Married	PS	5	Yes
16	Des Manikam	45	Married	PS	3	Yes
17	Muksin Tabuan	43	Married	JHS	4	Yes
18	Misba Nungan	34	Married	JHS	3	Yes
19	Ibrahim Kamuntuan	28	Married	PS	4	Yes
20	Naim Kaser	60	Married	PS	6	Yes
21	Salim Mahmud	65	Married	PS	1	Yes
22	Latif Kaser	50	Married	PS	1	Yes
23	Isnawir Bugis	43	Married	JHS	4	Yes
24	Haris Pidu	37	Married	PS	4	No
25	Hamdan Papente	37	Married	JHS	3	No
26	Agam Danise	44	Married	HS	2	Yes
27	SufYesul Lajolo	27	Married	JHS	2	Yes
28	Abdulah Lahmade	38	Married	PS	2	Yes

No.	Name	Age	Status	Education	Dependent (No. of People)	Inhabitant (Native/Not Native)
29	Aslam Tabuan	29	Married	HS	3	Yes
30	Abubakar Ama	72	Married	PS	2	Yes
31	A. Kaser	42	Married	PS	2	No
32	Muksin Kaser	29	Married	PS	2	Yes
33	Sama Podung	56	Married	PS	2	Yes
34	Hambli Manikam	28	Married	PS	1	Yes
35	Ari Saraih	26	Married	JHS	2	Yes
36	Adi Saraih	37	Married	PS	2	Yes
37	Lukman Tamenggeh	35	Married	PS	4	Yes
38	Idam Nungan	40	Married	PS	5	Yes
39	HJ. JiHSn Sorongan	55	Married	JHS	2	Yes
40	Arsad TuYesh	47	Married	PS	2	Yes
41	Hamlanungan	32	Married	JHS	5	Yes
42	Acidan TuYesh	40	Married	PS	4	Yes
43	HJ. Nong Lajolo	47	Married	JHS	2	Yes
44	Fatli Tamenggeh	35	Married	JHS	4	Yes
45	Rakbih Saraih	35	Married	PS	4	Yes
46	Hamid Tamenggeh	60	Married	PS	3	Yes
47	Alamsah Tahumil	37	Married	PS	5	Yes
48	Saadan Bugis	39	Belum Married	PS	2	Yes
49	Samsudin Bugis	52	Married	PS	4	Yes
50	Alfatun Tjulimanis	37	Married	PS	2	No
51	Mis Bugis	41	Married	JHS	3	Yes
52	Arki Sumampouw	25	Married	JHS	1	Yes
53	Raup Sarai	45	Married	PS	5	Yes
54	Faisal Sumampou	35	Married	PS	4	Yes
55	Mustafa Sarai	57	Married	PS	1	No

No.	Name	Age	Status	Education	Dependent	Inhabitant
					(No. of People)	(Native/Not Native)
56	Robo Nungan	56	Married	PS	2	Yes
57	Kartum Sorongan	50	Married	JHS	1	Yes
58	Sabtu Kasar	57	Married	PS	3	Yes
59	Saptu Sirai	69	Married		2	No
60	Rahman Nungan	45	Married	PS	4	No
61	Marjin Nungan	50	Married	PS	2	?
62	Taufik Akase	28	Married	JHS	4	Yes
63	Jai Samaan	40	Married	PS	3	Yes
64	Basiri Yunus	35	Married	PS	2	Yes
65	Arip Sarai	71	Married	PS	1	Yes
66	Iqbal Darisa	36	Married	PS	3	No
67	RuPSin Kamuntuan	38	Married	PS	3	Yes
68	Sidik Tawas	46	Married	PS	3	Yes
69	Rukban Maumud-	33	Married	PS	2	Yes
70	Budi Dotabuga-	37	Married	JHS	3	No
71	Irwati Nungan-	24	Married	PS	2	Yes
72	Sarpin Lahengko-	44	Married	PS	3	Yes
73	Suleman Panah	29	Married	PS	1	Yes
74	Mansyur Samaun	37	Married	PS	2	Yes
75	Subahan Mandi-	30	Married	PS	3	Yes
76	Musa Budiman	43	Married	PGA	3	Yes
77	SurYesni / Samsuri	38/32		JHS/PS	3	No
78	Kasri Hasim	56	Married	PS	1	Yes
79	Tawil	43	Married	PS	2	Yes
80	UHSn Saray	55	Married	PS	1	Yes
81	Suparman	43	Married	JHS	3	No
82	Salim Sarai	50	Married	PS	1	Yes
83	Kusno Tamenggi	43	Married	PS	2	Yes
84	Rebo Tamenggi	65	Married	PS	1	Yes

No.	Name	Age	Status	Education	Dependent (No. of People)	Inhabitant (Native/Not Native)
85	Mahmud	45	Married	PS	2	Yes
86	Nursamiah Bugis	19	Belum Married			
87	Mado Bugis	52	Married	PS	4	Yes
88	Abdul Haris Hontong	62	Married	PS	6	Yes
89	IHSil Hontong	41	Married	JHS	5	Yes
90	Baka Sarai	47	Married	PS	4	Yes
91	Ramulan Tamenggi	36	Married	JHS	5	Yes
92	Safar Sailan	34	Married	PS	4	Yes
93	Djuttry Sarai	35	Married	PS	5	Yes
94	Ahmad Darise	42	Married	PS	5	Yes
95	Akdiy TuYes	37	Married	PS	5	Yes
96	IHSil Janis	21	Married	JHS	3	No
97	Samai Sarai	69	Married	PS	1	Yes
98	Ismis Tamengge	35	Married	PS	4	Yes
99	Mustamin	52	Married	PS	4	No
100	Jama Sarai	47	Married	PS	6	Yes
101	Sawal	35	Married	PS	5	Yes
102	Marwan Ama	37	Married	PS	6	No
103	Wisnu	37	Married	PS	4	No
104	Rivay TuYes	27	Married	PS	3	Yes
105	Juma Tangkap	48	Married	PS	4	Yes

PS = Primary School, JHS = Junior High School, HS = High School

No.	Name	Ability to Send Children to School	Social Activities	Average Income (Rp./Month)	Average Additional Income Rp./Month)
1	Rustam Madji		Participate	1750000	
2	Muchsin Tabuan	HS	Participate	1750000	
3	Movrie Mamesah	Collage	Participate	4000000	1500000
4	Mukdir Tabuan	Collage	Participate	1750000	750000
5	Lucky Saray	Collage	Participate	1750000	750000
6	Sudirman Tabuan	HS	Participate	1200000	
7	Mursad Sabakang	Akademi	Participate	1500000	
8	Natip Yunus	HS	Participate	600000	
9	RiHSn Nungan	Collage	Participate	3000000	1500000
10	Hanafi Tamengge	PS	Participate	600000	
11	Musli Sarai	Collage	Participate	1500000	
12	Isam Pitola	Collage	Participate	1500000	
13	IHSil Sumampouw	HS	Participate	1500000	
14	Robo Mahmud	JHS	Participate	1200000	
15	Salim Libukota	HS	Participate	1500000	
16	Des Manikam	Collage	Participate	3000000	
17	Muksin Tabuan	Collage	Participate	1500000	
18	Misba Nungan	HS	Participate	3000000	
19	Ibrahim Kamuntuan	HS	Participate	1500000	
20	Naim Kaser	PS	Participate	3000000	
21	Salim Mahmud	PS	Participate	600000	
22	Latif Kaser	HS	Participate	1500000	
23	Isnawir Bugis	Collage	Participate	3000000	
24	Haris Pidu	HS	Participate	2000000	
25	Hamdan Papente	Collage	Participate	1500000	750000
26	Agam Danise	Collage	Participate	1500000	750000
27	SufYesul Lajolo	Collage	Participate	1500000	
28	Abdulah Lahmade	Collage	Participate	3000000	

No.	Name	Ability to Send Children to School	Social Activities	Average Income (Rp./Month)	Average Additional Income (Rp./Month)
29	Aslam Tabuan	Collage	Participate	1500000	
30	Abubakar Ama	JHS	Participate	1500000	
31	A. Kaser	HS	Participate	1500000	
32	Muksin Kaser	HS	Participate	2000000	
33	Sama Podung	HS	Participate	500000	1500000
34	Hambli Manikam	Collage	Participate	1000000	
35	Ari Saraih	HS	Participate	1500000	
36	Adi Saraih	HS	Participate	1500000	
37	Lukman Tamenggeh	PS	Participate	1500000	
38	Idam Nungan	PS	Participate	1500000	
39	HJ. JiHSn Sorongan	Collage	Participate	2000000	1600000
40	Arsad TuYesh	HS	Participate	1500000	
41	Hamlanungan	Collage	Participate	900000	500000
42	Acidan TuYesh	Collage	Participate	2000000	
43	HJ. Nong Lajolo	Collage	Participate	2500000	500000
44	Fatli Tamenggeh	JHS	Participate	1500000	
45	Rakbih Saraih	PS	Participate	1500000	
46	Hamid Tamenggeh	PS	Participate	1500000	
47	Alamsah Tahumil	HS	Participate	1500000	
48	Saadan Bugis	HS	Participate	1500000	
49	Samsudin Bugis	Collage	Participate	1000000	200000
50	Alfatun Tjulimanis	HS	Participate	1500000	
51	Mis Bugis	JHS	Participate	1000000	1000000
52	Arki Sumampouw	Collage	Participate	2100000	800000
53	Raup Sarai	HS	Participate	750000	
54	Faisal Sumampou	HS	Participate	750000	
55	Mustafa Sarai	HS	Participate	1200000	
56	Robo Nungan	HS	Participate	1500000	

No.	Name	Ability to Send Children to School	Social Activities	Average Income (Rp./Month)	Average Additional Income (Rp./Month)
57	Kartum Sorongan	HS	Participate	1200000	
58	Sabtu Kasar	HS	Participate	1500000	
59	Saptu Sirai	HS	Participate	500000	
60	Rahman Nungan	HS	Participate	1500000	
61	Marjin Nungan	HS	Participate	1500000	
62	Taufik Akase	Collage	Participate	1500000	
63	Jai Samaan	HS	Participate	1500000	
64	Basiri Yunus	HS	Participate	1500000	
65	Arip Sarai	PS	Participate	500000	
66	Iqbal Darisa	HS	Participate	750000	
67	RuPSin Kamuntuan	HS	Participate	1500000	
68	Sidik Tawas	Collage	Participate	1500000	
69	Rukban Maumud-	HS	Participate	1500000	
70	Budi Dotabuga-	Collage	Participate	1500000	
71	Irwati Nungan-	HS	Participate	1500000	
72	Sarpin Lahengko-	HS	Participate	1500000	
73	Suleman Panah	HS	Participate	750000	
74	Mansyur Samaun	PS	Participate	1500000	
75	Subahan Mandi-	HS	Participate	1500000	
76	Musa Budiman	Collage	Participate	700000	
77	SurYesni / Samsuri	HS	Participate	1500000	
78	Kasri Hasim	JHS	Participate	1500000	
79	Tawil	JHS	Participate	1500000	
80	UHSn Saray	HS	Participate	1500000	
81	Suparman	Collage	Participate	1500000	
82	Salim Sarai	HS	Participate	1500000	
83	Kusno Tamenggi	HS	Participate	3000000	
84	Rebo Tamenggi	JHS	Participate	500000	

No.	Name	Ability to Send Children to School	Social Activities	Average Income (Rp./Month)	Average Additional Income (Rp./Month)
85	Mahmud	JHS	Participate	1500000	
86	Nursamiah Bugis	JHS	Participate	500000	
87	Mado Bugis	HS	Participate	1500000	
88	Abdul Haris Hontong	HS	Participate	1500000	
89	IHSil Hontong	Collage	Participate	1500000	
90	Baka Sarai	HS	Participate	1500000	
91	Ramulan Tamenggi	HS	Participate	1500000	
92	Safar Sailan	HS	Participate	1500000	200000
93	Djuttry Sarai	JHS	Participate	1500000	
94	Ahmad Darise	JHS	Participate	1500000	200000
95	Akdiy TuYes	HS	Participate	1500000	
96	IHSil Janis	HS	Participate	1000000	500000
97	Samai Sarai	JHS	Participate	1000000	
98	Ismis Tamengge	HS	Participate	1000000	
99	Mustamin	HS	Participate	2000000	
100	Jama Sarai	JHS	Participate	1000000	
101	Sawal	HS	Participate	1000000	
102	Marwan Ama	HS	Participate	3000000	
103	Wisnu	HS	Participate	2000000	
104	Rivay TuYes	HS	Participate	1500000	
105	Juma Tangkap	HS	Participate	1500000	

No.	Name	Operating Budget of Housewife (Rp./Month)	Average Expenditure (Rp./Month)	Fishing Gear	Boat + Machine	Understands Climate Change
1	Rustam Madji		1250000	Fishing Nets	Ketinting	No
2	Muchsin Tabuan		1250000	Fishing Nets	Ketinting	No
3	Movrie Mamesah		2250000	Fishing Nets	Ketinting	Unsderstand
4	Mukdir Tabuan		1750000	Fishing Nets	Ketinting	No
5	Lucky Saray		1750000	Fishing Nets	Ketinting	No
6	Sudirman Tabuan		1500000	Fishing Nets	Ketinting	No
7	Mursad Sabakang		1500000	Fishing Nets	Ketinting	No
8	Natip Yunus		500000	Fishing Nets	No Machine	No
9	RiHSn Nungan	300000	1500000	Fishing Nets	Ketinting	No
10	Hanafi Tamengge		500000	Fishing Nets	No Machine	No
11	Musli Sarai		1500000	Fishing Nets	Ketinting	No
12	Isam Pitola		1500000	Fishing Nets	Ketinting	No
13	IHSil Sumampouw		1500000	Fishing Nets	Ketinting	No
14	Robo Mahmud		1000000	Fishing Nets	Ketinting	No
15	Salim Libukota		1500000	Fishing Nets	Ketinting	No
16	Des Manikam		2500000	Fishing Nets	Ketinting	No
17	Muksin Tabuan		1500000	Fishing Nets	Ketinting	No
18	Misba Nungan	900000	2500000	Fishing Nets	On Board Motor	No

No.	Name	Operating Budget of Housewife (Rp./Month)	Average Expenditure (Rp./Month)	Fishing Gear	Boat + Machine	Understands Climate Change
19	Ibrahim Kamuntuan		1500000	Fishing Nets	Ketinting	No
20	Naim Kaser		2500000	Fishing Nets	Ketinting	No
21	Salim Mahmud	750000	600000	Fishing Nets	Ketinting	No
22	Latif Kaser		1800000	Fishing Nets	Ketinting	No
23	Isnawir Bugis		2500000	Fishing Nets	Ketinting	No
24	Haris Pidu		1500000	Fishing Nets	Ketinting	No
25	Hamdan Papente	1400000	1800000	Fishing Nets	Ketinting	No
26	Agam Danise	1400000	1800000	Fishing Nets	Ketinting	No
27	SufYesul Lajolo		1500000	Fishing Nets	No Mechine	No
28	Abdulah Lahmade		2500000	Fishing Nets	Ketinting	No
29	Aslam Tabuan		1500000	Fishing Nets	Ketinting	No
30	Abubakar Ama		1500000	Fishing Nets	Tanpa mesin	No
31	A. Kaser		1500000	Fishing Nets	Tanpa mesin	No
32	Muksin Kaser		1500000	Fishing Nets	Ketinting	No
33	Sama Podung	150000	900000	Fishing Nets	No Mechine	No
34	Hambli Manikam		1500000	Fishing Nets	No Mechine	No

No.	Name	Operating Budget of Housewife (Rp./Month)	Average expenditure (Rp./Month)	Fishing Gear	Boat + Machine	Understands Climate Change
35	Ari Saraih		1500000	Fishing Nets	Ketinting	No
36	Adi Saraih	200000	900000	Fishing Nets	Ketinting	No
37	Lukman Tamenggeh		1500000	Fishing Nets	Ketinting	No
38	Idam Nungan		1500000	Fishing Nets	Ketinting	No
39	HJ. JiHSn Sorongan	750000	2000000	Fishing Nets	On Board Machine	No
40	Arsad TuYesh	300000	1500000	Fishing Nets	Ketinting	No
41	Hamlanungan		1500000	Fishing Nets	Ketinting	No
42	Acidan TuYesh		1500000	Fishing Nets	Ketinting	No
43	HJ. Nong Lajolo	300000	2000000	Fishing Nets	On Board Machine	No
44	Fatli Tamenggeh		1500000	Fishing Nets	Ketinting	No
45	Rakbih Saraih		1500000	Fishing Nets	Ketinting	No
46	Hamid Tamenggeh		1500000	Fishing Nets	Ketinting	No
47	Alamsah Tahumil		1500000	Fishing Nets	Ketinting	No
48	Saadan Bugis		1500000	Fishing Nets	Ketinting	No
49	Samsudin Bugis		1500000	Fishing Nets	Ketinting	No
50	Alfatun Tjulimanis		1500000	Fishing Nets	Ketinting	No

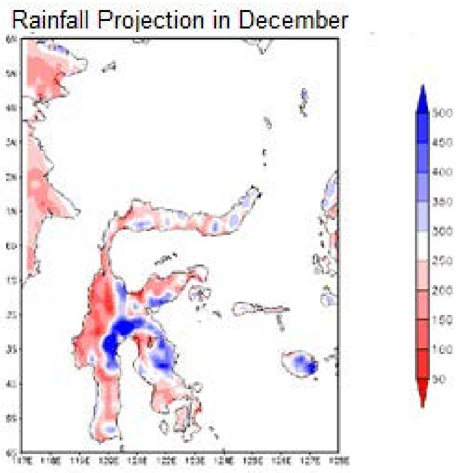
No.	Name	Operating Budget of Housewife (Rp./Month)	Average Expenditure (Rp./Month)	Fishing Gear	Boat + Machine	Understands Climate Change
51	Mis Bugis		1500000	Fishing Nets	Ketinting	No
52	Arki Sumampouw		2000000	Fishing Nets	On Board Machine	No
53	Raup Sarai		1000000	Fishing Nets	Ketinting	No
54	Faisal Sumampou		1000000	Fishing Nets	Ketinting	No
55	Mustafa Sarai		1000000	Fishing Nets	Ketinting	No
56	Robo Nungan		1500000	Fishing Nets	Ketinting	No
57	Kartum Sorongan		1000000	Fishing Nets	Ketinting	No
58	Sabtu Kasar		1500000	Fishing Nets	Ketinting	No
59	Saptu Sirai		300000	Fishing Nets	Ketinting	No
60	Rahman Nungan		1500000	Fishing Nets	Ketinting	No
61	Marjin Nungan		1500000	Fishing Nets	Ketinting	No
62	Taufik Akase		1500000	Fishing Nets	Ketinting	No
63	Jai Samaan		1500000	Fishing Nets	Ketinting	No
64	Basiri Yunus		1500000	Fishing Nets	Ketinting	No
65	Arip Sarai		300000	Fishing Nets	Ketinting	No
66	Iqbal Darisa		600000	Fishing Nets	Ketinting	No
67	RuPSin Kamuntuan		750000	Fishing Nets	Ketinting	No
68	Sidik Tawas		750000	Fishing Nets	Ketinting	No

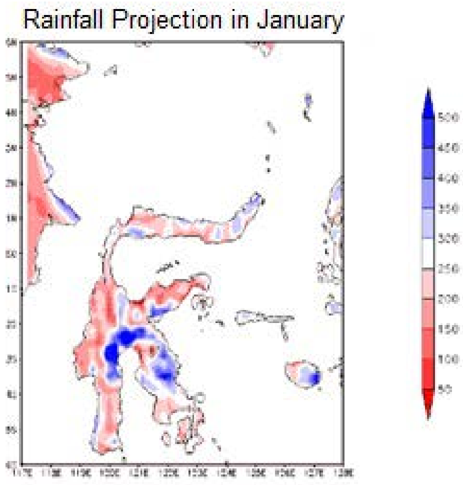
No.	Name	Operating Budget of Housewife (Rp./month)	Average Expenditure (Rp./month)	Fishing Gear	Boat + Machine	Understands Climate Change
69	Rukban Maumud-		750000	Fishing Nets	Ketinting	No
70	Budi Dotabuga-		750000	Fishing Nets	Ketinting	No
71	Irwati Nungan-		750000	Fishing Nets	Ketinting	No
72	Sarpin Lahengko-	600000	1500000	Fishing Nets	Ketinting	No
73	Suleman Panah		600000	Fishing Nets	Ketinting	No
74	Mansyur Samaun		750000	Fishing Nets	Ketinting	No
75	Subahan Mandi-	1500000	1500000	Fishing Nets	Ketinting	No
76	Musa Budiman	500000	1200000	Fishing Nets	Ketinting	No
77	SurYesni / Samsuri		1500000	Fishing Nets	Ketinting	No
78	Kasri Hasim		750000	Fishing Nets	Ketinting	No
79	Tawil		750000	Fishing Nets	Ketinting	No
80	UHSn Saray		750000	Fishing Nets	Ketinting	No
81	Suparman		750000	Fishing Nets	Ketinting	No
82	Salim Sarai		750000	Fishing Nets	Ketinting	No
83	Kusno Tamenggi		2100000	Fishing Nets	On Board Machine	No
84	Rebo Tamenggi		300000	Fishing Nets	Ketinting	No
85	Mahmud		750000	Fishing Nets	Ketinting	No

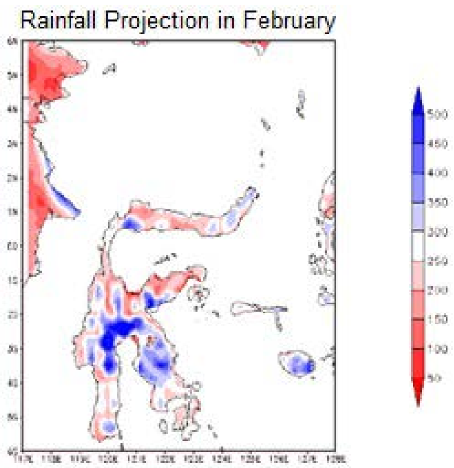
No.	Name	Operating Budget of Housewife (Rp./Month)	Average Expenditure (Rp./Month)	Fishing Gear	Boat + Machine	Understands Climate Change
86	Nursamiah Bugis		300000	Fishing Nets	Ketinting	No
87	Mado Bugis		750000	Fishing Nets	Ketinting	No
88	Abdul Haris Hontong		750000	Fishing Nets	Ketinting	No
89	IHSil Hontong		750000	Fishing Nets	Ketinting	No
90	Baka Sarai		750000	Fishing Nets	Ketinting	No
91	Ramulan Tamenggi		750000	Fishing Nets	Ketinting	No
92	Safar Sailan	750000	1500000	Fishing Nets	Ketinting	No
93	Djuttry Sarai		750000	Fishing Nets	Ketinting	No
94	Ahmad Darise		1500000	Fishing Nets	Ketinting	No
95	Akdiy TuYes		1500000	Fishing Nets	Ketinting	No
96	IHSil Janis		1500000	Fishing Nets	Ketinting	No
105	Juma Tangkap		750000	Fishing Nets	Ketinting	No

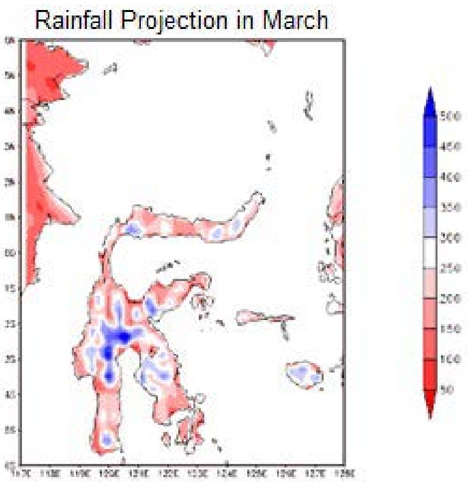
No.	Name	Operating Budget of Housewife (Rp./Month)	Average Expenditure (Rp./Month)	Fishing Gear	Boat + Machine	Understands Climate Change
97	Samai Sarai		900000	Fishing Nets	Ketinting	No
98	Ismis Tamengge		900000	Fishing Nets	Ketinting	No
99	Mustamin		2000000	Fishing Nets	Ketinting	No
100	Jama Sarai		750000	Fishing Nets	Ketinting	No
101	Sawal		750000	Fishing Nets	Ketinting	No
102	Marwan Ama	1000000	2500000	Fishing Nets	On Board Machine	No
103	Wisnu		1500000	Fishing Nets	Ketinting	No
104	Rivay TuYes		750000	Fishing Nets	Ketinting	No

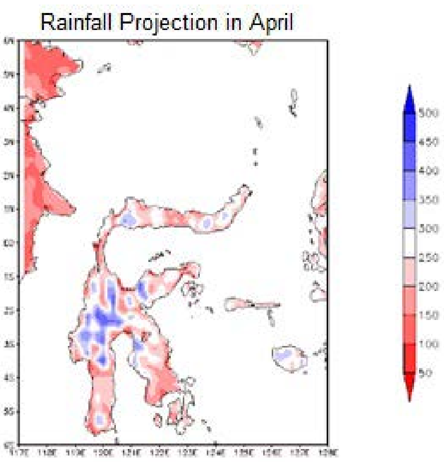
Appendix 20. Maps of Rainfall Projection in Near Period

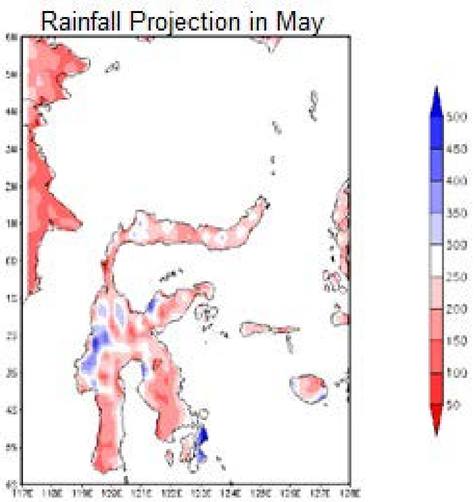




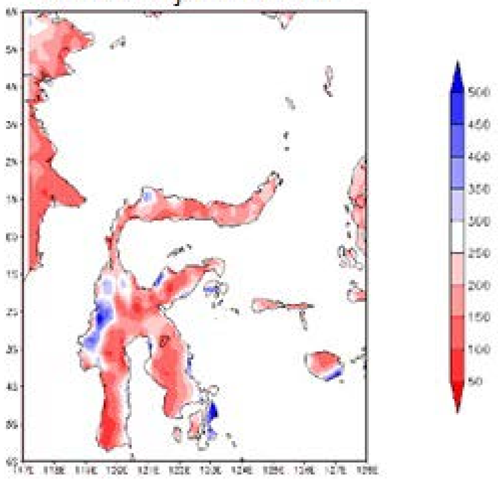




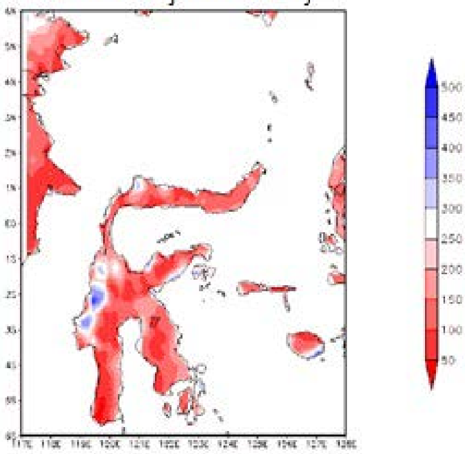




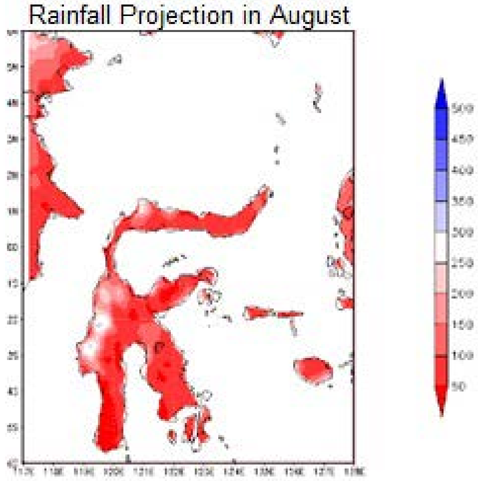
Rainfall Projection in June



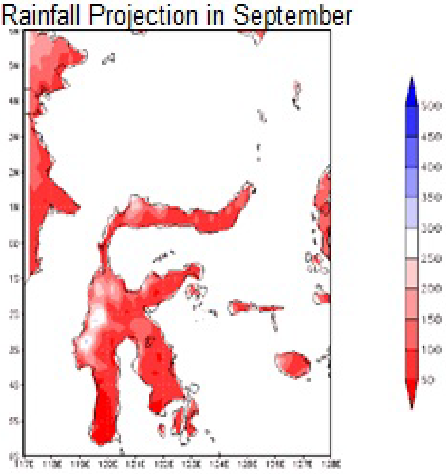
Rainfall Projection in July



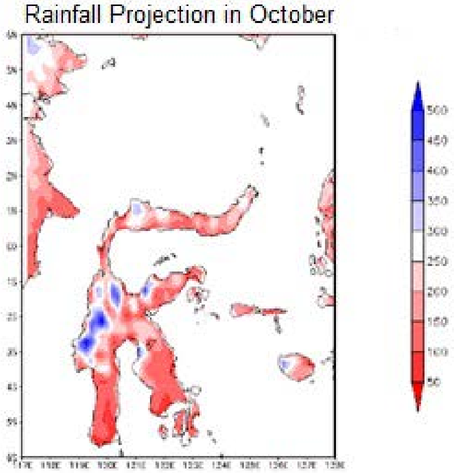
Rainfall Projection in August



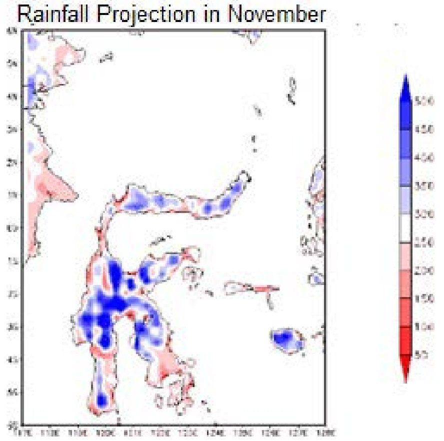
Rainfall Projection in September



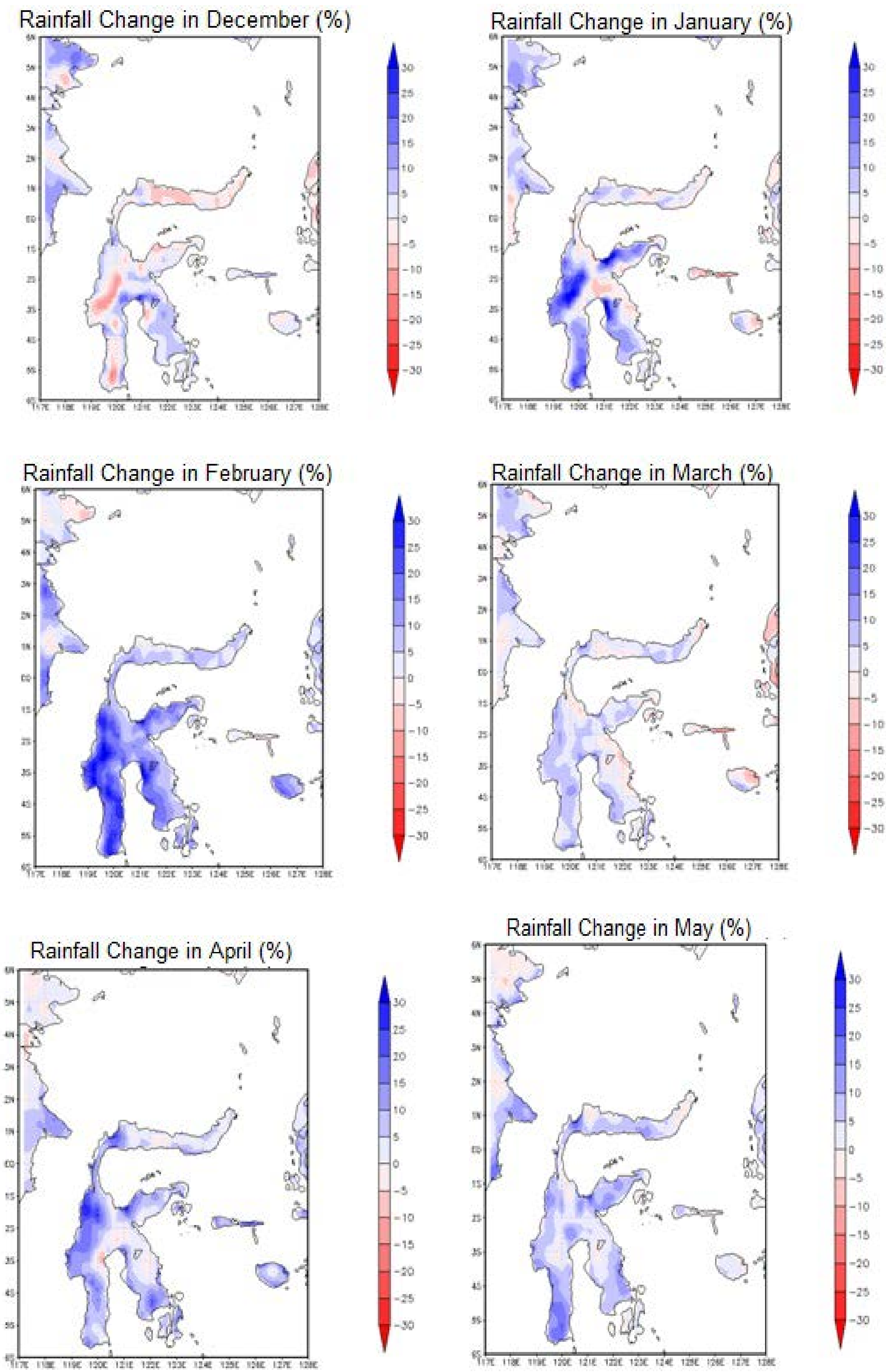
Rainfall Projection in October

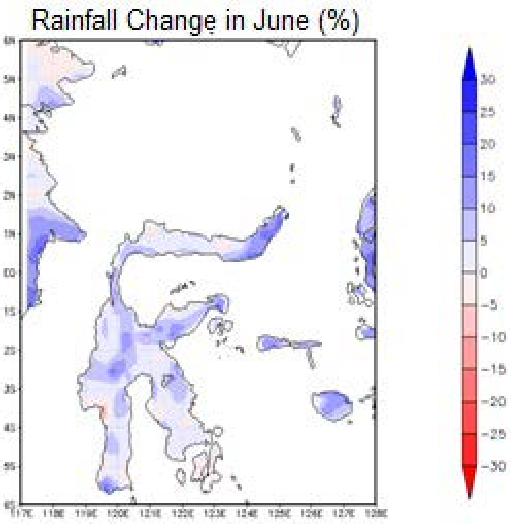


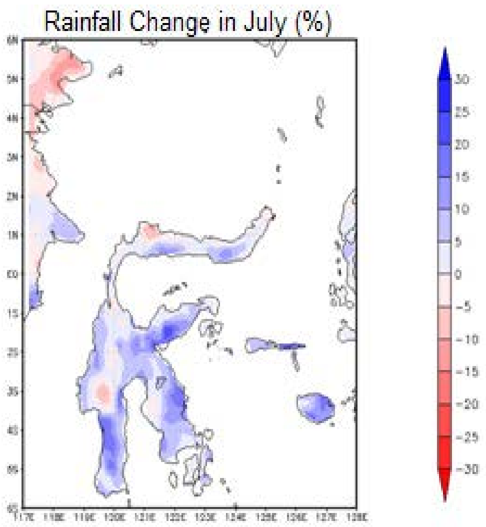
Rainfall Projection in November

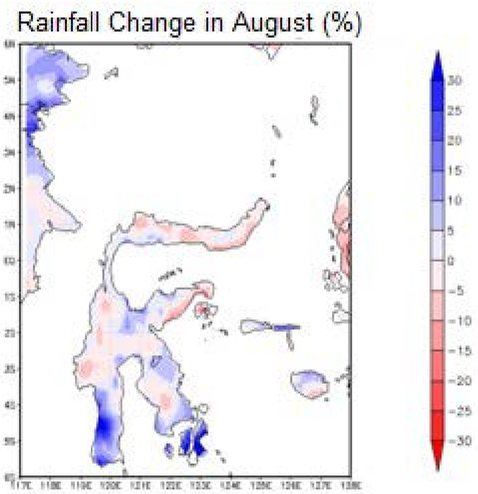


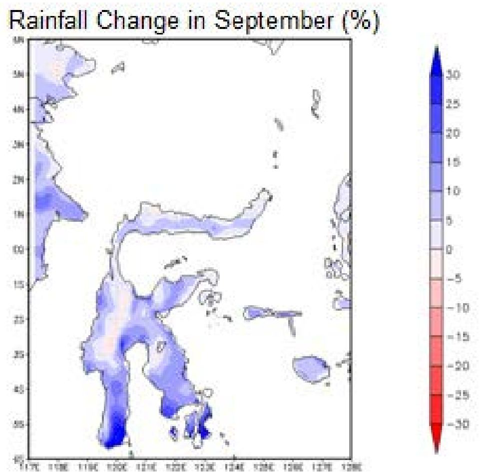
Appendix 21. Maps of Rainfall Change in Near Period to Baseline Period

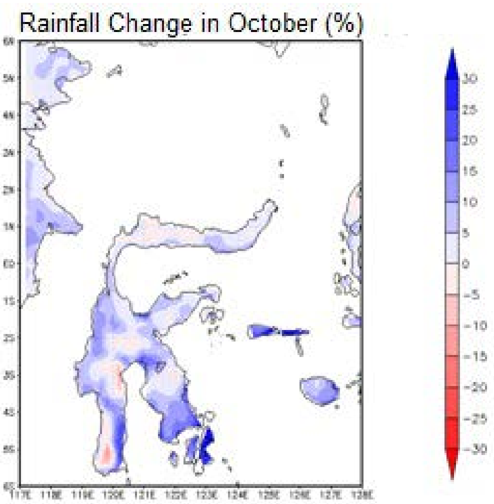


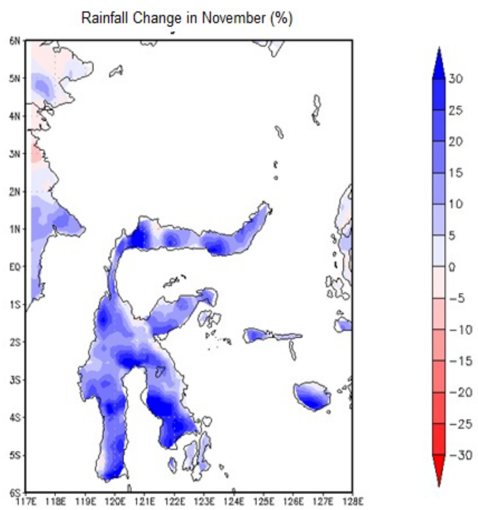

Rainfall Change in June (%)
30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30


Rainfall Change in July (%)
30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30


Rainfall Change in August (%)
30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30

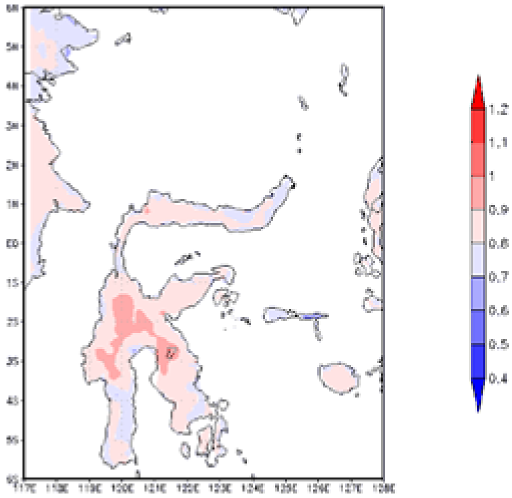

Rainfall Change in September (%)
30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30


Rainfall Change in October (%)
30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30

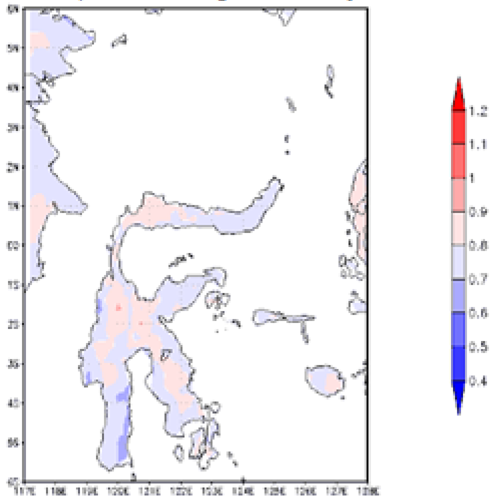

Rainfall Change in November (%)
30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30

Appendix 22. Maps of Temperature Projection in Near Period

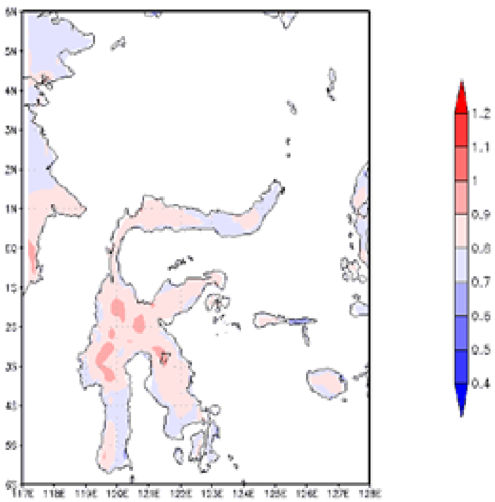
Temperature Changes in December



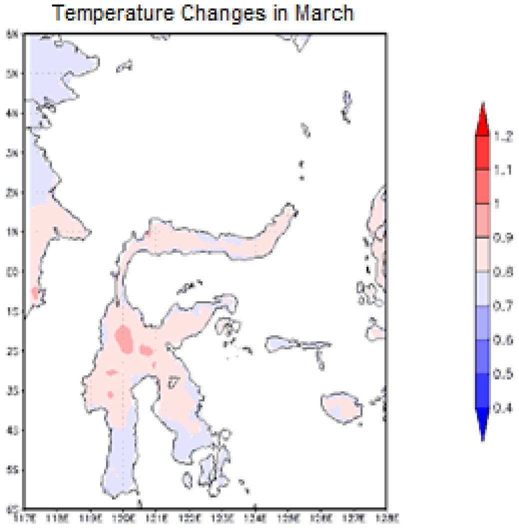
Temperature Changes in January



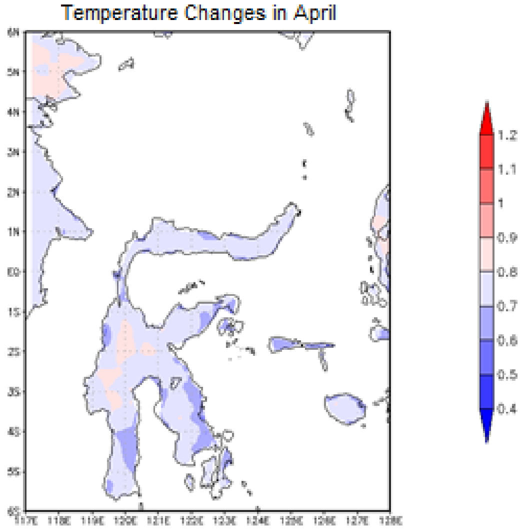
Temperature Changes in February



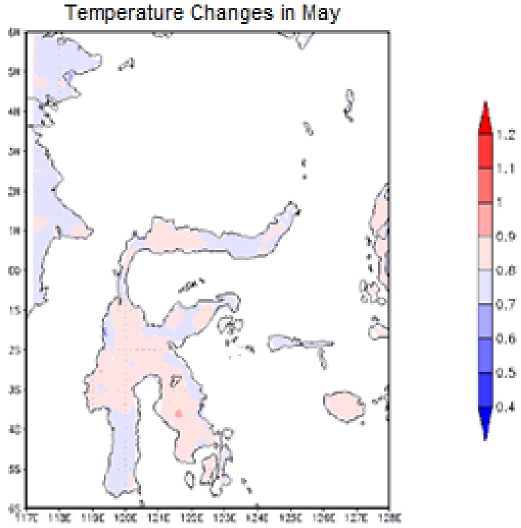
Temperature Changes in March



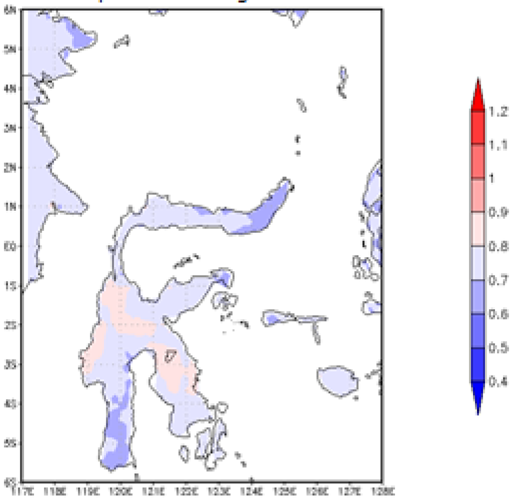
Temperature Changes in April



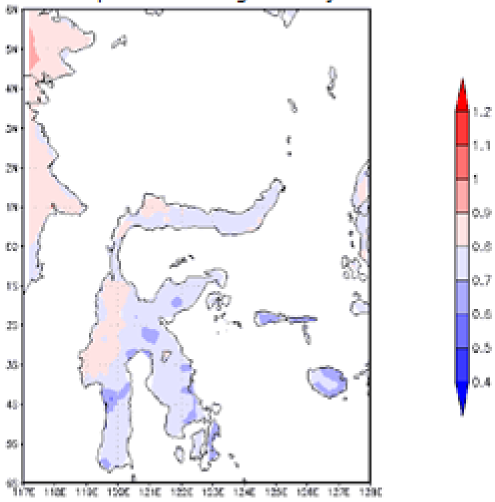
Temperature Changes in May



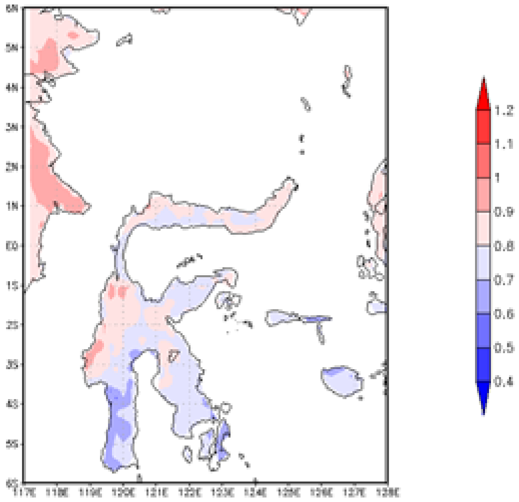
Temperature Changes in June



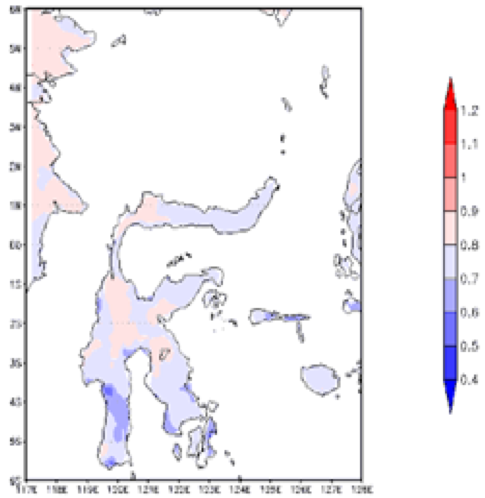
Temperature Changes in July



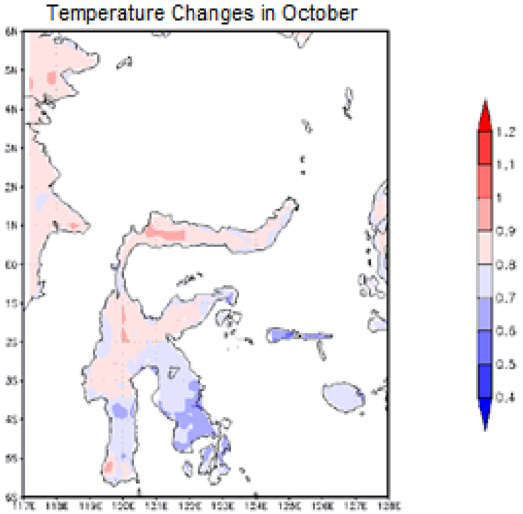
Temperature Changes in August



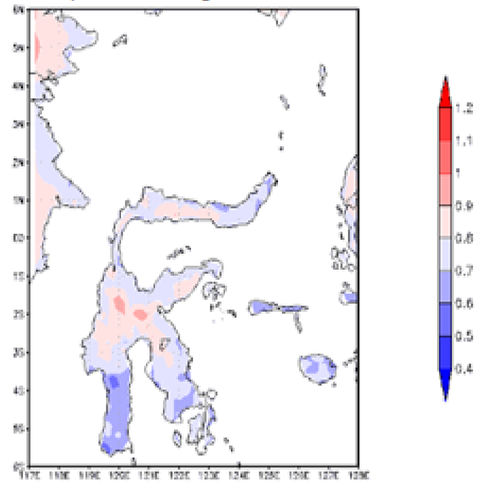
Temperature Changes in September



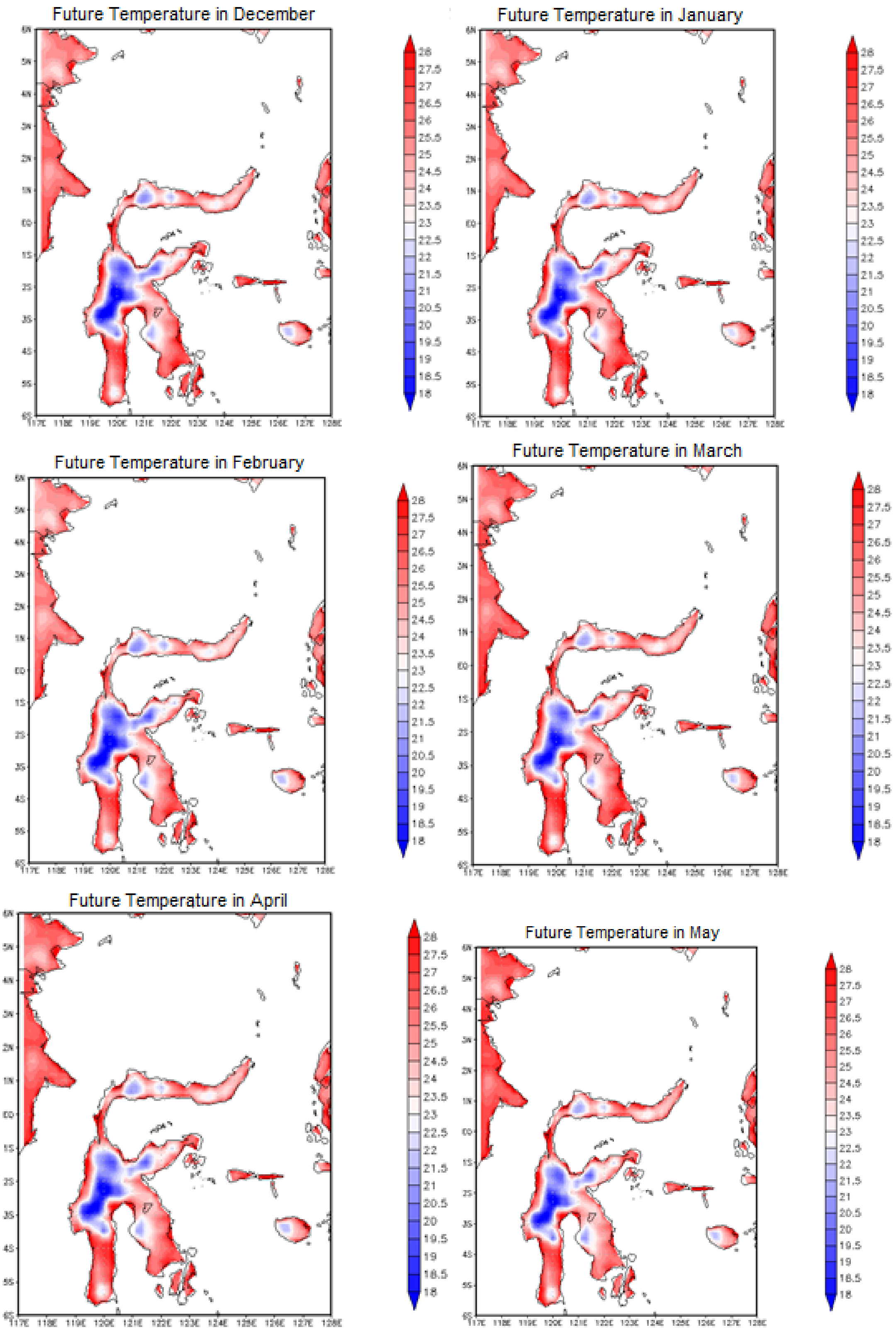
Temperature Changes in October



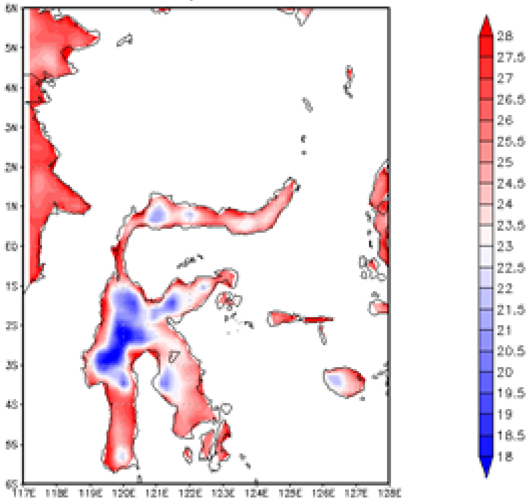
Temperature Changes in November



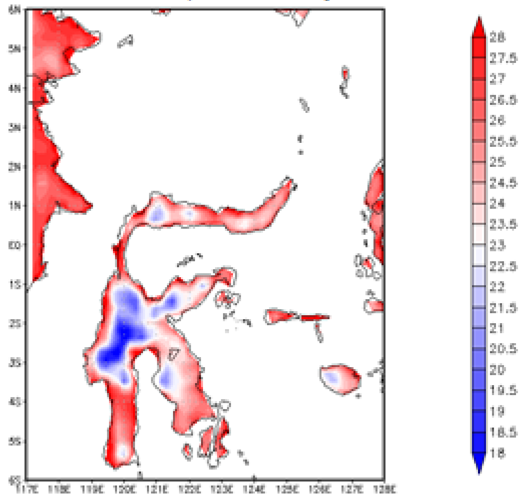
Appendix 23. Maps of Temperature Change in Near Period to Baseline Period



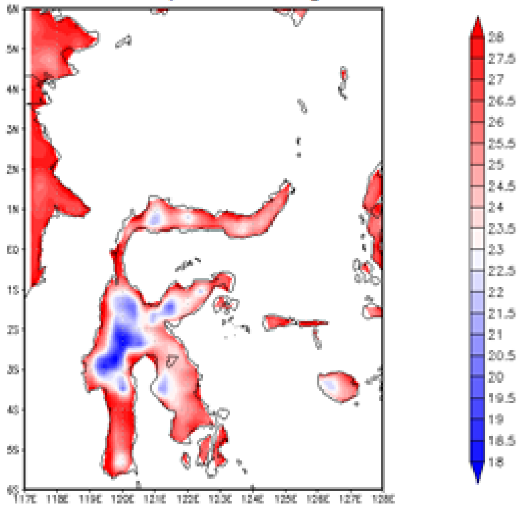
Future Temperature in June



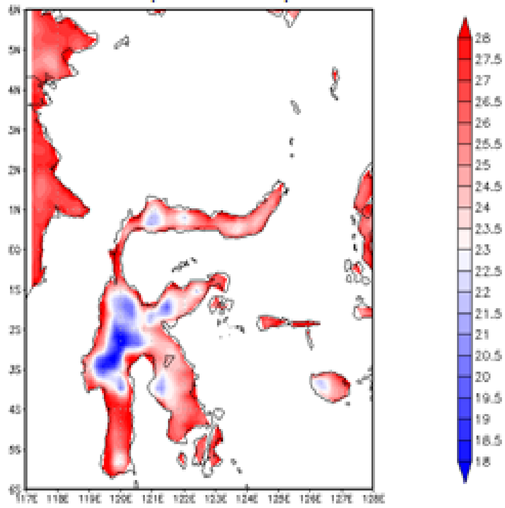
Future Temperature in July



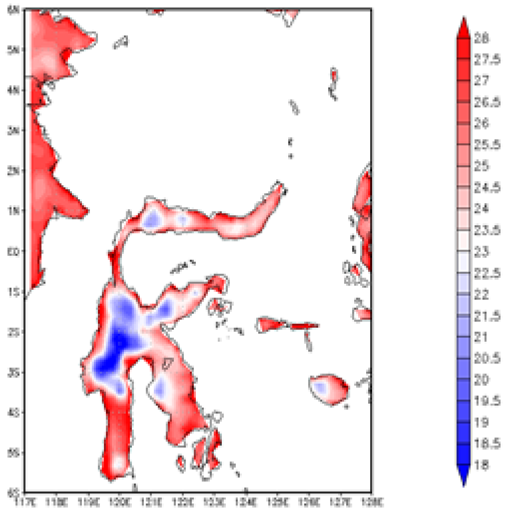
Future Temperature in August



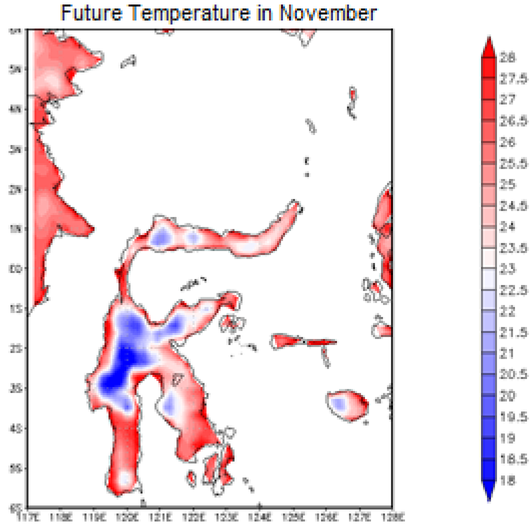
Future Temperature in September



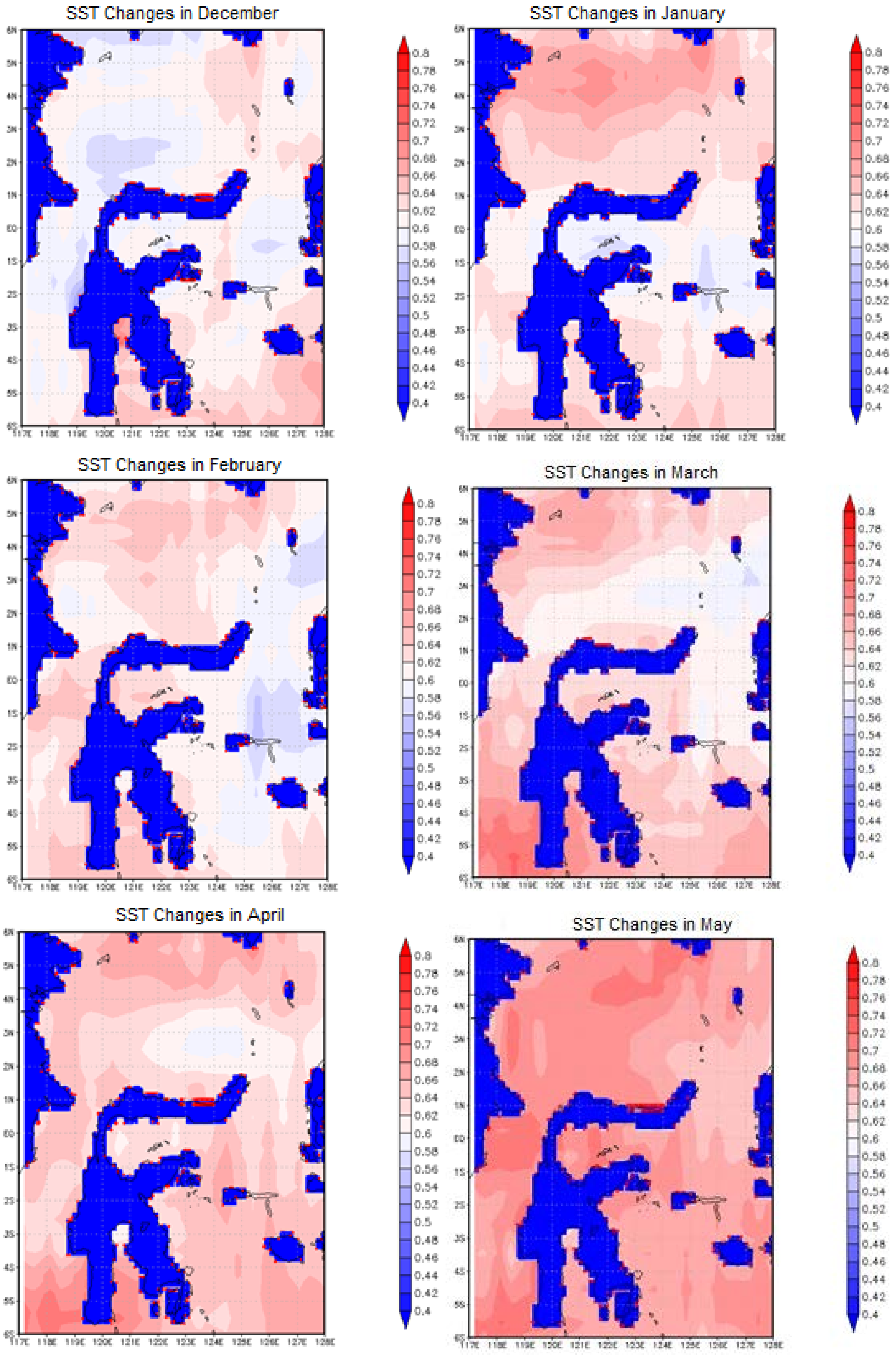
Future Temperature in October

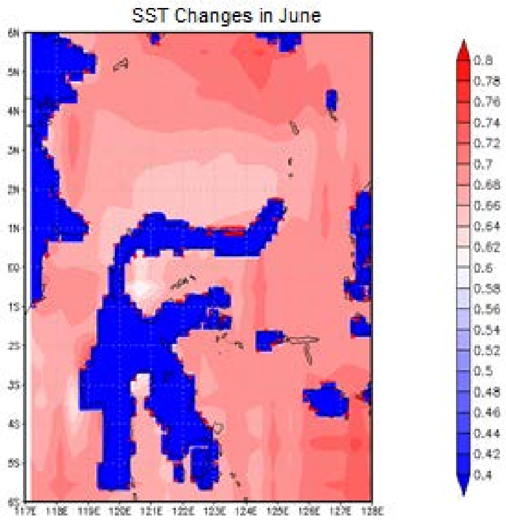


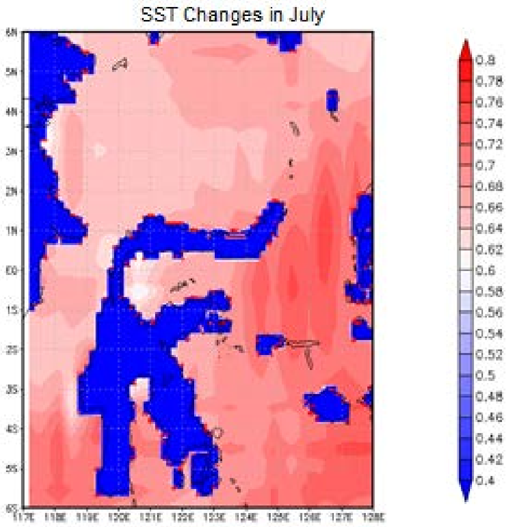
Future Temperature in November

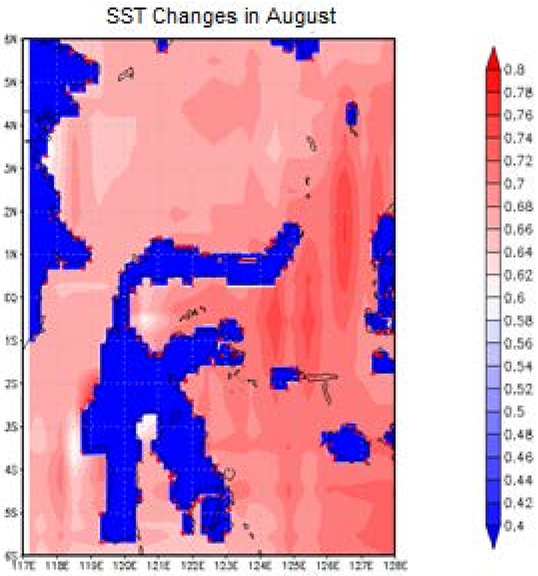


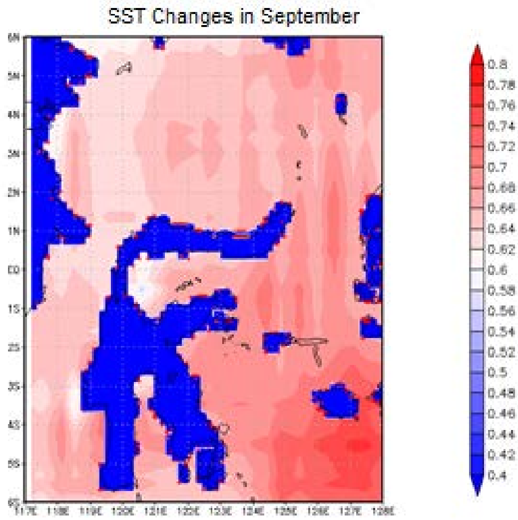
Appendix 24. Maps of Sea Surface Temperature in Near Period

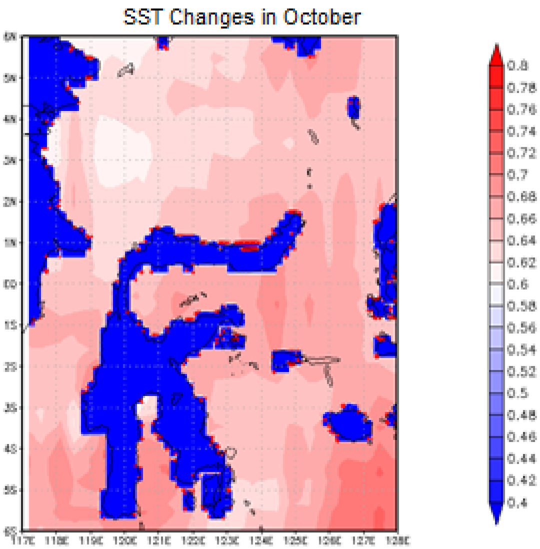


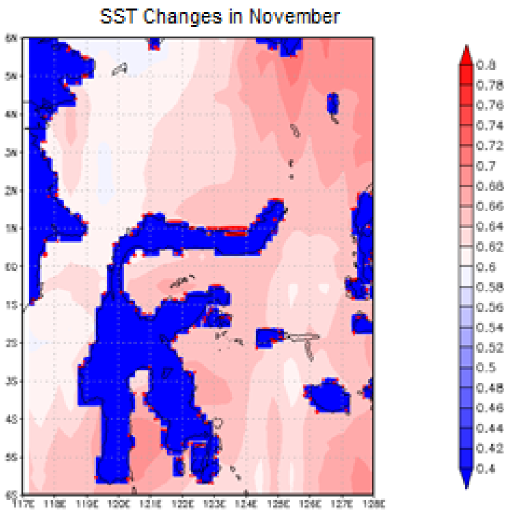

SST Changes in June


SST Changes in July

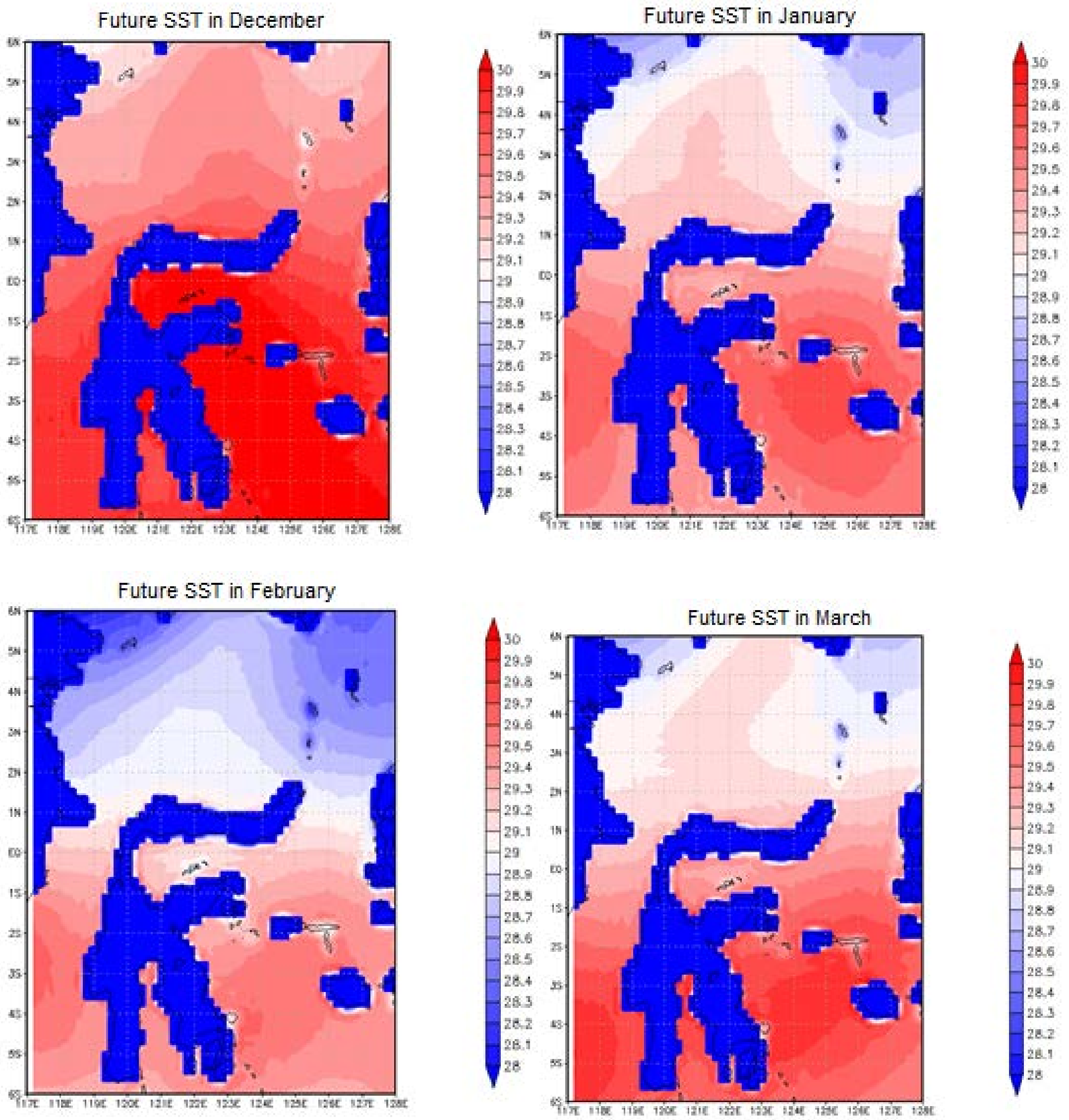

SST Changes in August

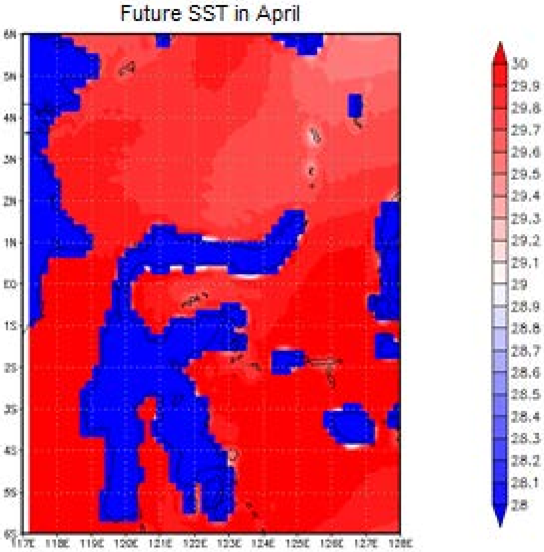

SST Changes in September

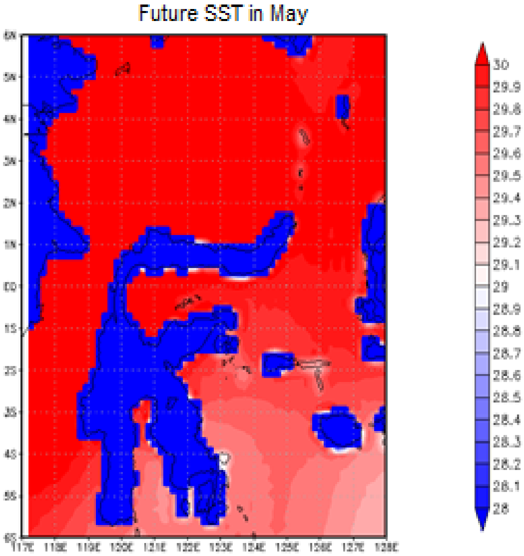

SST Changes in October

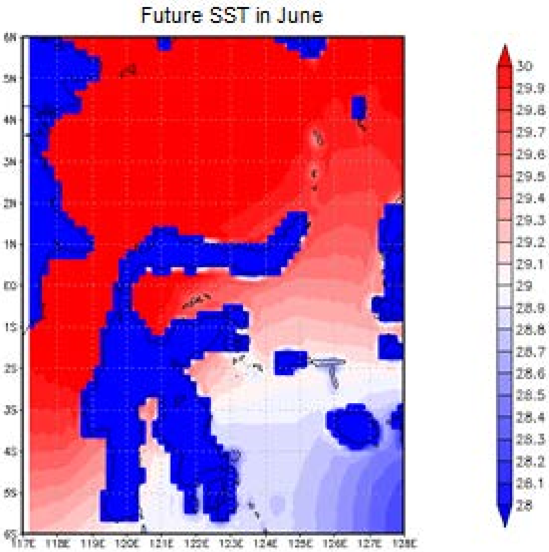

SST Changes in November

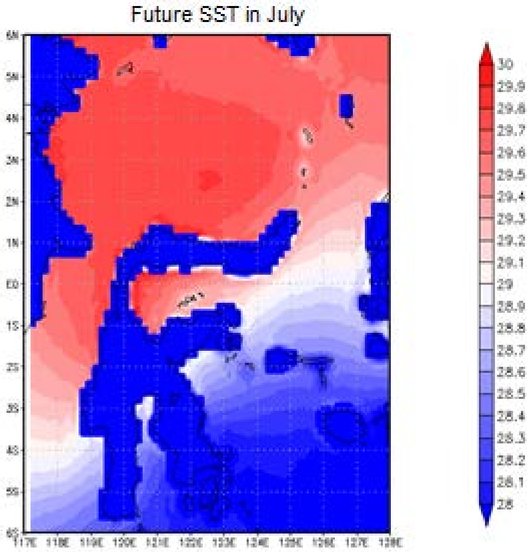
Appendix 25. Maps of Sea Surface Temperature Change in Near Period to Baseline Period

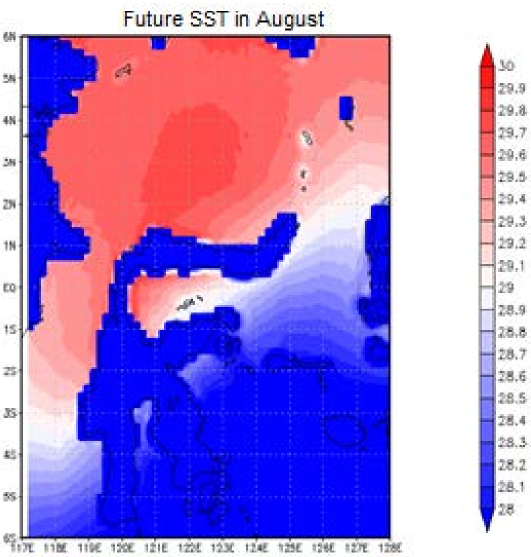


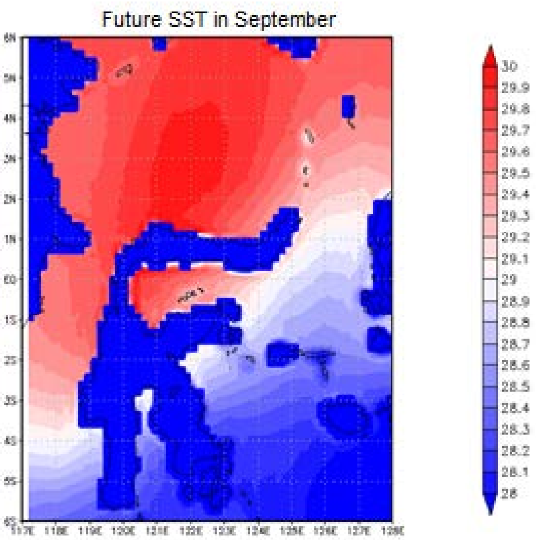

Future SST in April

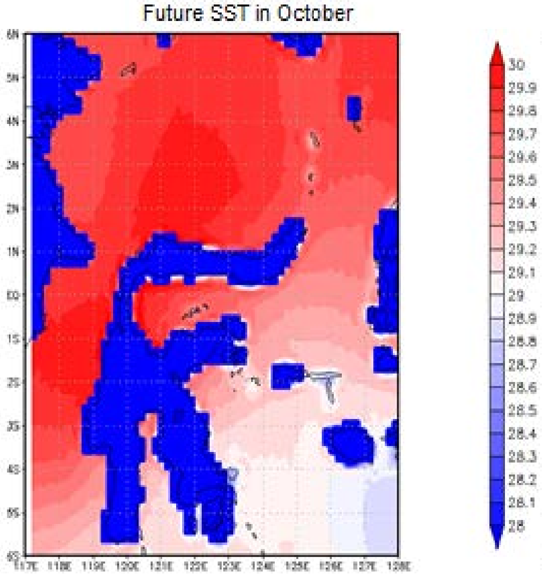

Future SST in May

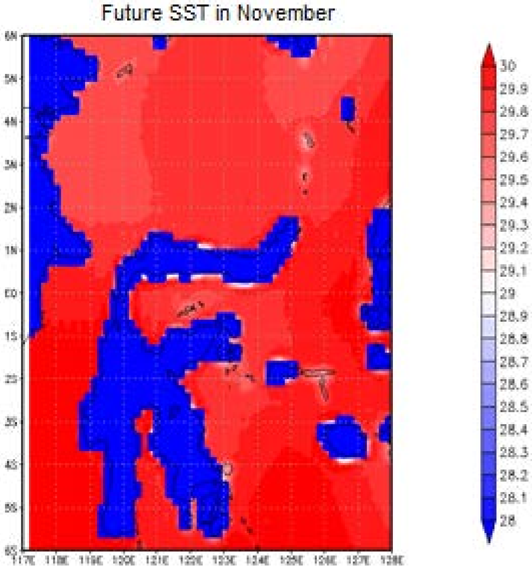

Future SST in June


Future SST in July

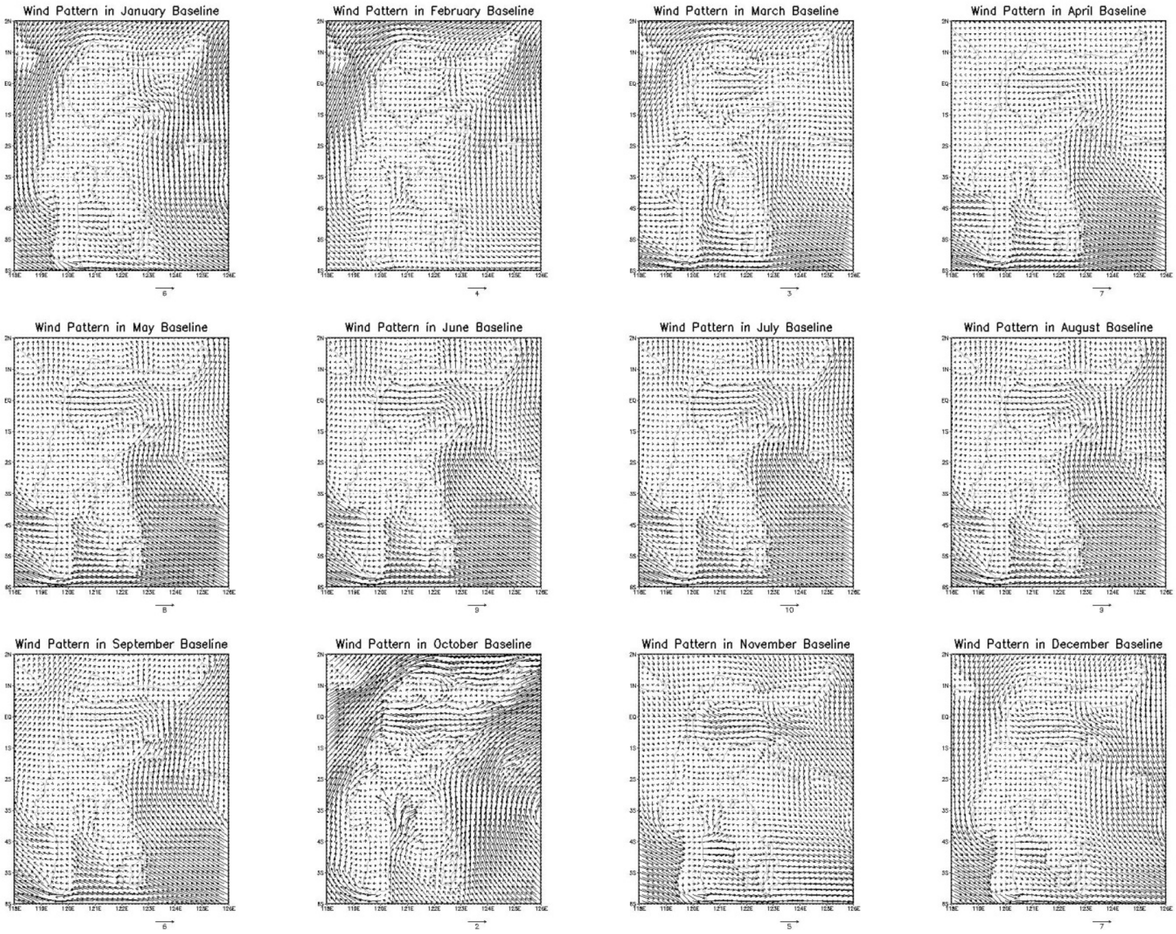

Future SST in August


Future SST in September

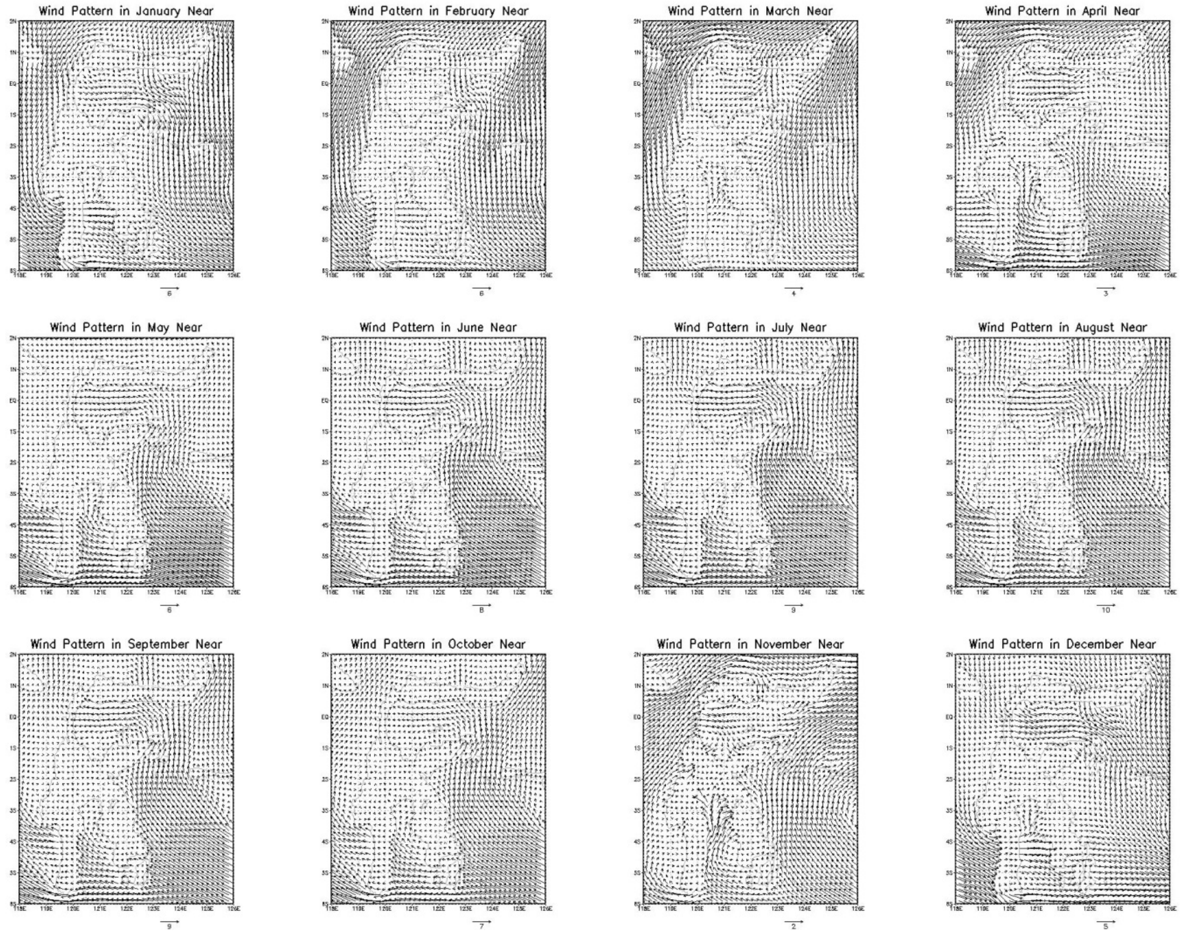

Future SST in October
30
29.9
29.8
29.7
29.6
29.5
29.4
29.3
29.2
29.1
29
28.9
28.8
28.7
28.6
28.5
28.4
28.3
28.2
28.1
28


Future SST in November
30
29.9
29.8
29.7
29.6
29.5
29.4
29.3
29.2
29.1
29
28.9
28.8
28.7
28.6
28.5
28.4
28.3
28.2
28.1
28

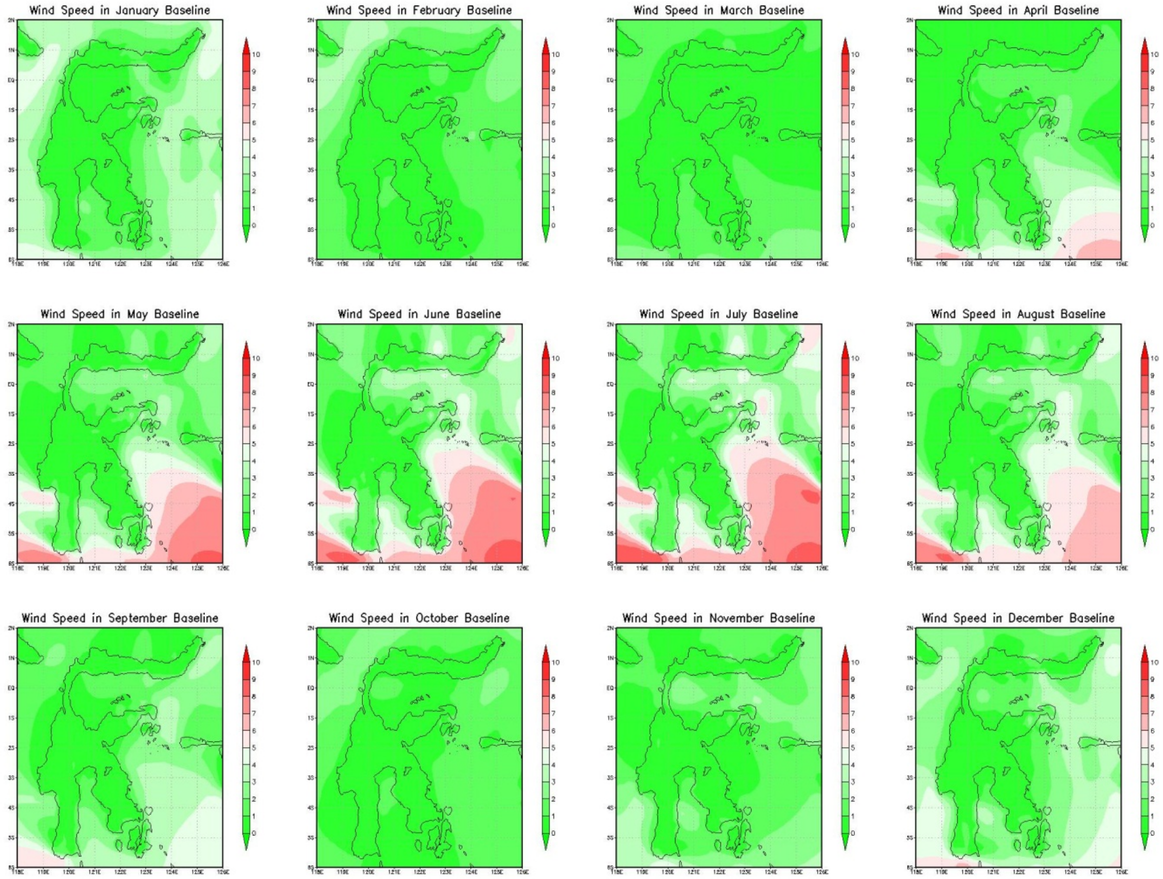
Appendix 26. Maps of Wind Pattern on Monthly Average in Sulawesi in Baseline Period



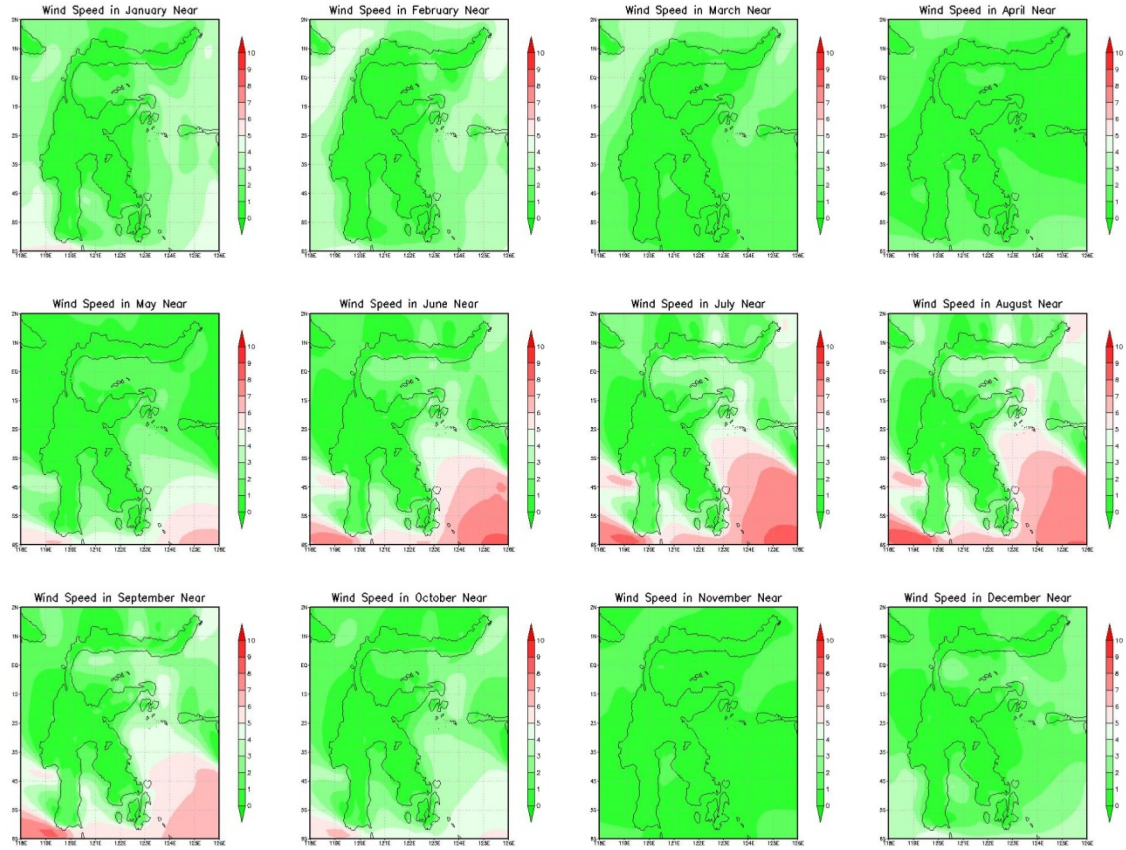
Appendix 27. Maps of Wind Pattern on Monthly Average in Sulawesi in Near Period



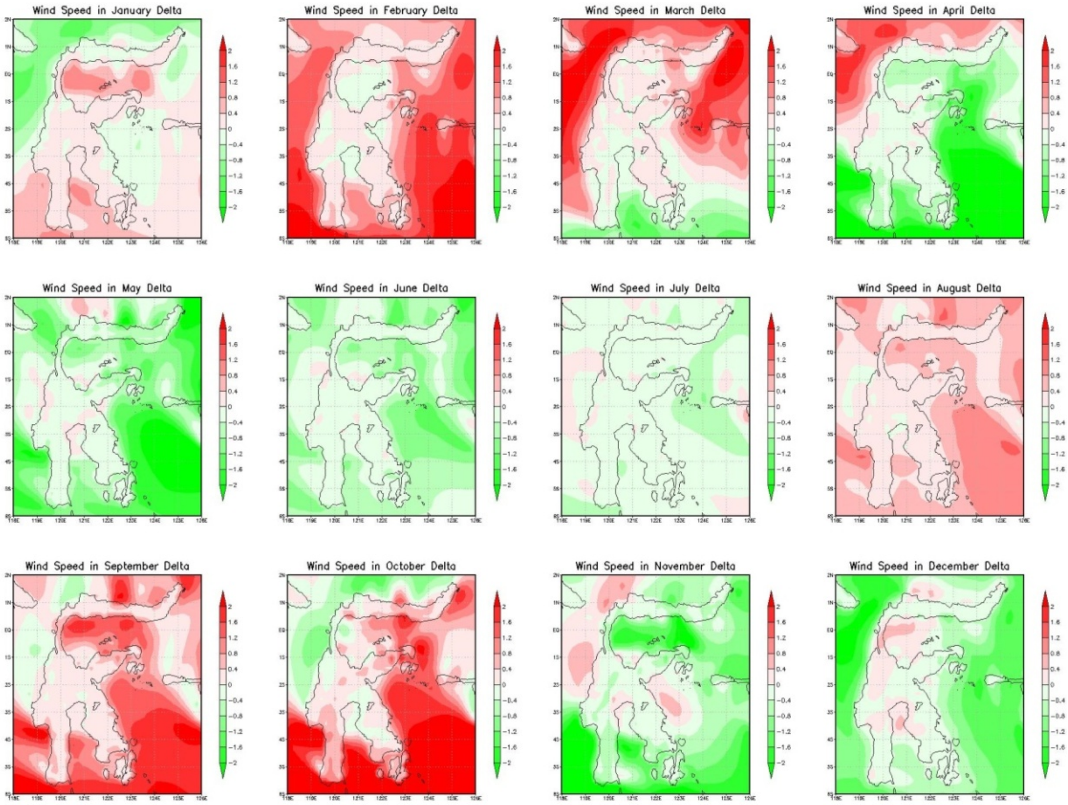
Appendix 28. Maps of Wind Speed on Monthly Average in Sulawesi in Baseline Period



Appendix 29. Maps of Wind Speed on Monthly Average in Sulawesi in Near Period



Appendix 30. Maps of Wind Speed Change on Monthly Average in Sulawesi in Near Period Relative to Baseline Period



Appendix 31. Demography and Social Data (Source: Statistics Indonesia, 2014)

No.	District	Village	Area (Km^2)	Population	Elevation (Mdpl)	Density (Population /Area)	Number of Schools (TK, PS, JHS, SLTA, SMK, PT)	Distance of Village to Main district (Km)	Number of Health Officers (Doctor, Nurse, Others)	Number of Health Facilities (Hospital, PuskeHSs, PKM Pembantu,PoskeP Sas, Polindes
1	Tatapaan	Sulu	12	1013	7	84.4	2	0.5	2	2
2	Tatapaan	Paslaten	18.85	1260	7	66.8	3	0.3	1	2
3	Tatapaan	Bajo	12.5	525	2	42.0	2	7.4	0	1
4	Tatapaan	Popareng	14	935	2	66.8	3	10.1	0	1
5	Tatapaan	Wawontulap	16.47	1080	8	65.6	2	19.9	0	1
6	Tatapaan	Wawona	20.53	829	4	40.4	2	6.9	0	1
7	Tatapaan	Sondaken	12	714	5	59.5	2	25.2	0	2
8	Tatapaan	Rap-Rap	14.34	1345	3	93.8	6	28	0	1
9	Tatapaan	Pungkol	3.5	390	3	111.4	2	4.8	0	1
10	Tatapaan	Paslaten Satu	21.35	828	10	38.8	2	3	0	1
11	Tatapaan	Arakan	0.17	1222	2	7188.2	2	28.1	0	1
12	Tumpaan	Tumpaan	3.75	1536	60	409.6	4	1	1	0
13	Tumpaan	Tumpaan Satu	2	1820	27	910.0	2	1	2	1
14	Tumpaan	Matani	1.78	1512	28	849.4	7	3	6	2
15	Tumpaan	Popontolen	4.5	1745	49	387.8	2	3	0	0

No.	District	Village	Area (Km^2)	Population	Elevation (Mdpl)	Density (Population /Area)	Number of Schools (TK, PS, JHS, SLTA, SMK, PT)	Distance of Village to Main district (Km)	Number of Health Officers (Doctor, Nurse, Others)	Number of Health Facilities (Hospital, PuskeHSs, PKM Pembantu,PoskeP Sas, Polindes
16	Tumpaan	Lelema	27.05	1634	59	60.4	2	4	2	0
17	Tumpaan	Tangkuney	25	1286	104	51.4	3	14	1	0
18	Tumpaan	Munte	128.5	1667	206	13.0	3	16	2	0
19	Tumpaan	Tumpaan Baru	3	1905	14	635.0	3	1	3	0
20	Tumpaan	Tumpaan Dua	3.27	1627	21	497.6	4	2	4	1
21	Tumpaan	Matani Satu	16	1976	60	123.5	3	2	7	0
22	Tareran	KaneYesn	7.33	963	375	131.4	4	11	3	3
23	Tareran	Koreng	6	1188	546	198.0	5	8.9	1	2
24	Tareran	Tumaluntung	6.25	665	661	106.4	2	5	1	3
25	Tareran	Lansot	3.15	929	609	294.9	3	0.4	5	4
26	Tareran	Rumoong Atas	2.4	1043	614	434.6	2	0.2	3	1
27	Tareran	Wuwuk	8.75	977	457	111.7	1	5	0	2
28	Tareran	Pinamorongan	24	1598	252	66.6	5	11	12	4
29	Tareran	Wiau Lapi	3.15	824	592	261.6	2	1	1	1
30	Tareran	Romoong Atas Dua	4	1496	614	374.0	5	0.4	15	3
31	Tareran	Tumaluntung Satu	10.16	977	629	96.2	2	5	1	2

No.	District	Village	Area (Km^2)	Population	Elevation (Mdpl)	Density (Population /Area)	Number of Schools (TK, PS, JHS, SLTA, SMK, PT)	Distance of Village to Main District (Km)	Number of Health Officers (Doctor, Nurse, Others)	Number of Health Facilities (Hospital, PuskeHSs, PKM Pembantu,PoskeP Sas, Polindes
32	Tareran	Wuwuk Barat	9.5	988	458	104.0	6	0.4	3	1
33	Tareran	Lansot Timur	2.71	721	607	266.1	1	5	0	1
34	Tareran	Wiau Lapi Barat	3.53	982	603	278.2	2	1	4	0
35	Amurang	Buyungon	1220	3287	1	2.7	5	0	13	5
36	Amurang	Ranoiapo	16	3714	1	232.1	7	0.1	7	2
37	Amurang	Uwuran Satu	8	1453	1	181.6	1	1	4	2
38	Amurang	Uwuran Dua	40	2373	1	59.3	4	1	1	3
39	Amurang	Lewet	15	1358	1	90.5	3	1.5	1	2
40	Amurang	Ranoketang Tua	1200	945	1	0.8	2	12	0	1
41	Amurang	Bitung	6600	2041	1	0.3	6	2	19	1
42	Amurang	Kilometer Tiga	350	945	1	2.7	2	4	4	1
43	Amurang Barat	Pondos	15	1114	310	74.3	4	8	2	1
44	Amurang Barat	Elusan	26	1056	300	40.6	4	10.5	4	1
45	Amurang Barat	Tewasen	21	1448	300	69.0	6	7	4	1

No.	District	Village	Area (Km²)	Population	Elevation (Mdpl)	Density (Population /Area)	Number of Schools (TK, PS, JHS, SLTA, SMK, PT)	Distance of Village to Main District (Km)	Number of Health Officers (Doctor, Nurse, Others)	Number of Health Facilities (Hospital, PuskeHSs, PKM Pembantu,PoskeP Sas, Polindes
46	Amurang Barat	Teep	5.5	1517	3	275.8	4	1	2	1
47	Amurang Barat	Kapitu	0.33	2115	3	6409.1	3	0.5	4	3
48	Amurang Barat	Kawangkoan Bawah	17.16	2979	2	173.6	6	5.5	2	2
49	Amurang Barat	Rumoong Bawah	41.18	2396	5	58.2	2	6	5	1
50	Amurang Barat	Desa Rumoong Bawah	7.5	889	10	118.5	2	8	2	1
51	Amurang Barat	Wakan	11	1203	340	109.4	3	23	2	1
52	Amurang Barat	Teep Trans	2.5	376	3	150.4	2	1	13	1
54	Amurang Timur	Ranomea	24.5	2887	27	117.84	3	2	11	1
55	Amurang Timur	Pondang	45.0	2912	16	64.71	4	2	2	0
56	Amurang Timur	Pinaling	27.0	1606	111	59.48	4	32	4	1

No.	District	Village	Area (Km²)	Population	Elevation (Mdpl)	Density (Population /Area)	Number of Schools (TK, PS, JHS, SLTA, SMK, PT)	Distance of Village to Main District (Km)	Number of Health Officers (Doctor, Nurse, Others)	Number of Health Facilities (Hospital, PuskeHSs, PKM Pembantu,PoskeP Sas, Polindes
57	Amurang Timur	Kota Menara	17.0	844	761	49.65	3	20	0	1
58	Amurang Timur	Maliku	20.2	716	400	35.45	4	8	1	0
59	Amurang Timur	Ritey	10.4	251	220	24.13	4	4	3	1
60	Amurang Timur	Malenos Baru	4.7	496	103	105.53	2	2	6	1
61	Amurang Timur	Lopana	6.0	1208	7	201.33	2	1	2	0
62	Amurang Timur	Lopana Satu	0.5	1590	46	3180.00	3	1	4	0
63	Amurang Timur	Maliku Satu	15.0	909	398	60.60	0	8	1	0

Appendix 32. Sensitivity and Adaptive Capacity Index Based on Statistics Indonesia Data, 2014

No.	District	Village	Elevation Index	Density Index	Sensitivity Index	Number of Schools Index	Distance of Village to Main District Index	Number of Health Officers Index	Number of Health Facilities Index	Adaptive Capacity Index
1	Tatapaan	Sulu	0.99	0.01	0.26	0.29	0.98	0.11	0.40	0.66
2	Tatapaan	Paslaten	0.99	0.01	0.25	0.43	0.99	0.05	0.40	0.63
3	Tatapaan	Bajo	1.00	0.01	0.25	0.29	0.77	0.00	0.20	0.83
4	Tatapaan	Popareng	1.00	0.01	0.26	0.43	0.68	0.00	0.20	0.80
5	Tatapaan	Wawontulap	0.99	0.01	0.25	0.29	0.38	0.00	0.20	0.92
6	Tatapaan	Wawona	1.00	0.01	0.25	0.29	0.78	0.00	0.20	0.83
7	Tatapaan	Sondaken	0.99	0.01	0.25	0.29	0.21	0.00	0.40	0.87
8	Tatapaan	Rap-Rap	1.00	0.01	0.26	0.86	0.13	0.00	0.20	0.77
9	Tatapaan	Pungkol	1.00	0.02	0.26	0.29	0.85	0.00	0.20	0.81
10	Tatapaan	Paslaten Satu	0.99	0.01	0.25	0.29	0.91	0.00	0.20	0.80
11	Tatapaan	Arakan	1.00	1.00	1.00	0.29	0.12	0.00	0.20	0.97
12	Tumpaan	Tumpaan	0.92	0.06	0.27	0.57	0.97	0.05	0.00	0.75
13	Tumpaan	Tumpaan Satu	0.97	0.13	0.34	0.29	0.97	0.11	0.20	0.74
14	Tumpaan	Matani	0.96	0.12	0.33	1.00	0.91	0.32	0.40	0.33
15	Tumpaan	Popontolen	0.94	0.05	0.27	0.29	0.91	0.00	0.00	0.89

No.	District	Village	Elevation Index	Density Index	Sensitivity Index	Number of Schools Index	Distance of Village to Main District Index	Number of Health Officers Index	Number of Health Facilities Index	Adaptive Capacity Index
16	Tumpaan	Lelema	0.92	0.01	0.24	0.29	0.88	0.11	0.00	0.85
17	Tumpaan	Tangkuney	0.86	0.01	0.22	0.43	0.56	0.05	0.00	0.89
18	Tumpaan	Munte	0.73	0.00	0.18	0.43	0.50	0.11	0.00	0.88
19	Tumpaan	Tumpaan Baru	0.98	0.09	0.31	0.43	0.97	0.16	0.00	0.76
20	Tumpaan	Tumpaan Dua	0.97	0.07	0.30	0.57	0.94	0.21	0.20	0.61
21	Tumpaan	Matani Satu	0.92	0.02	0.24	0.43	0.94	0.37	0.00	0.67
22	Tareran	KaneYesn	0.51	0.02	0.14	0.57	0.66	0.16	0.60	0.52
23	Tareran	Koreng	0.28	0.03	0.09	0.71	0.72	0.05	0.40	0.58
24	Tareran	Tumaluntung	0.13	0.01	0.04	0.29	0.84	0.05	0.60	0.62
25	Tareran	Lansot	0.20	0.04	0.08	0.43	0.99	0.26	0.80	0.37
26	Tareran	Rumoong Atas	0.19	0.06	0.09	0.29	0.99	0.16	0.20	0.72
27	Tareran	Wuwuk	0.40	0.02	0.11	0.14	0.84	0.00	0.40	0.78
28	Tareran	Pinamorongan	0.67	0.01	0.17	0.71	0.66	0.63	0.80	0.18
29	Tareran	Wiau Lapi	0.22	0.04	0.08	0.29	0.97	0.05	0.20	0.77
30	Tareran	Romoong Atas Dua	0.19	0.05	0.09	0.71	0.99	0.79	0.60	0.13
31	Tareran	Tumaluntung Satu	0.17	0.01	0.05	0.29	0.84	0.05	0.40	0.71
32	Tareran	Wuwuk Barat	0.40	0.01	0.11	0.86	0.99	0.16	0.20	0.52
33	Tareran	Lansot Timur	0.20	0.04	0.08	0.14	0.84	0.00	0.20	0.87

No.	District	Village	Elevation Index	Density Index	Sensitivity Index	Number of Schools Index	Distance of Village to Main District Index	Number of Health Officers Index	Number of Health Facilities Index	Adaptive Capacity Index
34	Tareran	Wiau Lapi Barat	0.21	0.04	0.08	0.29	0.97	0.21	0.00	0.79
35	Amurang	Buyungon	1.00	0.00	0.25	0.71	1.00	0.68	1.00	0.00
36	Amurang	Ranoiapo	1.00	0.03	0.27	1.00	1.00	0.37	0.40	0.29
37	Amurang	Uwuran Satu	1.00	0.03	0.27	0.14	0.97	0.21	0.40	0.67
38	Amurang	Uwuran Dua	1.00	0.01	0.26	0.57	0.97	0.05	0.60	0.50
39	Amurang	Lewet	1.00	0.01	0.26	0.43	0.95	0.05	0.40	0.63
40	Amurang	Ranoketang Tua	1.00	0.00	0.25	0.29	0.63	0.00	0.20	0.86
41	Amurang	Bitung	1.00	0.00	0.25	0.86	0.94	1.00	0.20	0.17
42	Amurang	Kilometer Tiga	1.00	0.00	0.25	0.29	0.88	0.21	0.20	0.72
43	Amurang Barat	Pondos	0.59	0.01	0.16	0.57	0.75	0.11	0.20	0.69
44	Amurang Barat	Elusan	0.61	0.01	0.16	0.57	0.67	0.21	0.20	0.66
45	Amurang Barat	Tewasen	0.61	0.01	0.16	0.86	0.78	0.21	0.20	0.54
46	Amurang Barat	Teep	1.00	0.04	0.28	0.57	0.97	0.11	0.20	0.64
47	Amurang Barat	Kapitu	1.00	0.89	0.92	0.43	0.98	0.21	0.60	0.48

No.	District	Village	Elevation Index	Density Index	Sensitivity Index	Number of Schools Index	Distance of Village to Main District Index	Number of Health Officers Index	Number of Health Facilities Index	Adaptive Capacity Index
48	Amurang Barat	Kawangkoan Bawah	1.00	0.02	0.27	0.86	0.83	0.11	0.40	0.49
49	Amurang Barat	Rumoong Bawah	0.99	0.01	0.25	0.29	0.81	0.26	0.20	0.71
50	Amurang Barat	Desa Rumoong Bawah	0.99	0.02	0.26	0.29	0.75	0.11	0.20	0.79
51	Amurang Barat	Wakan	0.55	0.02	0.15	0.43	0.28	0.11	0.20	0.84
52	Amurang Barat	Teep Trans	1.00	0.02	0.27	0.29	0.97	0.68	0.20	0.50
54	Amurang Timur	Ranomea	0.97	0.02	0.25	0.43	0.94	0.58	0.20	0.50
55	Amurang Timur	Pondang	0.98	0.01	0.25	0.57	0.94	0.11	0.00	0.74
56	Amurang Timur	Pinaling	0.86	0.01	0.22	0.57	0.00	0.21	0.20	0.80
57	Amurang Timur	Kota Menara	0.00	0.01	0.01	0.43	0.38	0.00	0.20	0.87
58	Amurang Timur	Maliku	0.48	0.00	0.12	0.57	0.75	0.05	0.00	0.80
59	Amurang Timur	Ritey	0.71	0.00	0.18	0.57	0.88	0.16	0.20	0.64

No.	District	Village	Elevation Index	Density Index	Sensitivity Index	Number of Schools Index	Distance of Village to Main District Index	Number of Health Officers Index	Number of Health Facilities Index	Adaptive Capacity Index
60	Amurang Timur	Malenos Baru	0.87	0.01	0.23	0.29	0.94	0.32	0.20	0.66
61	Amurang Timur	Lopana	0.99	0.03	0.27	0.29	0.97	0.11	0.00	0.83
62	Amurang Timur	Lopana Satu	0.94	0.44	0.57	0.43	0.97	0.21	0.00	0.73
63	Amurang Timur	Maliku Satu	0.48	0.01	0.13	0.00	0.75	0.05	0.00	1.00
64	Sulta	KapoYes	0.63	0.03	0.18	0.43	0.83	0.11	0.60	0.55
65	Sulta	Pinapalangkow	0.52	0.02	0.14	0.57	0.94	0.11	0.60	0.48
66	Sulta	Suhun Dua	0.37	0.03	0.12	0.29	1.00	0.11	0.20	0.74
67	Sulta	Suhun Empat	0.36	0.04	0.12	0.14	1.00	0.11	0.60	0.62
68	Sulta	Suhun Satu	0.37	0.04	0.12	0.14	1.00	0.05	0.40	0.73
69	Sulta	Suhun Tiga	0.37	0.04	0.12	0.43	0.97	0.00	0.60	0.57
70	Sulta	Talaitad	0.20	0.02	0.06	0.57	0.78	0.11	0.60	0.51
71	Sulta	KapoYes Satu	0.63	0.03	0.18	0.14	0.83	0.00	0.20	0.87
72	Sulta	Talaitad Utara	0.21	0.01	0.06	0.43	0.78	0.05	0.40	0.67