Climate Change Risk and Adaptation Assessment

Tarakan

Sectoral Report
Coastal

June 2012

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Climate Risk and Adaptation Assessment for the Coastal Sector – Tarakan

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Climate Risk and Adaptation Assessment for the Coastal Sector - Tarakan

Final Draft Report

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June 2012

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Chapter I Introduction

1.1 Background

Tarakan is a typical small island which its coastal areas are strongly exposed to some hazards due to global climate change stimuli. Interestingly, Tarakan is also a representative area that is vulnerable to climate change due to its administrative status as a city which has quite dense population and high economic activities.

As a consequence, there will be some needs to assess levels of risk along the coastal areas of Tarakan City in order to have comprehensive understanding about how climate change impose these areas and how to design some strategies to adapt these impacts of climate change, especially the influence to sea level rise.

The most general definition of *climate change* is a change in the statistical properties of the climate system over periods of decades or longer. It may be a change in the average weather conditions or a change in the distribution of weather events with respect to an average condition.

This term sometimes used to specifically refer to climate change caused by human activity; for example, the United Nations Framework Convention on Climate Change (UNFCC) defines the climate change as *"a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods In the latter sense climate change is synonymous with global warming".* Moreover, global warming is basically a phenomenon of global temperature increase from year to year because of the greenhouse effect, which is caused by the increase of greenhouse gas emissions.

Several factors that can shape the global climate are climate forcing, such as variations of solar radiation, deviations of the Earth's orbit, mountain-building, continental drift, and changes in greenhouse gas concentrations. There are a variety of climate change feedbacks that can either amplify or diminish the initial forcing. Some parts of the climate system, such as the oceans and ice caps, respond slowly in reaction to climate forcing because of their large mass. Therefore, the climate system can take centuries or longer to fully respond to new external forcing.

One direct impact of climate change or global warming to the coastal sector is sea level rise. In the aim to see the effects of global warming to sea level changes, first need to know whether the phenomenon of sea long-term and short term changes, as follows:

a. ***Long term sea level changes***; Long term change of sea level is also called as secular change. It is categorized into two classes according to its causes: (1) Eustatic changes or changes of sea water volume, and (2) Local changes that includes land uplift or subsidence or called isostasy effect. This isostasy effects comprises thermal isostasy, due to changes in temperature or density of the Earth's interior; glacio isostasy, related to the presence of ice; hydro-isostasy, associated with the presence of water; volcanic isostasy, due to magma extrusion; and sediment isostasy, linked to deposition and erosion.

   The existence of fault causes tectonic plates to rise (up-lift) or fall (subsidence) and could affect sea level changes of about 1 to 3 mm/year. Sediment compaction could cause land compression, or subsidence of oil and ground water extraction. One of the eustatic effects is a change of ocean basin due to the expansion of the ocean floor, changes of oceanic ground floor elevation, and seabed sedimentation. In addition, changes of sea water mass, as a consequence of polar ice caps melting, release water from the earth's interior, as well as release the accumulation of the reservoir that are included in the eustatic changes.

b. ***Short term sea level changes***; Short term sea level changes could occur due to several forces, including ocean tides, storm tide, and storm surge (cyclone). A rise in sea surface height will occur when the storm surge coincides with the highest tide level, known as storm tides. These phenomena have periods between daily and weekly. El Nino and La Nina phenomena also affect sea level in a short time period. At the time of the El Nino occurrence, sea surface in Indonesian waters decrease, while the La Nina increases the sea level. Furthermore, flooding in certain seasons is also a seasonal variation that may affect sea level in the short term, which increases runoff from rivers into the sea and causes additional sea level rise. These changes occur in seasonal to annual periods. In addition, the sea surface oscillations occur at harbors, known as a seiche, and it is also a factor that affects the sea level in short-term period. These changes could occur within a period of minutes to hours. The earthquake that caused land deformation could cause relative changes in sea level. Earthquake could lead to land subsidence and/or uplift, which changes sea level relative to the land.

Therefore, accelerating sea-level rise and extreme climate events are the major issues, especially in coastal areas. Moreover, climate change will increase the intensity and frequency of the oceanic variability, such as La-Nina and storm surges which causes major floods. On the other hand, land subsidence and floods have already caused considerable damages in Indonesia. Adaptive measures could mitigate damage and avoid aggravating impacts of natural disasters.

Therefore, the necessity of adaptation measures in national and local levels is rapidly emerging as central issue in the debate of policy responses to climate change. In order to prioritize, design, and implement interventions to adapt to climate change, it is essential to adopt a coherent set of approach, framework, and methodologies for examining vulnerability and adaptive capacity.

Many vulnerability studies, while being effective in raising awareness to the possible effect of climate change on a general level, have limited effectiveness in providing local scale guidance on adaptation. Methods and tools for vulnerability studies at local level are different from the ones used on provincial, national and even global scales. To effectively formulate adaptation strategies at the Tarakan municipal level, it is proposed to apply the ***”micro level-multi sectoral approach” (McLMSA)***, which means assessing vulnerability at micro-level but still considering the multi sectoral impacts of climate change, in which the coastal sector is considered beside water and health sectors. This approach is a detailed “replication” of ***”meso level-multi sectoral approach” (MsLMSA)*** that had been successfully developed and applied in Lombok Island.

1.2 General Objectives

This assessment was conducted, in general, to perform Climate Change Risk and Adaptation Assessment (CCRA) of Coastal Sector in the Tarakan City (City) according to or based on the "*micro level-multi sectoral approach*" (McLMSA). Furthermore, on this basis, this assessment is also aimed to formulate an appropriate adaptation strategy with precise adaptation options which will be endorsed to the local authorities (City Government of Tarakan).

1.3 Scopes of Assessment

Implementation of these objectives becomes following step-by-step tasks of the CCRA:

- Conceptualize framework and step by step simple methods for assessing climate risk on coastal sector and identify the required data, based on the formulated methods, in the Tarakan City
- Collection, analysis, and synthesis of the data, according to the methods above, in the Tarakan City.
- Analysis of Climate Hazards and Vulnerability of Coastal Sector in the Tarakan City;
- Synthesis of Climate Change Risk on the Coastal Sector of Tarakan City
- Formulation of Adaptation Strategies in Response to Climate Change for the Tarakan City;

As implemented in micro level of Tarakan City, the assessment needs supports of the modeling of coastal dynamics as follows:

- Wind-rose analysis to study wind domain directions, frequencies, and return periods;
- Wave prediction model, wave rose analysis, and wave climate analyses to study significant waves, wave domain directions, frequencies, and return periods;
- Wave refraction and diffraction models to study the convergence and divergence of wave energy attack to the shorelines;
- Longshore current and sediment transport models to study the movements of sediment along the coastal zones;
- Shoreline change model, with and without coastal structures;
- Tidal prediction to study significant high water levels and their frequencies;
- Roles of vegetation to reduce wind waves and maintain the stability of coastal bank.

Chapter II General Description of Coastal Sector and Climate Change Issues in Tarakan

2.1 Physical and Socioeconomic Description of Tarakan

2.1.1 Geographical Condition of Tarakan

Tarakan Island is located northeast of the Kalimantan. The geographical position is 3°.19'-3°.20' N and 117°.34'-117°.38' E, as shown in Figure 2.1. Tarakan is a typical small island, which its area is approximately 20 km long north-to-southward and 10 km wide west-to-eastward, so that the total territorial areas of its land and sea are 250.80 km^2 and 406.53 km^2, respectively. Geographical boundaries of the Tarakan Island are:

- Bunyu Island, as orientated from the north coast of Tarakan.
- Bunyu Island and Sulawesi Sea, as orientated from the east coast of Tarakan.
- Tanjung Palas, as orientated from the south coast of Tarakan.
- Kalimantan Island and Sesayap District, as orientated from the west coast of Tarakan.

Figure 2.1 Location of Tarakan Island and its surrounding areas (*source:* Googlemap)

Tarakan shows a considerable diversity of coastal morphology, exposures, and ecosystems.

2.1.2 Administrative Area and Demography

According to the Law No. 27, Year 2007 (Article 2) the administration boundaries are designed with sub-district and villages administration as unit analysis as shown in Figure 2.2. The administrative area of Tarakan Island comprises of 4 sub-districts and 21 villages.

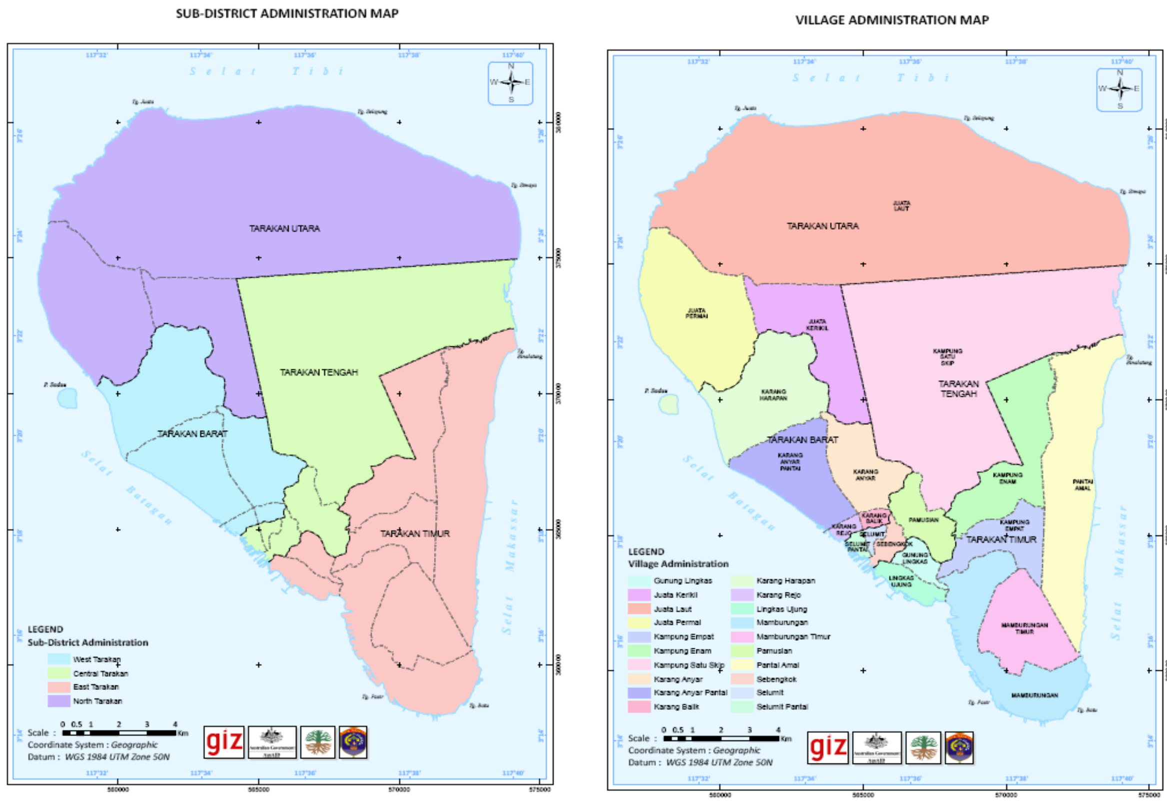


Figure 2.2 Administrative map of sub-district (left) and village (right).

Table 2.1 shows the demographic information of each subdistrict and village, i.e., population, area, population density and distribution, based on Population Census in 2010.

Table 2.1 Population, Area, Density and Distribution of Tarakan City by Village in 2010

No	Sub-district	Village	Population	Area (sq km)	Density (per sq km)	Distribution (%)
1	East Tarakan	Lingkas Ujung	10.409	1,16	8.973	5,39
2		Gunung Lingkas	7.905	3,19	2.478	4,09
3		Mamburungan	7.633	8,51	897	3,95
4		Kampung Empat	4.529	11,39	398	2,35
5		Kampung Enam	5.433	11,21	485	2,81
6		Pantai Amal	4.469	12,15	368	2,31
7		Mamburungan Timur	2.531	10,40	243	1,31
8	Central Tarakan	Selumit Pantai	16.347	0,48	34.056	8,47
9		Selumit	6.490	0,43	15.093	3,36
10		Sebengkok	15.019	1,48	10.148	7,78
11		Pamusian	14.131	2,54	5.563	7,32
12		Kampung 1 Skip	8.410	50,61	166	4,36
13	West Tarakan	Karang Rejo	6.856	0,76	9.021	3,55
14		Karang Balik	7.875	0,80	9.844	4,08
15		Karang Anyar	27.573	5,61	4.915	14,28
16		Karang Anyar Pantai	17.855	8,51	2.098	9,25
17		Karang Harapan	7.621	12,21	624	3,95
18	North Tarakan	Juata Permai	6.877	14,23	483	3,56
19		Juata Kerikil	4.705	10,59	444	2,44
20		Juata Laut	10.401	84,54	123	5,39
		City of Tarakan	193.069	250,80	770	100,00

Source: BPS Kota Tarakan, 2010, p. 9

Table 2.1 also showed that the population of Tarakan based on the Census 2010 was 193.069, which is a big increase from 116.995 in Census 2000. Population growth rate in the period between the two censuses is 6,50% per year, which means higher than the national growth rate of 1,49% per year during the same period (BPS Kota Tarakan, 2010).

At present, almost 80% of populations in Tarakan are living in the coastal areas (within area of 2 km inlandward from shoreline; see Figure 2.3). Moreover, the populations are highly concentrated in the western coast of Tarakan Island, especially in the southwest part where the economical and governmental activities are concentrated. In administrative view, the major population concentrations are in some villages of West Tarakan subdistrict, especially Karang Anyar and Karang Anyar Pantai. However, the village with the highest population density (i.e, number of population per area of village) is Selumit Pantai (340 per hectare) in Central Tarakan subdistrict (see Figure 2.4).

Meanwhile, the subdistrict with the fastest growth rate is North Tarakan subdistrict. Thus, although the Central and West Tarakan subdistricts have been the major areas for settlement todays, the North Tarakan subdistrict will be growing to be a major settlement area in the future.

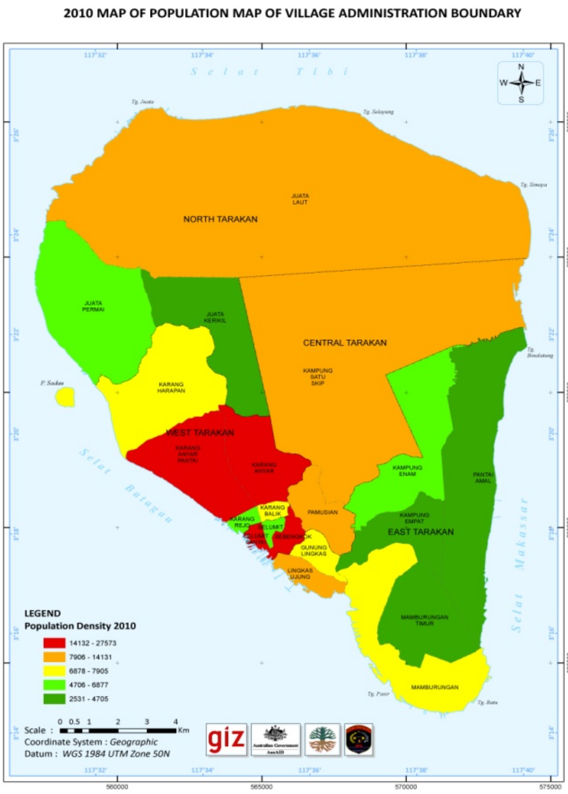


Figure 2.3 Population map on village administration 2010

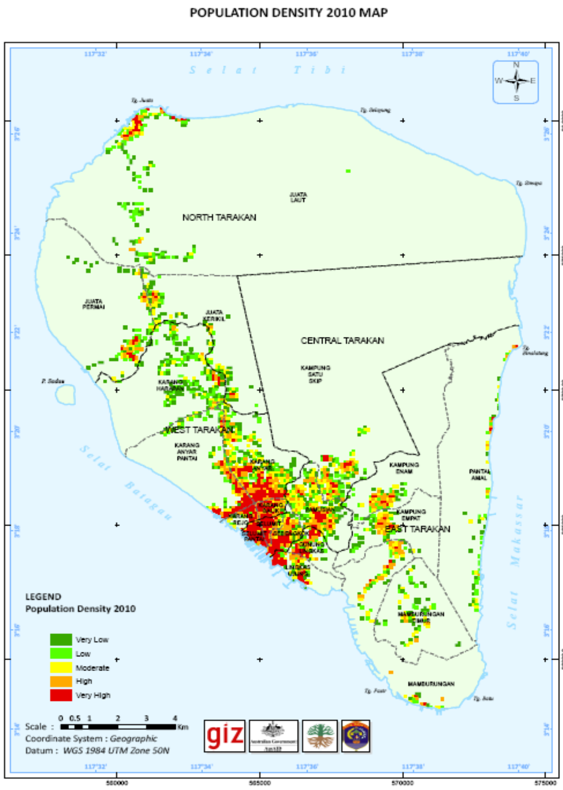


Figure 2.4 Population density in each settlement in 2010

Remarks are noted on the above maps that the distribution of population in Figure 2.3 had not been corrected yet, while the correction was done by putting the population density number in residential areas as shown in Figure 2.4.

2.1.3 Livelihood

Most people in Tarakan work as fishermen, crops growers, factory workers, or in business and services, which are scattered around the island as follow (Bappeda Kota Tarakan, 2011):

1. Fishermen activities are mostly performed in North Tarakan subdistrict and Karanganyar Pantai (West Tarakan).
2. Crops and agricultural activities are scattered in North Tarakan, Central Tarakan and East Tarakan subdistricts.
3. Factory workers perform activities in some industrial zones around the island.
4. Major business and service activities take place in the old part of the city, such as: Karanganyar Pantai, Karanganyar, Karangrejo, Karangbalik villages in West Tarakan subdistrict; Selumit Pantai, Selumit, Sebengkok villages in Central Tarakan subdistrict; Lingkas Ujung, Gunung Lingkas, Pamusian, and Mamburungan villages in East Tarakan subdistrict.

In cultural view, the native resident of Tarakan is Tidung tribe, a subgroup of the Dayak people. In addition, multi-ethnics from other parts of Indonesia compose the populations in the Tarakan City, especially Bugis, Javanese, and Tionghoa or Indonesian Chinese. The majority of population is Muslim, with Christian and other religions as a minority. Relationships between these different ethnic groups are generally peaceful (Wikipedia, 2010).

2.1.4 Economic Structure

The economy of Tarakan, measured by the Gross Regional Domestic Product (GRDP) in 2008 was at the amount of Rp. 5.24 trillion (with oil and gas) or Rp. 4.77 trillion (without oil and gas). This equals to US$ 582 million or US$ 530 million, respectively (with US$1 = Rp. 9,000). The economy is dominated by trades, hotel and restaurant sector, which contributes 38,14% of the total GRDP in 2008. Out of that the trade subsector is actually the major contributor with 36.34%. Then manufacturing sector contributes 15.27% of the economy at the second place (Bappeda Kota Tarakan, 2011). Agriculture sector contributes 11.30% of the economy at the third place. Out of this the fisheries subsector contributes 7.45%, as the major contributor from agriculture sector. The value of GRDP of each sector and its share in the economy are depicted in Table 2.2 below.

Table 2.2 Gross Regional Domestic Product of Tarakan in 2008 (current prices)

Economic Sector	Amount (Rp. Million)	Share (%)
- Agriculture - Fisheries	591.744 390.279	11,30 7.45
- Mining and quarrying (with oil and gas) - Oil and gas	493.597 464.574	9,42 8.87
- Manufacturing	799.850	15,27
- Electricity, water and gas	91.978	1,76
- Construction	197.009	3,76
- Trade, hotel and restaurant - Trade	1.998.016 1.903.679	38,14 36.34
- Transportation and communication - Air transportation	456.952 184.871	8,72 3,53
- Financial services	326.639	6.24
- Government and other services - Government	282.399 235.670	5.39 4.50
Total (with oil and gas)	5.238.185	100.00

Source: modified from Bappeda Kota Tarakan, 2011, p. 102

2.1.5 Climate Condition

The climate condition in Tarakan is humid, tropic, and warm, with high temperature and rainfall, but they are varying due to the position of Inter-tropical Convergences Zone (ITCZ) of unstable air and heavy rainfall, which migrate in the north and south over Indonesia (see Figure 2.5), crossing the equator in May and November each year and reaching about 15° S in January. When this zone is in the south, they are prevailing westerly winds and heavier rainfall, although northeasterly trade winds reach some northern coasts when it moves north, southeasterly winds bring drier conditions. Winds are generally light to moderate (Ongkosongo, 2010).

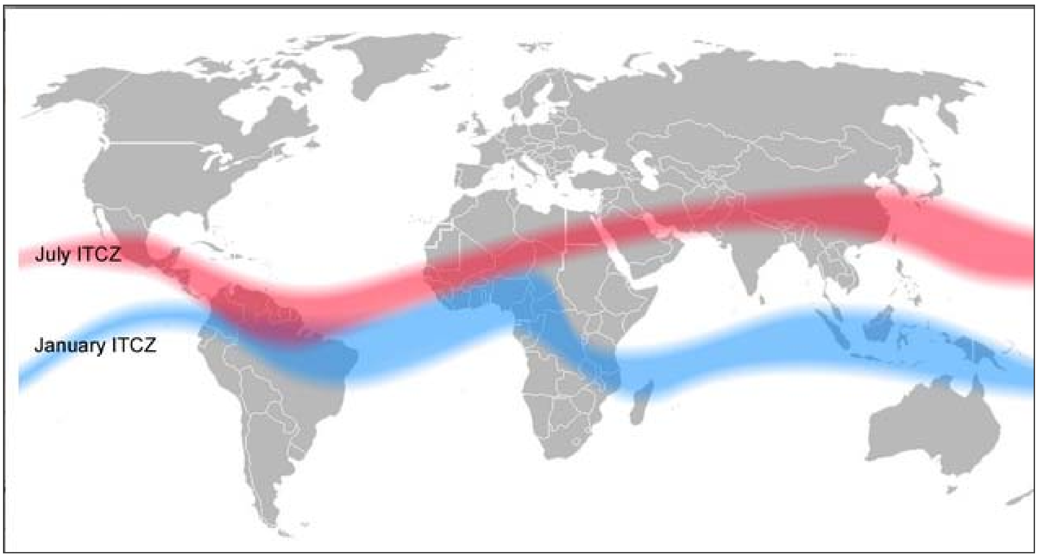


Figure 2.5 The position of ITCZ (source: http://www.india-karnataka.info/ITCZ)

There are three typical rainfall areas in Indonesia, that is: monsoonal, equatorial, and local type as shown in Figure 2.6 (BMG, 2007), while the Tarakan Island has an equatorial type.

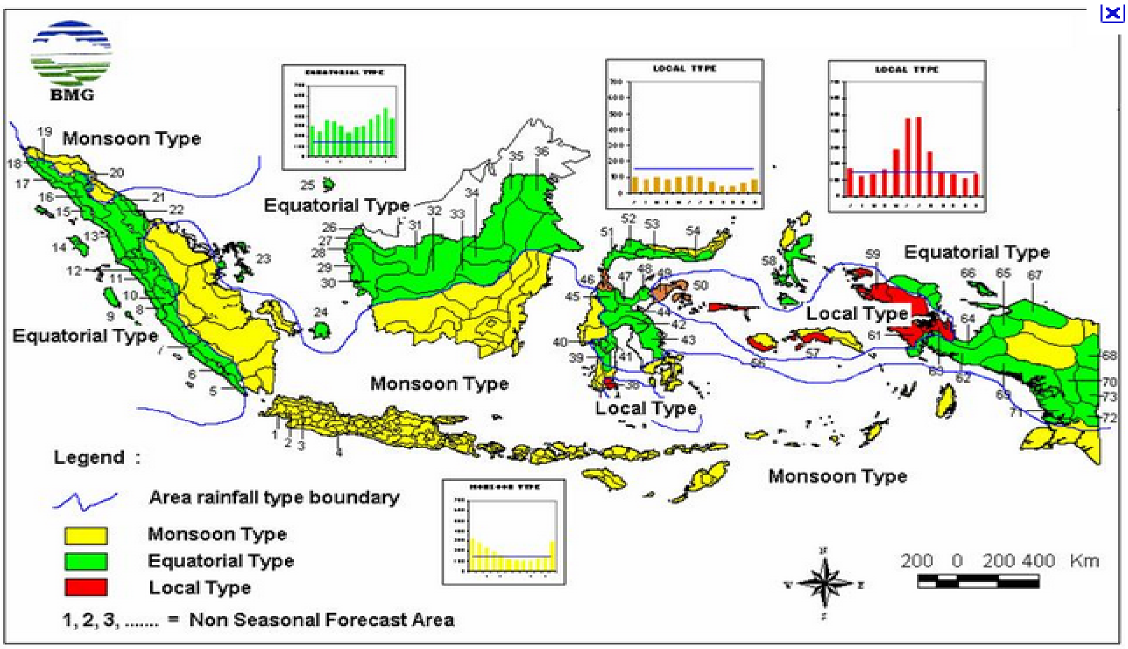


Figure 2.6 Rainfall types in Indonesia (source: BMG, 2007)

Regarding the Scientific Basis of Climate in Tarakan, which is prepared by Hadi, et.al (2010), the surface temperature and rainfall pattern are described as follows:

- The surface temperature changes in Tarakan are analyzed using UDEL temperature data for long-term changes (Figure 2.7), and presents simple trend analysis of ten-year averaged temperature. They found that, although there are relatively large fluctuations, the surface temperature of Tarakan is steadily increasing throughout 1901 to 2008. The rate of temperature increase is different for each month of the year. The largest increase was in March with a rate of about 0.03° C/decade, or about 0.3° throughout the 20th century. This value is much lower than the value estimated by Harger, 1995 in Hadi et.al, 2010, which is about 1.8° C/100 year. Moreover, there has been an increase of temperature (trend) of about 0.3° C/60 years (from 1940s to 2000s) or about 0.5° C/100 years. This result is comparable with our previous analysis of temperature trend in Indonesia, as well as IPCC's estimation of global temperature trend (Hadi et.al. 2010).

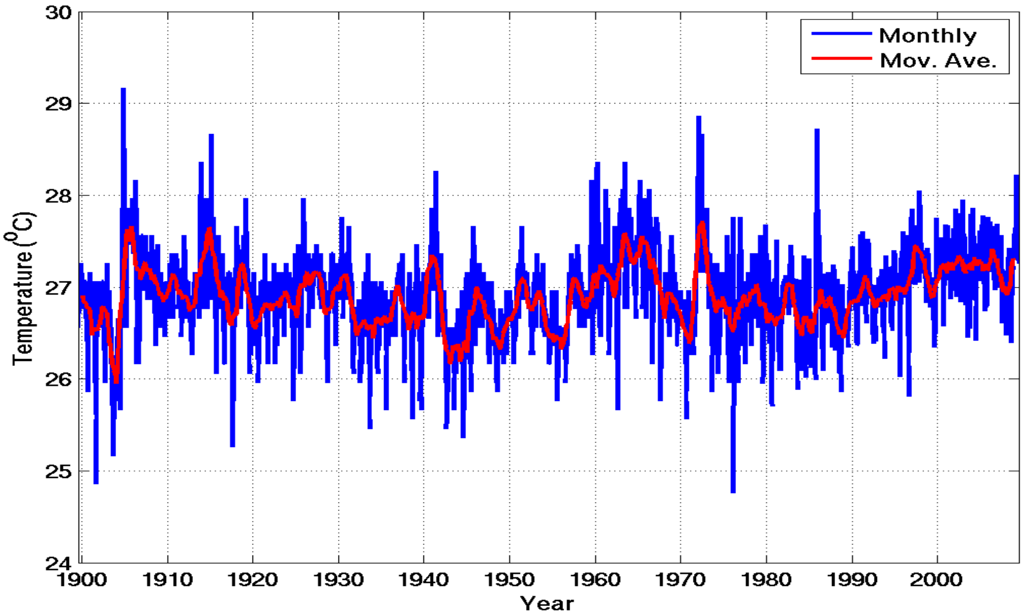


Figure 2.7 Time series of surface temperature at Tarakan from interpolation of University of Delaware (UDEL) global gridded temperature data (source: Hadi et., al., 2010)

- The rainfall pattern (see

-
-

- **Figure 2.8**) is described as follows:
  - Annual rainfall pattern over Tarakan has two peaks around April (338 mm monthly mean temperature/mmt) and November, with the highest value of rainfall occurs in November (360 mm mmt), while February (252 mm mmt) is the driest, as well as the coolest month in a year (
  -
  -
  - **Figure 2.8**);
  - On inter annual time scale, strong El Nino events are correlated with drought as indicated by the correlations between the SPI (Standard Precipitation Index) and MEI (Multivariate ENSO Index), but the role of IOD (Indian Ocean Dipole) phenomena is not important. However, it is interesting to note that the wettest climate in Tarakan tends to occur when both ENSO (El Nino Southern Oscillations) and IOD activities are weak. In other words, it can be said that the wettest climate over Tarakan occurs during the neutral phase, i.e. when both ENSO and IOD are not very active (indicated by positive SPI and almost zero values of the indices);
  - The inter decadal variations of rainfall indicate potential climate hazards, as illustrated by the data from 1960s, when the decadal mean of monthly rainfall during April-August decreased by an amount of approximately 100 mm compared to its long-term average. Data from other places near Tarakan confirm this finding;
  - Monthly mean surface temperature that is analyzed from the UDEL gridded data indicates that there is an increasing trend with the rate of about 0.3° C from 1900 to 2008. The estimated rate is higher, about 0.5° C/100 years if

calculated from 1940s. These results are comparable to the temperature trend in Indonesia from our previous studies;

- When flood and land-slide analyses are needed, model scenarios with extreme rainfall intensity of up to 100 mm/hour can be developed. The duration of these extreme rainfall events may not sustain for more than 2 hours.

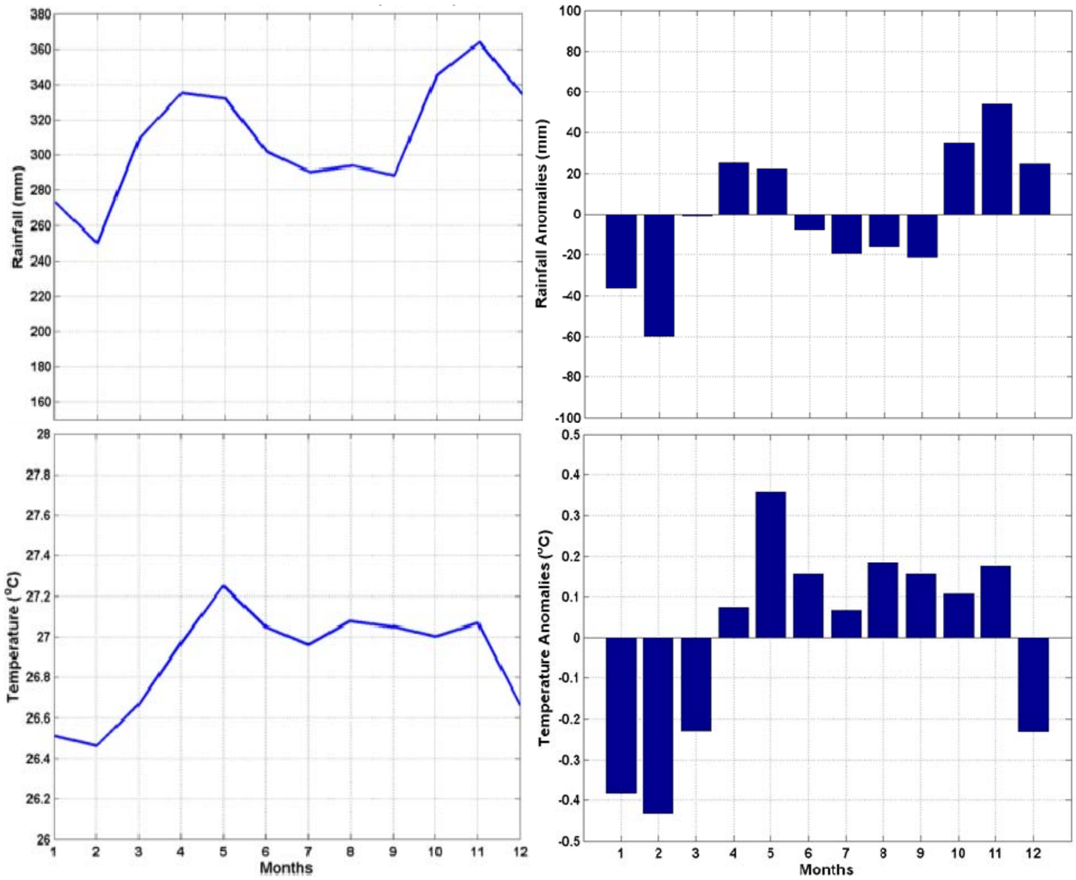


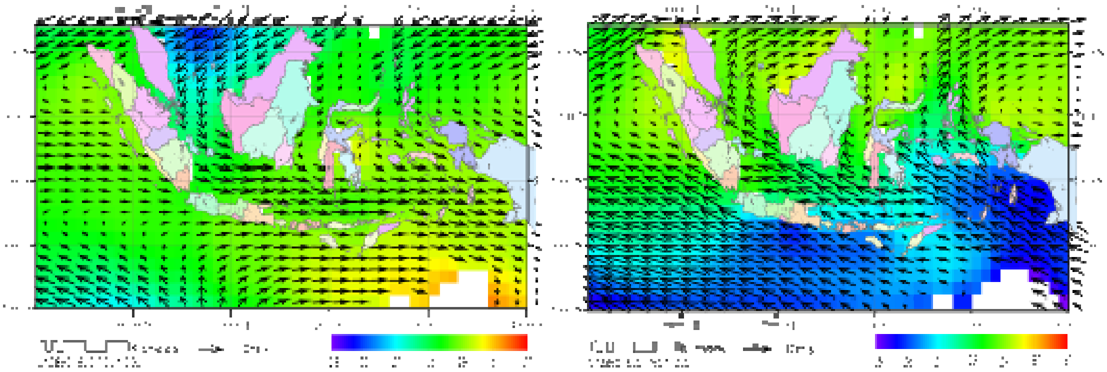
Figure 2.8 (A) and (B) are the annual patterns of rainfall and composite rainfall anomalies, while (C) and (D) are the annual patterns of temperature and composite temperature anomalies in Tarakan (Source: Hadi, et al, 2010).

2.1.6 Ocean Conditions

Ocean always interacts with the atmosphere through the mechanisms of heat transfer as well as energy and momentum. There are two forms of energy and momentum transfer: (1) surface winds that are wave propagation and ocean currents or movement (wave generation, where strong winds during storms or cyclones can cause a storm surge) and (2) interaction between ocean and atmosphere is realized by the interplay of surface wind (blowing just above the sea surface) and ocean surface currents. However, wind patterns and ocean currents are also influenced by other factors such as air and sea temperatures.

The wind circulation patterns and its changes

Indonesia is a maritime region between two oceans (Indian and Pacific Oceans) and two continents (Asia and Australia) so that the wind pattern is dominantly depend on monsoonal or seasonal pattern (Figure 2.9). In westerly wind (wind blowing from the west) from October to March, the weather conditions in Indonesia are influenced by the west monsoon, the wind blows from the northeast and turned toward the southeast after passing the equator. In contrast to the east wind season from May to September, the wind blows from the southeast and turn toward the northeast after passing through the equatorial region. The influence of Pacific Ocean become dominant in the period of western wind, except on most of western Sumatra, which is influenced by the characteristics of the western Indian Ocean. In contrast to the east wind season, the influence of Indian Ocean becomes dominant.



a. January b. August

Figure 2.9 Wind and average sea surface temperatures patterns in Indonesia in January and August (Sofian, 2009)

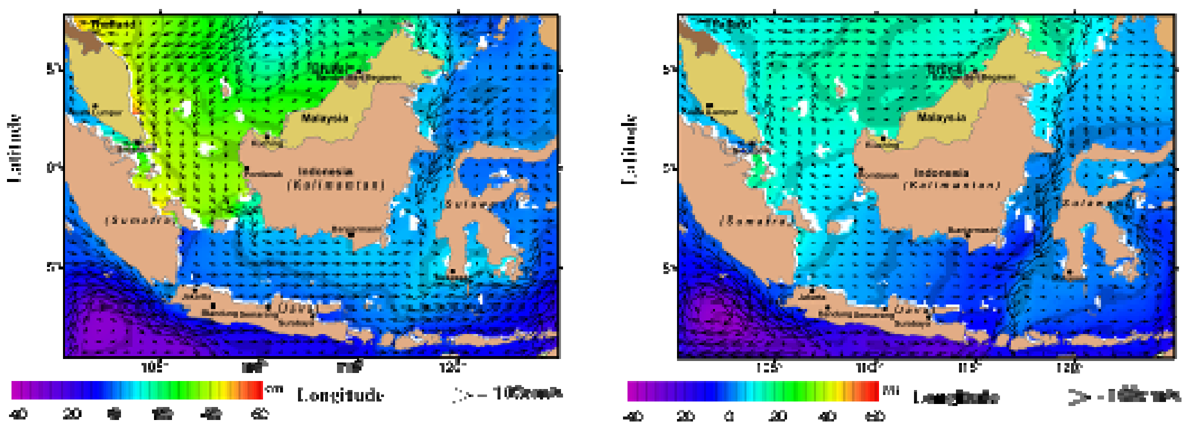
The propagation of north wind from October to March pushes the warm water of the Pacific Ocean to the Indian Ocean so most of Indonesian waters are warm. In contrast to the east season, from May to September the easterly wind pushes back the low temperatures water of the Indian Ocean to the Pacific Ocean through the Java Sea, Karimata Strait and South China Sea, so some of the waters in the southern Indonesia are colder than the north.

Ocean currents circulation patterns and its changes

In general, the Indonesian Throughflow pattern (ITF; Murray, Arief, 1988) can affect the characteristics of the global climate through the mechanism of heat transfer between the Pacific and Indian Oceans through the Makassar and Lombok Strait (Figure 2.10).

In January, when the west monsoon occurs, southwest wind causes the current in the Java Sea flows to the east, and the current in the Karimata Strait flows to the south. While the current in the Sunda Strait flows to the east and enter the Java Sea, carrying water mass from the Indian Ocean to Java Sea. The effect of topography with shrinking and shallowing in the depth of southern part of Karimata Strait may lead to different sea level of 40 cm between the Java Sea and the Karimata Strait.

When the southeast monsoon or dry season occurs, the winds push the currents in the Java Sea to the west and the currents in the Karimata Strait to the north. Waters on the surface of Java Sea flows out to the Indian Ocean through the Sunda Strait.



a. January b. August

Figure 2.10 Distribution of sea water level and flow pattern in January and August. Sea water level and flow pattern above are the monthly average for 7 years, from 1993 to 1999 (Sofian, 2009).

Unlike the flow pattern in the Java Sea and the Karimata Strait, surface currents in the Makassar Strait do not follow in the pattern of seasonal wind direction. These currents tend to move to the south. The speed of surface currents in the Makassar Strait is low in the west wind, though the north wind is very intensive. Weak flow in Makassar Strait surface is caused by the strong currents in the Java Sea surface which moves to the east, thus blocking the current flow in the Makassar Strait surface. In contrast, the surface currents in the Makassar Strait will be strengthened in the dry season (south-east wind), and encourage saline surface water and low-temperature back to the Java Sea. Strong surface currents in the Makassar Strait also cause decreases in sea level on the north coast of the Lombok Island, Flores Sea, and the eastern and central parts of Java Sea on August.

Characteristic of the Tides

Tides are the main hydrodynamic feature in Tarakan. The characteristic of tide at the region is semi-diurnal type, with the maximum level of 2.5-2.8 m as shown in Figure 2.11 (Ongkosongo, 2010) and Figure 2.12 (WX-Tide32). Furthermore the tide prediction in May, 2010 at Tarakan port (Figure 2.13) shows the tidal range is about 3 m.

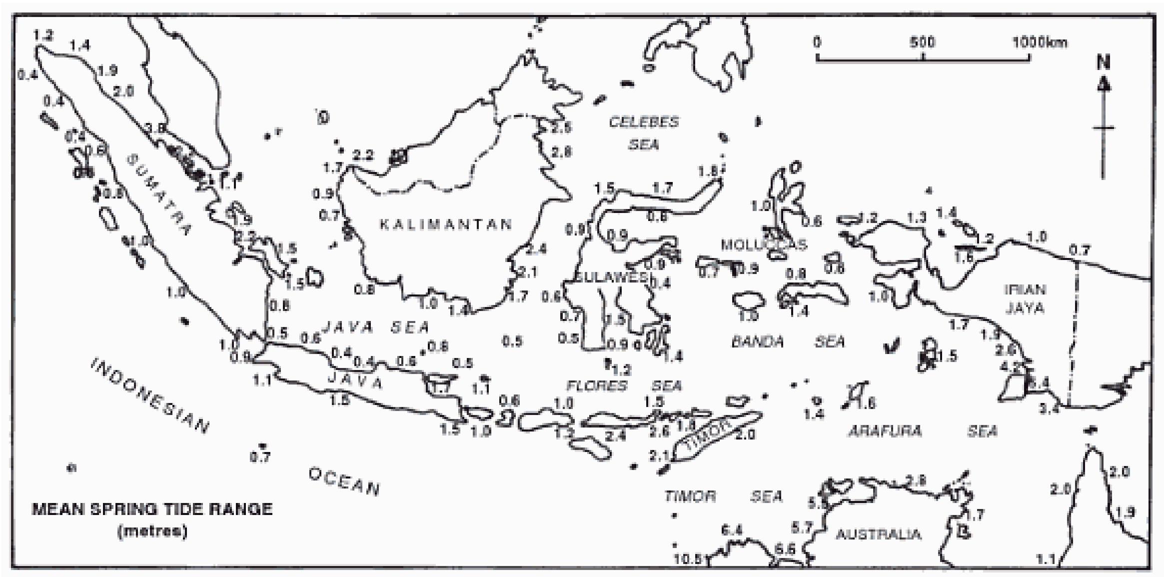


Figure 2.11 Variations of tide range around the Indonesian Archipelago (Courtesy of Geostadies in Ongkosongo, 2010)

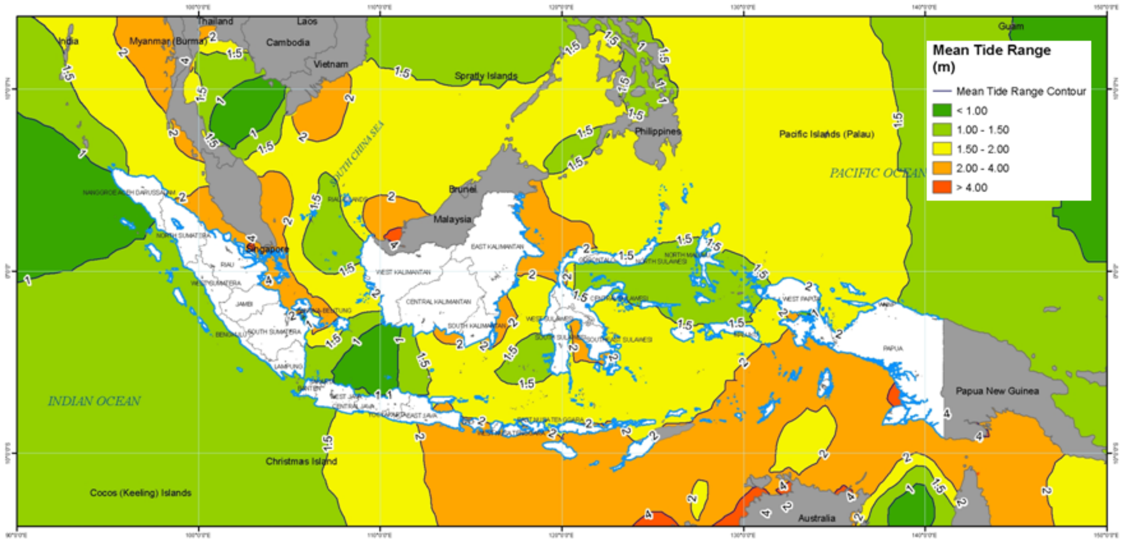


Figure 2.12 Variations of tide range around the Indonesian Archipelago
(Data source: WX-Tide32)

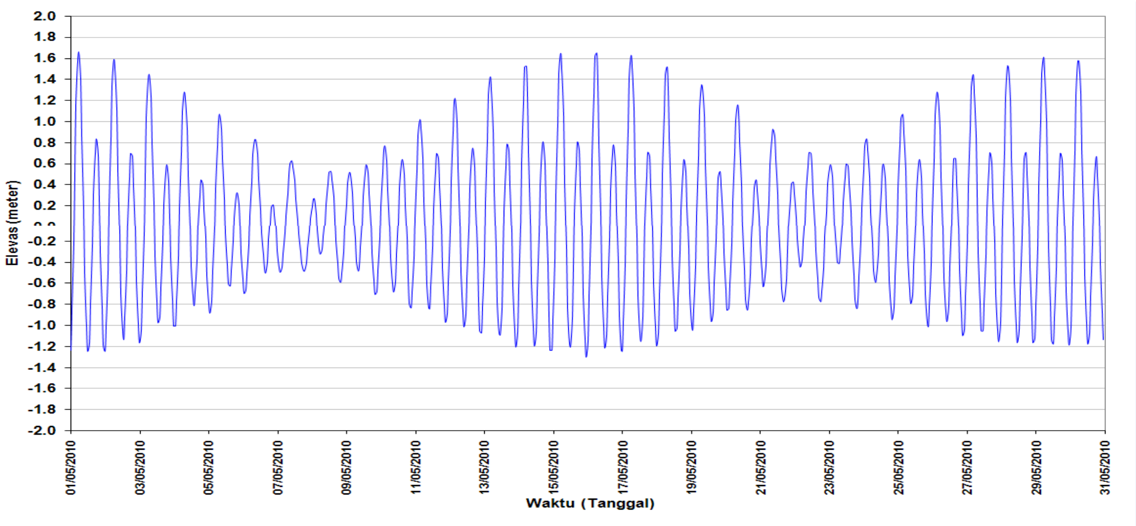


Figure 2.13 Prediction of tidal elevation at the Tarakan port in the period of May 1st-30th, 2010
(Data source: WX-Tide Version 4.70)

2.1.7 Topography and Bathymetry

The topography of Tarakan Island is characterized by the hilly ridge in the middle of the island which extends from the north coast to the south coast with elevation varies from 60 to 90 meter, where the maximum height is about 100 meters. While the western coast has a mild slope topography as well as on the eastern coast (see Figure 2.14), the topography slope in the eastern coast ramps until the bottom of the sea (bathymetry).

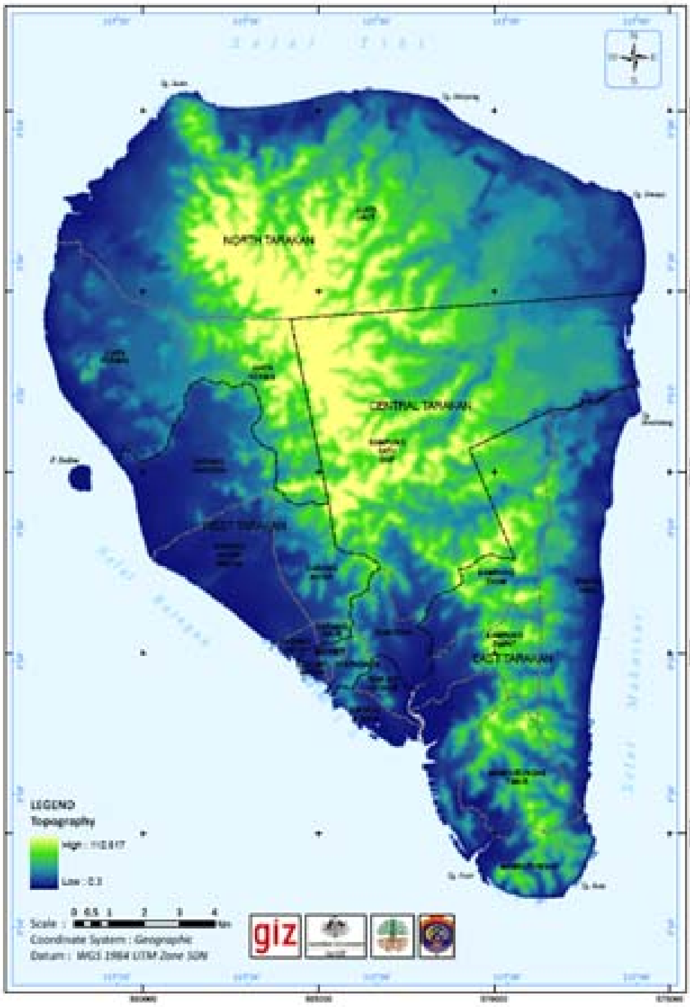


Figure 2.14 Topography map

A strait between the Kalimantan and Tarakan Islands shows a former ancient river which is constantly parallel with the coastline toward to the south, with water depths of 6 to 9 meter, and then turned to the east toward the Sulawesi Sea, with water depth increases from approximately 25 to 40 meter with channel width about 1.5 km. As well as on the north Tarakan, the bathymetry also shows the channel of the river that flows from the inland of Sasayap Lama, with the depth at north Tarakan about 5 to 10 meter. And then toward Sulawesi Sea with depth varies between 7 and 14 meter, the channel width of about 1 km. While the bathymetry in the eastern part of Tarakan Island is very mild and continuous up to the continental edge of Kalimantan, the water depth in eastern Tarakan is very shallow of about 2 to 6 meter form MSL (see Figure 2.15).

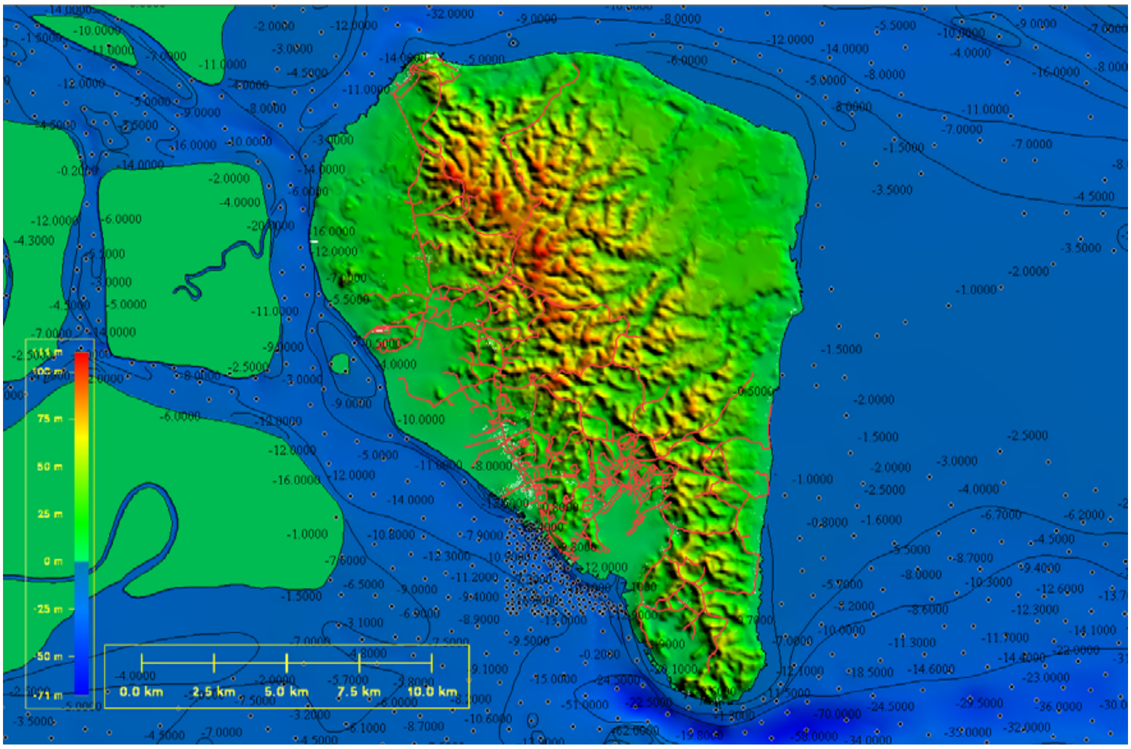


Figure 2.15 Bathymetry map of Tarakan and its surrounding areas

2.1.8 Geology, Geomorphology, and Landform

Prior to geological condition, it is important to identify the morphological condition of the site since morphology is strongly controlled by the geological condition. The morphology, which is a qualitative description of land form of a site, is accompanied with quantitative description of its slopes (Figure 2.16). Furthermore, all these physical conditions will lead to the predictive condition of coastal flooding and erosion. The slopes condition itself will be one of the physical vulnerability components of the site, which is related to the hazards of coastal sector.

In general, the Tarakan Island consists of flatland or plain and surrounded by coastal part and highland which is distributed from the north to the south in the middle of the island. The morphology of the site is divided into 3 (three) units as follow:

1) *Flatland or plain*. This plain is formed by coastal alluvial sediments (mud, silt, sand, gravel and coral) and usually located in coastal areas. It is a relatively flat area with fine relief (1-2 m), low elevation (0-10 m above sea level/m.asl), and slopes less than 5%;
2) *Wavy terrain.* This unit is formed by the Sajau Formation (quartz sandstone, clay stone, siltstone, coal, lignite, and conglomerate) and distributed in the western, southern, and eastern part of the island. It is relatively flat with a rough relief between 1-5 m in low elevation (10-25 m asl) and 5 to 10% slope;
3) *Hills*. It has fine coarse reliefs (5-50 m) at elevation of 25-100 m ASL and slope of 5% to more than 15%. Characterized by rocks of Sajau Formation lithologies and river flow of sub-dendritic and sub-parallel pattern sand partly seasonal flow.

In this quantitative and spatial distribution map, slopes of the site are divided into four groups: 1) Slopes more than 15%, light green-coloured, 2) Slopes between 10-15%, yellow coloured, 3) Slopes between 5-10%, brown-coloured, and 4) Slopes less than 5%, red-coloured.

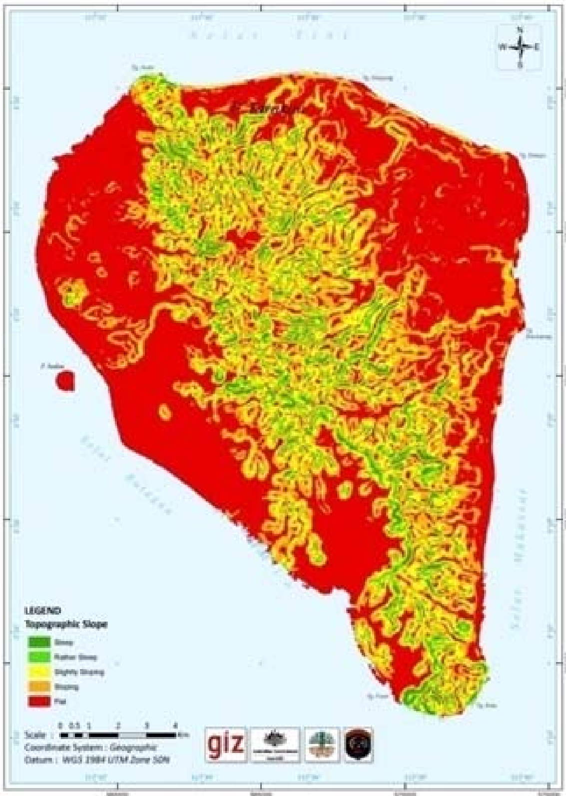


Figure 2.16 Topography map of Tarakan

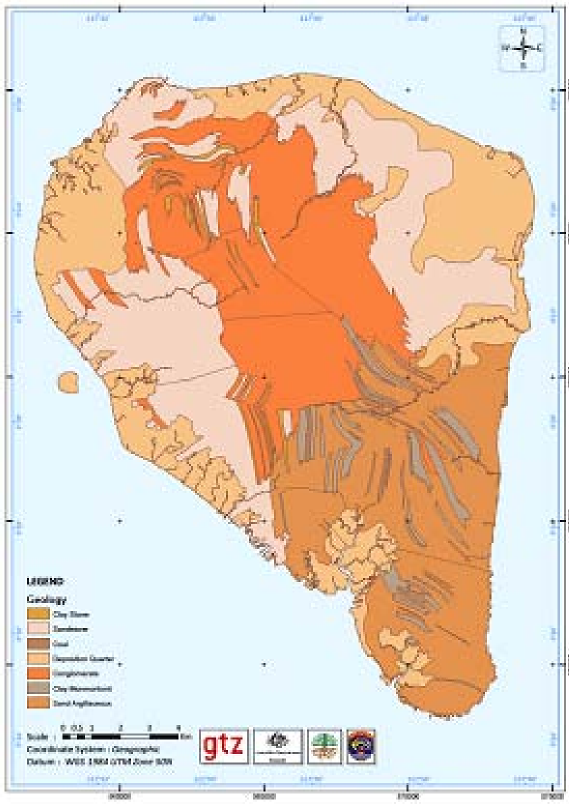


Figure 2.17 Geological map of Tarakan

In general, the geological condition of the site (Figure 2.17) consists of Sajau Formation, which is older and consolidated rocks, and alluvial unit which is younger and mostly unconsolidated rock. Vertically and laterally these two major unit areas are as follow:

1) Aluvium unit. This unit consists of mud, silt, sand, gravel, and coral. The rock is sediment products of quarter time of coastal, rivers, and swamps depositional environment distributed over the western and eastern of Tarakan Island;

2) Sajau Formation. This formation consists of quartz sandstone, clay stone, silt stone, coal, lignite, and conglomerate. It is Plio-Pleistocene-old sediments and deposited in the fluvial to delta environment with a thickness of 600 - 2000 meters. Its distribution is located in the north, central, and southern regions of the site.

It can be seen from the map, that the geological condition of Tarakan City consists of: (1) Claystone, Sajau Formation (light brown-coloured), (2) Sandstone, Sajau Formation (very light brown-coloured), (3) Coal, Sajau Formation (darker brown-coloured), (4) Quarter deposites or Alluvial units (darker orange-coloured), (5) Conglomerate, Sajau Formation (orange coloured), (6) Monmorilonite clay, Sajau Formation (darker tan-coloured), and (7) Argilaceous sand, Sajau Formation (brown coloured).

The geological structures of the site are bedding, faults, folds or anticline, and rock joints. In general, the fault trend of west east dip cut is anticline axis and fault lithology of Sajau Formation.

The old structures are anticline and syncline, elongated from the north to the south of the axis direction. The structure can be found in rocks that are strongly folded. By considering the geological conditions, it can be predicted that alluvium rocks unit and Sajau formation are more vulnerable to abrasion due to wind waves and inundation of sea level rise compare to the coastal rock and sand materials.

2.1.9 Land Use

Land use is a significant parameter to analyze the vulnerability and risk due to coastal hazards. Changes of land use as well as population growth and inhabitants' activities and their developments give consequences of vulnerability and risk on the coastal sector. Physically, changes of land use from natural area into man-made area which often found in urban regions, especially in the coastal zone, will increase the number of losses in term of economical point of view and reduce the capacity against coastal hazards, such as removal of coastal forest, mangrove and dune, and also give pressure to the coral reef. The change of land use will increase run off, flood events, and sediment supply from inland to the coastal areas and then can affect coastal system (i.e. biotic and ecosystem). This change can also extend the present of degraded area caused by land erosion which increase river sedimentation. Hence the existing land use needs to be considered in the assessment.

LAND USE MAP 2010 MAP

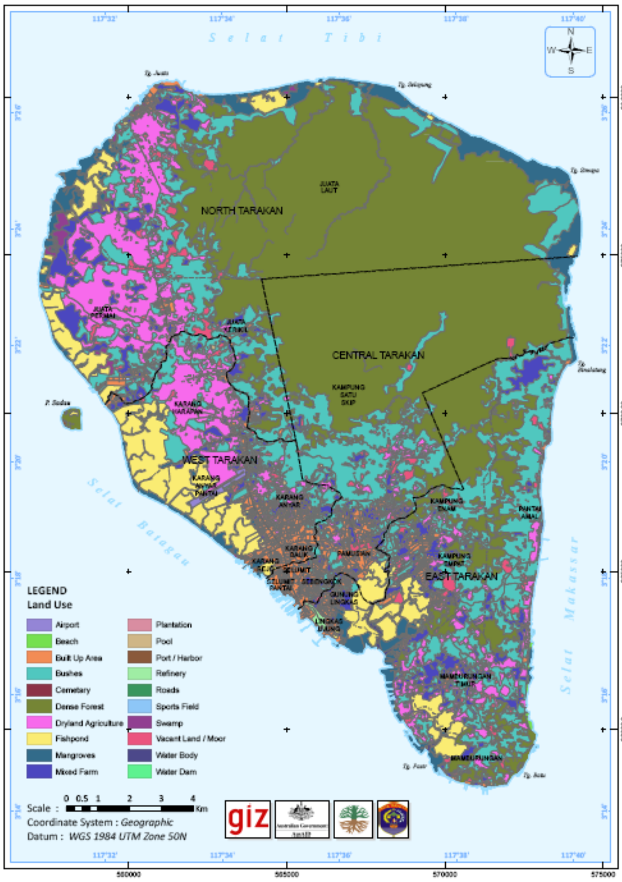


Figure 2.18 Land use map of Tarakan City
(Source: GIS team)

Map of land use, which is shown in Figure 2.18, is arranged by the GIS (geographic information system) team based on data from the Bappeda of Tarakan City. In this map, the land use of Tarakan City is divided into 22 groups. Twelve of widely distributed areas among these groups of land use are (see Figure 2.18): 1) Dense forests (dark-green coloured), 2) Bushes (light-green coloured); 3) Vacant lands/Moore (light-pink coloured), 4) Fish ponds (sky-blue coloured); 5) Dry land agriculture (dark-pink coloured), 6) Mangrove (lime coloured), 7) Plantations (dark-red coloured), 8) Built up area or Settlements (rose coloured), 9) Mixed farms (dark-aqua coloured), 10) Swamps (blue coloured), 11) Water bodies (light-blue coloured), and 12) Beaches (light-yellow coloured). The rests are infrastructures such as water dams, air port, final disposal areas, navy compounds, pools, port/harbor, refinery, roads, and sport fields.

2.2 Coastal Zone Description

The description of Tarakan coastal areas as highly prone zones to climate-induced hazards led to an increasing attention of the coastal risks due to sea level rise and attempts to understand and adapting them on the side of government and administrations. Therefore, it is crucial to assign these descriptions of Tarakan into the framework of coastal zone system. This framework is used for the next discussion to describe and identify similarities as well as differences characteristics of all sides of the Tarakan coastal areas.

The coastal zone is difficult to define clearly due to the dynamic nature of the coast. The simplest definition is the coast can be thought of an interaction area between the land and the ocean. *Ketchum (1972)* defined the coastal zone as: “A band of dry land and adjacent ocean space (water and submerged land) in which terrestrial processes and land use directly affect oceanic processes and uses, and vice versa”.

Regarding to the ***IPCC AR4 WG2-Ch.6 (Nicholls, R.J., et.al, 2007)***, the coastal and low-lying areas consist of two systems such as: natural and societal sub-systems, depicted as the dashed-line circle in Figure 2.19. The natural sub-system consists of land forms, such as beaches, rocky shorelines and cliffed coasts, deltas, estuaries, and lagoons, and the ecosystems contained within it, such as mangroves, salt marshes and sea grasses, and coral reefs; while the societal sub-system consists of infrastructures and human, including their activities. Both sub-systems are highly vulnerable to the hazards of climate change through some climate stimuli such as: global sea level rise, temperature rise, and the increase of CO_2 concentration (Figure 2.19).

The global increase of sea level contributes to the increase of coastal inundation, erosion, and loses of ecosystems. The temperature rise stimulus affects the quantity of global sea level rise and the associated coastal retreat, more frequent coral bleaching and mortality, intensification of tropical and extra-tropical cyclones, larger extreme waves and storm surges, alters precipitation/run-off, and ocean acidification and ENSO.

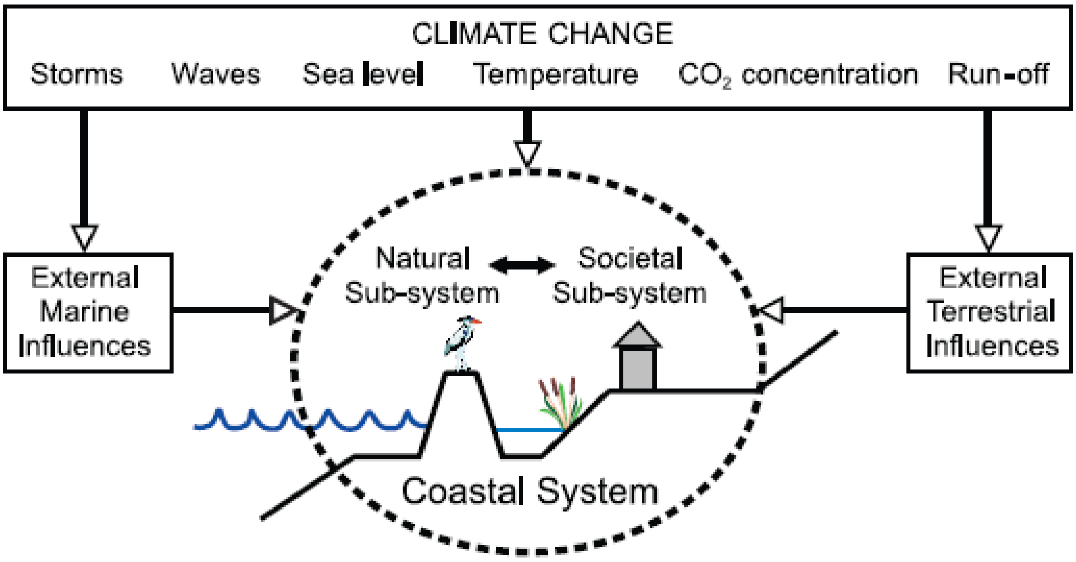


Figure 2.19 Climate change and the coastal system, showing the major climate change factors, including external marine and terrestrial influences (Nicholls, R.J.,et.al, IPCC AR4, 2007 WG2-Ch.6)

In the other side, the coastal zone of Tarakan itself can be considered as a set of relatively contrast areas in term of land uses. For instance, the area in the south-western coasts is intensively developed, such as: urban areas, port systems, and industry, fishing and oil exploitation activities. On the other hand, the eastern and northern coasts have a low population density and well-preserved ecosystems of great environmental value, which recently become a focus for seaside tourism resorts.

Natural disasters, induced by climate change, are one of most severe problems in the coastal area of Tarakan. In particular, low-lying areas, which are strongly affected by flooding in the west coast or by active processes of shoreline erosion and sedimentation in the east coast, pose the most serious consequences for local communities in the future. Functions and values of the coastal system have been degraded. These problems could be accentuated due to the rapid increase of population pressures, which often lead to inconsiderate or poorly planned development in natural hazard-prone areas.

2.3 Identification of Problem, Strategic Issues in Coastal Sector, Climate Change and Development

2.3.1 Identification of Problem Related to Climate Change

The global rise of sea level, temperature rise, the increase of CO_2 concentration are the hazards stress in the coastal system, directly and indirectly through external terrestrial and marine influences (Nicholls, R.J., et.al, IPCC AR4, 2007 WG2-Ch.6, see Figure 2.19). The impacts are almost devastatingly negative, such as:

- The increase of sea surface temperature, resulting in more frequent coral bleaching events and extensive mortality;
- Increase of sedimentation, threatening the coastal wetland ecosystems;
- Degradation of coastal ecosystems (wetlands and coral reefs), seriously impacting the well-being of coastal societies;
- Increased flooding and degradation of freshwater, fisheries, and other resources, finally impacting people and its socio-economic system, causing lose of properties, natural resources, and environment.

The increasing numbers of people living in almost all parts of the Tarakan coastal areas increase the pressures dramatically. There are also additional stresses due to land-utilizations and hydrological changes in the catchment areas, which will reduce or increase sediment supply to the coast.

2.3.2 Strategic Issues Related to Climate Change

The very active and complex coastal areas dynamic is the origin of the processes of shoreline erosion and sedimentation in Tarakan coastal zone, which have direct and indirect consequences for the coastal communities. The coastal zone of Tarakan can also be described as a system which is affected by natural hazards and risks especially include coastal inundation, flooding and erosion, which can lead to loss of land, alteration of ecological characteristic, and severe property damages (Figure 2.20). In many opportunities, the dramatic effects of these negative impacts are reflected in numerous reports during the public consultation (June 2010). In the Tarakan Island, erosive processes have narrowed the beaches. In the East coast of Tarakan, successive erosion events have constantly affected the resident’s life, as shown in Figure 2.21.

Figure 2.20 Tidal plane during low tide, (Courtesy: Asep Sofyan, 2010)

Figure 2.21 Coastal erosion at the eastern coast (Courtesy: Asep Sofyan, 2010)

2.3.3 Strategic Issues Related to Development Planning

Assessment of coastal sector in Tarakan City could not be separated from the development planning, especially Spatial Planning that has been being developed by the City Government recently for the time span 2010 – 2029. Spatial Pattern Map is developed under the framework of the Spatial Plan (see Figure 2.22), by which projection of land use in 2030 are defined.

LAND USE MAP 2030 MAP

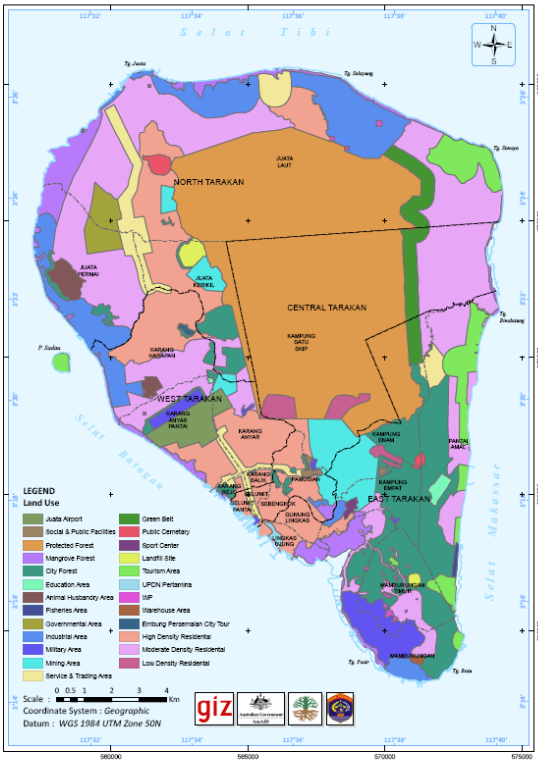


Figure 2.22 Land use map 2030 of Tarakan City according to Spatial Pattern of RTRW (Source: GIS team)

Some projected land use parameters are comparable to the current ones, e.g.:

- Protected forests, city forests, and green belts that are division of existing dense forests;
- High, moderate, and low density residentials, as well as some areas of education, governmental, industrial, service & trading, warehouse, tourism, and social & public facilities that are all separation of existing built area or settlements;
- Fisheries area is referred to fish ponds;

Meanwhile, other land use parameters are still exist such as mangrove, water dams, air port, landfill sites, navy or military areas, port/harbor, mining area (refinery), and sport centers (sport fields). In addition, there are several land use parameters (e.g., bushes, vacant lands/moore, plantations, dry land agriculture, mixed farms, swamps, water bodies, and beaches) that are converted into other usages.

This development plan also refers to the demographic population that is projected into the time frame of this assessment as well as of the spatial planning, i.e. 2030 (see Table 2.3 and Figure 2.23). Population projection of each village in Tarakan in 2030 is calculated based on population growth rate of Tarakan City between 2000 and 2010, which is 5,14% per year. Population density is then calculated and plotted into a map in Figure 2.24.

Table 2.3 Projected population for each sub-district and villages

Sub-districts	Villages	Area (Km^2)	Number of Projected Population 2030
East Tarakan		**58.01**	**111,209**
	Lingkas Ujung	1.16	26,978
	Gunung Lingkas	3.19	20,488
	Mamburungan	18.90	19,783
	Kampung Empat	11.39	11,738
	Kampung Enam	23.37	14,081
	Mamburungan Timur		6,560
	Pantai Amal		11,583
Central Tarakan		**55.54**	156,534
	Selumit Pantai	0.48	42,368
	Selumit	0.43	16,821
	Sebengkok	1.48	38,926
	Pamusian	2.54	36,624
	Kampung Satu Skip	50.61	21,797
West Tarakan		**27.89**	175,746
	Karang Balik	0.76	20,410
	Karang Rejo	0.80	17,769
	Karang Anyar	5.61	71,462
	Karang Anyar Pantai	8.51	46,354
	Karang Harapan	12.21	19,752
North Tarakan		**109.36**	56,975
	Juata Permai	10.59	17,824
	Juata Kerikil	14.23	12,192
	Juata laut	84.54	26,957
Total		**250.8**	**500,467**

Source: Dynamic Vulnerability, 2011

2030 MAP OF POPULATION MAP OF VILLAGE ADMINISTRATION BOUNDARY

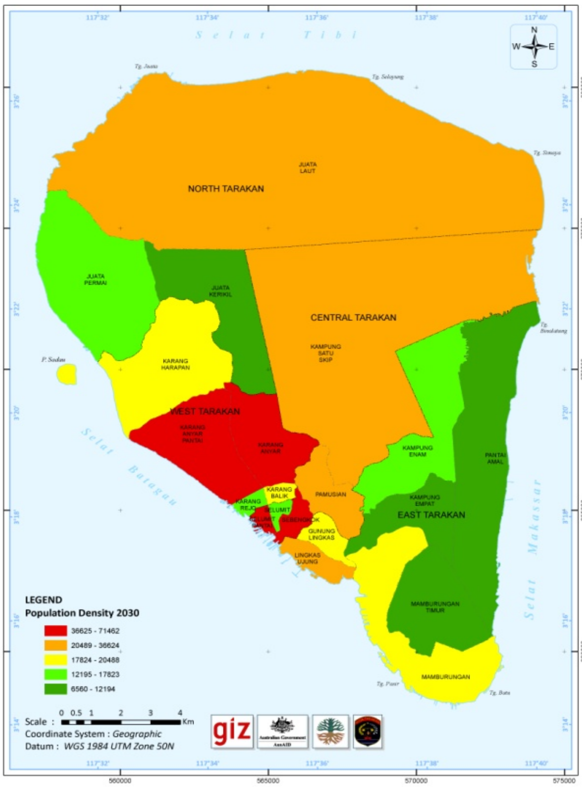


Figure 2.23 Population map on village administration 2030

POPULATION DENSITY 2030 MAP

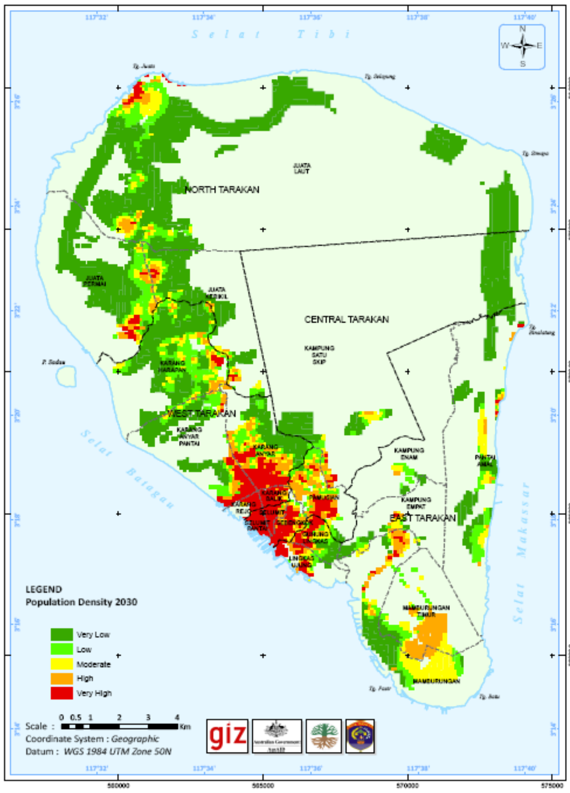


Figure 2.24 Population Density 2030

Chapter III Methodology of Assessment

3.1 Framework of Methodology

Since the climate change will not introduce any new types of coastal hazards, but it will affect and increase the existing hazards, and as development of coastal areas and property values increase, the risks (potential impacts) of coastal hazards increase, so that the methodological is used is Risk Assessment Approach as usually used in Disaster Risk Reduction as follows:

RISK (Potential Impact) = Hazards x Vulnerability

where the key hazards and vulnerabilities are listed in Table 3.1. In the aim to analysis the potential impact of climate change in coastal area, this assessment will implement an integrated inter-sectoral approach consisting of six primary steps as given Preuss, J. (2007) with some modifications, such as:

- Definition the Boundaries of the Assessment Area
- Assumption about Future Trends
- Analysis of Hazards
- Analysis of Vulnerabilities
- Analysis of Risks
- Adaptation Formulation

All steps will be described in the following sections.

Table 3.1 Phase of assessment and problem identification

Phase	Part	Problem Identification
Hazard Vulnerability and Risk Assessments	Definition boundaries of assessment area	• coastline and offshore limits of interest; • water bodies (rivers, lakes) • topography; bathymetry • major ecosystem features (forests, dunes, others); • major transportation • land uses • Ecosystems.
	Hazard identification and analysis	Identify key hazards: • Global Sea level rise • Wind waves • Severe storms • ENSO • Cyclones • Tsunami • Coastal Flooding • Coastal erosion
		Define incidence of previous disasters: • inundation boundaries; • other location indicators; and • General characteristics including, secondary effects such as location of scour, sediment transport and others.
	Vulnerability assessment	Identify and characterize impacts from prior events
		Correlate effects with coastal geometry:
		Ecosystem features (offshore and onshore): • Coral reefs • Sand dunes, berms, wetlands and marshes • bank erosion and scouring • forests, mangrove, and other vegetation
		Artificial features (land use and infrastructure): • Land use • Infrastructure • Interactions
	Risk assessment	Synthesis ("hot spots"):
		Calculate probability of occurrence:
Adaptation Strategy Planning	Identify adaptation tools	Engineered approaches: • Breakwaters and seawalls: • Dykes and levees: • Revetments
		Ecosystem management: • Preserve and enhance dune formation and sand bars: • Planned forests (porous barriers) • Wetlands
		Hybrid strategies:
	Selecting and evaluating integrative adaptation strategies	Integrative mitigation strategies:
		Adaptation concept
		Project status and evaluation considerations

3.2 Definition of Boundaries of Assessment Area in Tarakan

According to the Law No. 27, Year of 2007: Management of Coastal Regions and Small Islands, Article 2: The scope of Coastal Regions and Small Islands include the transitional area between marine and terrestrial ecosystems that are influenced by changes of land and sea, in the direction land covers an area of sub-district (*Kecamatan*) administration and towards the sea as far as 12 (twelve) nautical miles measured from the coastline. Base on the Law, so the administration boundaries are designed with district administration as unit analysis for Tarakan as shown in Figure 2.2. Furthermore the name of regencies, district and their area as listed in Table 2.1. However the level study of Tarakan is "***micro level-multi sectoral approach" (McLMSA),*** so that the administration unit of analysis is village boundaries.

The scale map for detail study is 1:20.000. Moreover a reconcile data sets for baseline variables and features for orientation which could include: coastline and offshore limits of interest; water bodies (rivers and lagoons); topography; major ecosystem features (forests, dunes, others); land uses and that possible impact of the communities and ecosystems. All data should be defined and collected.

3.3 Assumption about Future Trends

As mentioned above that the climate change will increase both magnitudes and frequencies of the existing hazards (such as: sea level rise, storms, La Nina, etc.), and development of coastal areas will increase the vulnerabilities (such as: population, land use, infrastructures, critical facilities, values of property, etc.). Increase of hazards and vulnerabilities will increase the potential impacts.

The phenomenon of hazards and vulnerabilities increased are highly complicated that it needs to be simplified by some assumptions for trends of the phenomenon in the future as follows:

- Trend of hazard will be calculated base on the IPCC scenarios, extrapolation of observation/ historical data, and model for current and future conditions of Year 2030.
- Trend of vulnerabilities:

- Trend of population is predicted base on the rate of population growth
- Trend of land use development is predicted base on the 2029 Spatial Planning of Tarakan.
- Trend of infrastructures and critical facilities are predicted base on the Short-Term Development Planning (RPJP), Long-Term Development Planning (RPJM), and Spatial Planning.
- Trend of property values is predicted may base on the economical growth.

Those trends of hazards and vulnerabilities above will be simulated with several scenarios of hazards and vulnerabilities to represent the current condition and the future condition of year 2030. The scenarios will be described in the next sections.

3.4 Analysis of Hazards and Data Availability

3.4.1 Introduction and Definition of Hazards

Coastal hazards induced by climate change tend to occur in the same area and exacerbate for each other, thus increasing the risk of repetitive loss from all hazards. For individual communities, occurrences to rare large-scale hazards such as storm surges, tidal surges (“rob”), ENSO (especially La Nina) and tsunamis are low (annually to decadal). On the other hand, medium and localized small-scale hazards such as floods due to rainfall, tide and wind waves might occur more frequently (daily, monthly to yearly). While coastal flooding or inundation due to sea-level rise is another type of hazard that has slow onset characteristic so that it would become real threat in the future but to be anticipated from today. It is noted that all these hazards could potentially be occur in Tarakan coastal areas, so they become elements of hazard to be assessed, except rainfall-triggered flood that will be considered in water sector. In cumulative manner, these all or some events may result in significant losses.

Threats of hazards vary within geomorphologic feature, such as: coastal areas and low laying areas and not all hazards constitute important threats to each community depending on their location, and characteristic and behavior of the hazards. It is therefore necessary to define hazards for further analysis and characterization.

The probability of specific hazards occurring in individual communities will differ depending on such variables as climate, geology, bathymetry/topography, coastal geometry and land-use patterns. For some hazards, the entire community will have similar susceptibility, such as from a cyclone and tsunami. For others, such as flooding/coastal flooding (from the rain fall and from the sea), some portions of the community may be impacted more than others; for example, low-lying areas are more susceptible to inundation. For this reason it is important to obtain maps for as many types of hazards as possible and to clearly delineate the specific characteristics and small-scale location based variables that will become important considerations when developing an adaptation strategy.

3.4.2 Hazards Model for Mapping

A hazard map is developed by a simple analytical model representing occurrence of cumulative hazards of flooding or inundation that could occur in coastal areas according to a scenario of condition. Mathematically, the model is presented as follows:

$$H = \sum_{i=1}^{N} h(i)$$

where: H is total coastal inundation hazard level above mean sea-level, h(i) is i-th level of each type of hazard (SLR, ENSO, surges, wind waves, tides, tsunami), and N is number of hazard type being assessed for each condition scenario. An illustration of this cumulative hazard model is depicted in Figure 3.1.

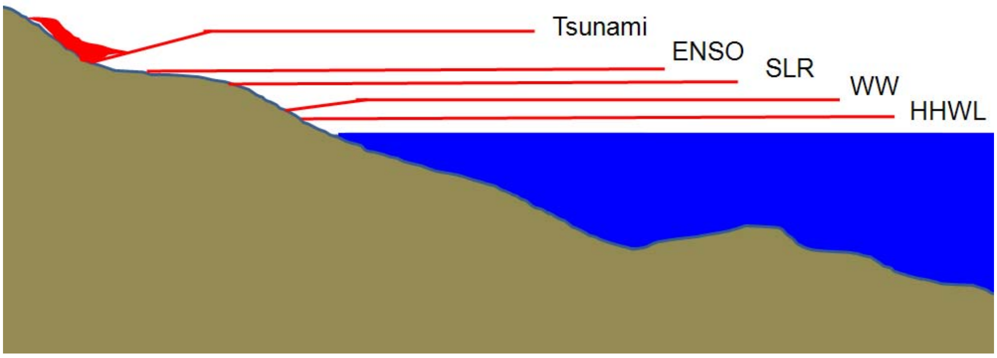


Figure 3.1 Elements of hazard induced by sea level change

In some cases the evidence of hazards may not be available in the map; therefore, it will be necessary to rely on qualitative information such as verbal histories through public hearing and field survey. For each hazard, variables could include to Inundation boundaries; location of abrasion, sediment transport and others. These ways such public consultation in Tarakan City has been done in June 2010 when this project introduced to the local government and field survey has been done in August 2010.

3.4.3 Hazards Data and their Sources

At most, input data for this hazard analysis of the coastal sector are obtained from the report of projections of sea-level rise and extreme events (Sofian, 2011) as listed in Table 3.1.

Table 3.2 Sea level hazard data and their sources

No.	Data of Hazards Elements	Length of data	Sources
1	Tidal Data of Tarakan		UHSLC (*University of Hawaii Sea Level Center*) (source:: http://uhslc.soest.hawaii.edu)
2	Indonesian Tidal Ranges data and variability of ENSO data		Roadmap of Mainstreaming Climate Change issues in the National Development Planning of Marine and Fisheries Sector, October, 2009
3	Altimetry Data		AVISO (Source: http://atoll-motu.aviso.oceanobs.com)
4	Projection of Sea Level Rise based on the A1B,A2 and B1 scenarios from the IPCC model-CGCM2.3.2 MRI, NIES:	2001 – 2100	WCRP CMIP3 multi-model database (Source: http://www-pcmdi.llnl.gov)

No.	Data of Hazards Elements	Length of data	Sources
	MIROC3_2-MED and CCCMA_CGCM3)		
5	Projection of Sea Surface Temperature based on the A1B,A2 and B1 scenarios from the IPCC model-CGCM2.3.2 MRI, NIES: MIROC3_2-MED andCCCMA_CGCM3)	2001 – 2100	WCRP CMIP3 multi-model database (Source: http://www-pcmdi.llnl.gov)
6	*ENSO Data*		Roadmap of Mainstreaming Climate Change issues into the National Development Planning of Marine and Fisheries Sector, October, 2009
7	Wind data		NCEP
8	Waves Prediction		Prediction from Wind Data by using SMB Method
9	*Significant Wave Height* (SWH) Data		AVISO (Source: http://atoll-motu.aviso.oceanobs.com)
10	Cyclone and Storm surges	1945 - 2009	
11	Tsunami		Pre-calculated tsunami Model (Latief, 2008)

3.5 Analysis of Vulnerabilities and Data Availability

3.5.1 Introduction and Definition of Vulnerability

Vulnerability is usually linked to a specific hazard or set of hazards and shows a clear separation between the *Natural* dimension - *"The susceptibility of resources to negative impacts from hazard events"* (NOAA, 1999 in Szlafsztein, C.F, **2005),**), and the *Socio-economic* dimension – *"The state of individuals, groups or communities characterized in terms of their capacity or ability to (i) be physically or emotionally wounded or hurt and (ii) anticipate, cope with, resist, and recover from the impact of natural hazards or unexpected changes placed on their livelihoods and well being"* (Adger and Kelly, 1999).

The objective of vulnerability assessment is to identify features that are susceptible to damage including ecosystems, artificial structures, societal variables (demographic profiles) and sites of potential human mortality.

Current conditions must be documented as benchmarks that can be compared with past land-use patterns or the future land use planning. To monitor trends, the documentation will identify changes that have occurred during a specified time period, for example, over the last 25 years. Land management practices that could influence the future will also be identified, for example, encroaching urbanization which threatens forested and coastal lands.

In term of assessment of climate change which is based on some projections to the future, it is essential to consider "future vulnerability" for the time of which the projections are referred. Due to dynamics of societal and demographic phenomena, we preferly use term of "dynamic vulnerability". In this assessment, reference of the projection is the time frame of the Longterm Development Planning and Spatial Planning, i.e., 2030 (see Figure 2.22). Therefore, the dynamic vulnerability of this assessment will describe the conditions in year 2030 with a major assumption of that all properties are developed as planned.

3.5.2 Vulnerabilities Data and their Sources

In this study the natural vulnerabilities are represented by topography and topography slope data, while the social and economical vulnerabilities are represented by the population, land use, infrastructure, utilities and transportation data. Moreover, the administrative data is used as boundary of study. Those data are collected from several sources as listed in Table 3.3.

Table 3.3 Vulnerabilities data and their sources

No.	Data	Length of data	Sources
1	Digital Elevation Model (DEM) Shuttle Radar Topography Mission (SRTM) of Tarakan area	2000	Global Land Cover Facility (Source: http://ftp.glcf.umd.edu/index.shtml)
2	Administration Boundaries Data		Bappeda of Tarakan City
3	Population Data		BPS (Podes)
4	Land- use Data		Bappeda of Tarakan City
5	Infrastructure Data		Bappeda of Tarakan City
6	Utilities and Transportation Data		Bappeda of Tarakan City
7	Spatial Pattern Data of 2029		Bappeda of Tarakan City

3.6 Analysis of Risk

Risk provides the basis for decision-making and institutional acceptance of protective measures. Risk is calculated by correlating information derived from the Hazard Assessment and the Vulnerability Assessment, i.e. **Hazard x Vulnerability = Risk**. The characteristics of risk are then analyzed in terms of estimated probability of occurrence, magnitude and incidence of losses, which can be calculated both in quantitative or qualitative terms.

Frequency of events is an important indicator of both past and future loss patterns. Because cumulative implications are important, the analysis must consider not only a large event such as a cyclone or tsunami, but also multiple and less severe events such as storms surges and tidal storms. Annualized losses over a ten- or 20-year time frame from lesser events may equal or even exceed the losses from a large event.

The probability of occurrence is based on frequency, as documented by historical records and scientific evidence. The time period for re-occurrence is based on criteria selected for a specific plan, for example over 20 years (following the RPJM), the frequency that an event may occur will be of high, medium or low probability.

Communities in close proximity to each other often have different probabilities of hazard occurrence. A comparison of two communities in the eastern and western portions of Tarakan illustrates similarities and differences in probable occurrences. Community at western Tarakan, is flat; prone to coastal and riverine and lagoon flooding, sedimentation from the big river and water pollution. Riverine flooding is often accompanied with extensive sediment transport and/or deposition. The probability of riverine flooding is high because the return period is annual. The historical experience of cyclones impacting Tarakan is low; the geological evidence indicates that the probability of another tsunami impacting the area is also low, because the frequency is very rarely greater than every 50 years.

Community at the east Tarakan, on the other hand, is characterized by variable flat area is prone to bank erosion, storm surge a coastal flooding due to the waves.

Some high probability events may have low consequence individually, but may occur many times each year. Over a 20- or 30-year period, losses such as from coastal erosion could be significant. Conversely, the consequences (losses) from a single cyclone or a tsunami would be high. The consequences from the more severe event may or may not exceed the more frequent lesser hazards.

Weighting of the consequences is therefore an important aspect of the risk assessment and the ensuing development of the adaptation strategy plan.

Comparison of characteristics and the approximate magnitude of potential loss under alternative event scenarios are important factors to help evaluate the consequences of various scenarios. The consequences should be evaluated in terms of the four variables identified during the Vulnerability Assessment: ecosystems, influences of geomorphology, and societal and economic variables (land use and infrastructure, existing protection (breakwaters, dykes, revetments, etc. demographic profiles, economic variables.

3.7 Adaptation Formulations

Adaptation formulation and strategy planning establishes the means to reduce the risk of losses. Such loss reduction is achieved through the application of adaptation tools and implementation strategies that address risk characteristics that are defined during the risk assessment. The adaptation phase consists of two parts: (i) Identify mitigation tools; (ii) evaluate and select mitigation tools as shown in Table 3.4.

Table 3.4 Adaptation strategic formulation and problem identification

Phase	Part	Problem Identification
Adaptation Strategy Planning	Identify adaptation tools	Engineered approaches: • Breakwaters and seawalls: • Dykes and levees: • Revetments
		Ecosystem management: • Enhance coral reefs: • Preserve and enhance dune formation and sand bars: • Planned forests (porous barriers) • Wetlands
		Hybrid strategies:
	Selecting and evaluating integrative adaptation	Integrative adaptation strategies:
		Adaptation concept

Phase	Part	Problem Identification
	strategies	Project status and evaluation considerations

A risk-based decision-making framework for adaptation formulations, following the cyclical steps in the diagram in Figure 3.1

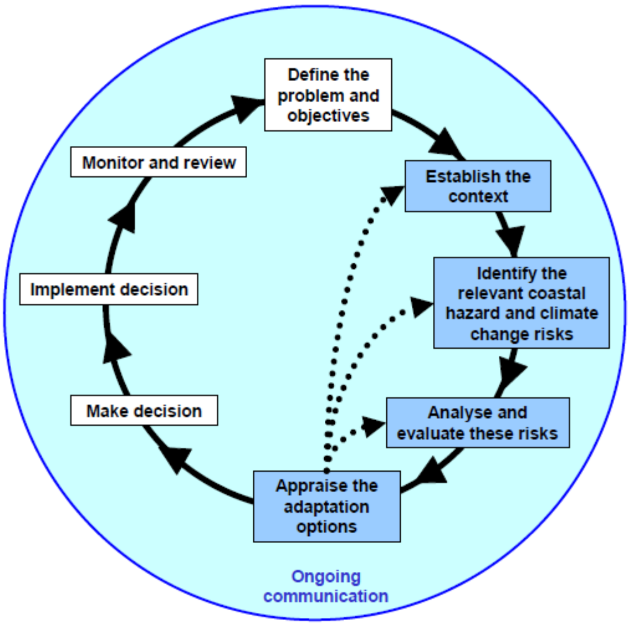


Figure 3.2 Diagram for decision-making framework for adaptation (Source: New Zealand CC Office)

Chapter IV Hazards Analysis

4.1 Elements of Hazard

As stated in point 3.4, this assessment analyzes global sea level rise, ENSO (especially La-Nina), wind-waves, cyclonic and storm surges, as well as tsunami as elements of hazard that could become threats to communities in Tarakan coastal areas.

4.1.1 Global Sea Level Rise

History of sea level rise could be analyzed from the long observed data that especially obtained by tide gauge and satellite altimetry. Near-term projection could be developed from this historical data, while long-term projection would be arised from some IPCC models.

4.1.1.1 Sea Level Changes from Tide Gauge data

The long recorded tidal data near Tarakan were obtained from database of the University of Hawaii Sea Level Center (UHSLC), such as Tawau and Sandakan (Malaysia), and Bitung (Indonesia), as shown in Figure 4.1. These data are analyzed to find the trend of sea level rise in Tarakan (see Figure 4.2). The rate of sea level rise at Tawau is about 5.0 mm/year, while ones at Sandakan and Bitung are about 4.5 mm/year and 6.2 mm/year, respectively.

Figure 4.1 Yellow circles depict the UHSLC Tidal stations.

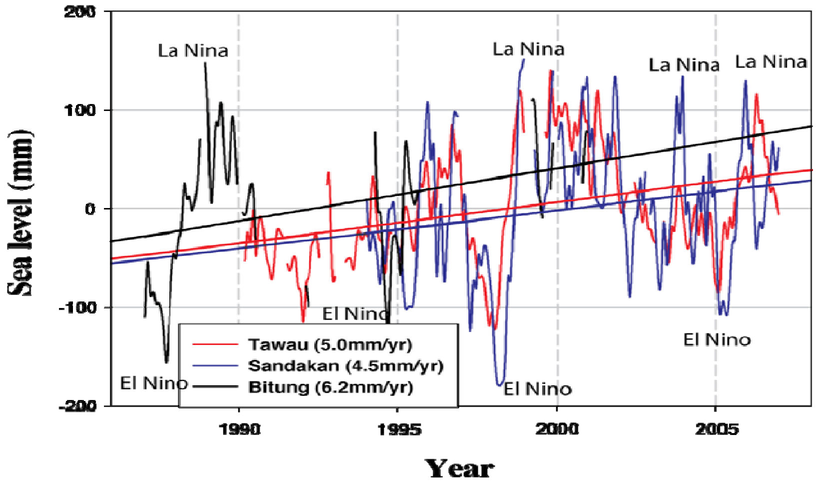


Figure 4.2 Data of uptrend tides for each tidal station in each region. Source data: http://uhslc.soest.hawaii.edu, 2010 (source: Sofian, 2010).

Based on these tide gauge data, the sea level rise at Tarakan is ranging from 4.5 mm/yr to 6.2mm/yr, with mean sea level rise of 5.4 mm. The sea level rise at the coast of Tarakan is higher than the global sea level rise, which is only 3.3mm/yr. However, the sea level rise at the coast of Tarakan is lower than the regional sea level rise that reaches 6mm/yr to 7mm/yr. If these trends continue, the sea level in 2030, 2050, 2080 and 2100 will rise 16.2cm, 43.2cm, and 54cm relative to the one in 2000, respectively (Sofian, 2010).

4.1.1.2 Sea Level Changes from Altimetry Data

Satellite altimetry data are used as historical data to complement the tidal data. The data are combination of data from satellite altimetry TOPEX/Poseidon (T/P), GFO, Enlist, ERS-1 and 2, and Jason. The aaltimeter-estimated of sea level from 1993 to mid-2009 is shown in Figure 4.3.

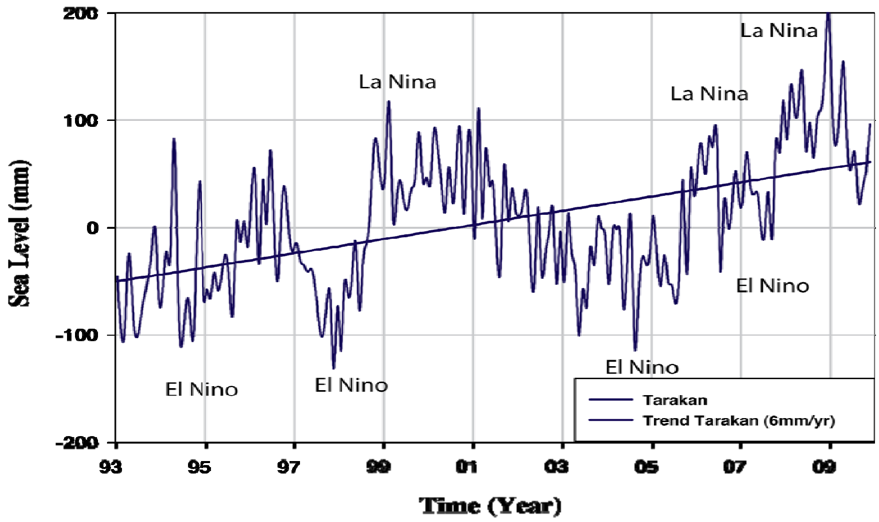


Figure 4.3 The time series of mean sea level based on the altimeter from 1993 to mid-2009 (source: Sofian, 2010)

4.1.1.3 Sea Level Changes from Projection Model

Projected sea level rise from the IPCC model: MRI-CGCM2.3.2 (Japan), NIES: MIROC3_2-MED (Japan), and GISS ER with the scenario SRES A1B, A2, and B1 from the WCRP CMIP3 multi-model databases is shown in Figure 4.4, Figure 4.5, and Figure 4.6 respectively. And summary of sea level rise and its projection for years of 2030, 2050, 2080 and 2100 are listed in Table 4.1.

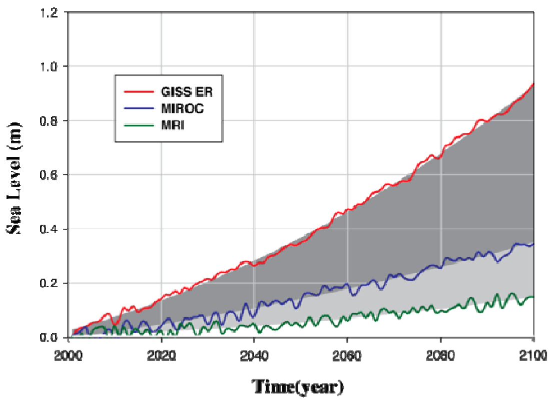


Figure 4.4 Projected sea level rise of SRES-A1B (Sofian, 2010)

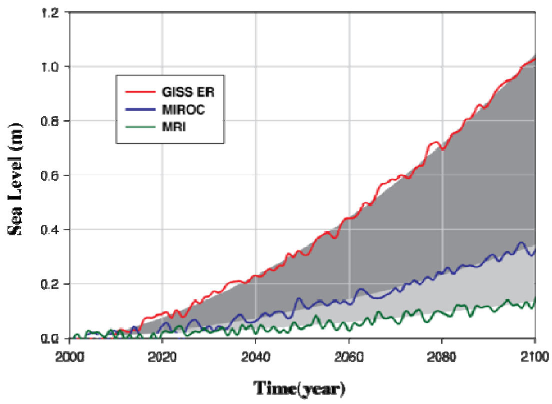


Figure 4.5 Projected sea level rise of SRES-A2 (Sofian, 2010)

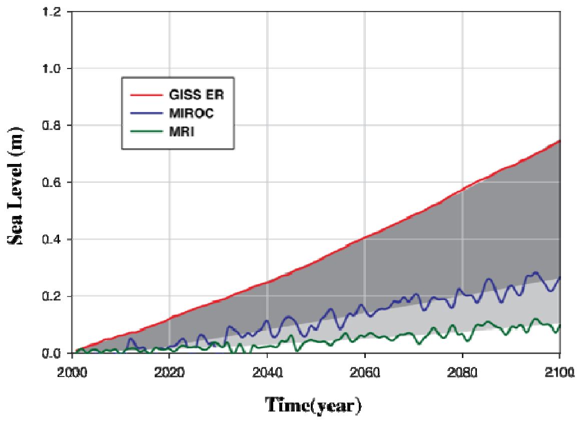


Figure 4.6 Projected sea level rise of SRES-B1 (Sofian, 2010)

Table 4.1 Projection of sea level rise based on the observational data and models

Year	Observation		Model			Unit	Level of Confident
	Tide Gauge	Altimeter	SRESA1B	SRESA2	SRESB1		
2030	16.2	18.0	14.7 ±6.25	10.0 ±5.0	12.0 ±6.0	cm	High
2050	27.0	30.0	26.0 ±11.0	22.0 ±11.0	22.5±10.5	cm	High
2080	43.0	48.0	48.0 ±22.0	48.5±23.5	39.0 ±18.0	cm	Very high
2100	54.0	60.0	65.5±28.5	70.0 ±35.0	50.5±22.5	cm	Very high

(Source: Sofian, 2010)

4.1.2 ENSO (El-Nino Southern Oscillations)

The sea level is highly affected by the ENSO. The sea level is high during La Nina and drops to the lowest level during the El Nino phase. The sea level is increasing more than 10 cm above the long-term mean, and 15 cm of decreases during the La Nina and El Nino phases, respectively (Figure 4.7). The Tarakan sea level response to the climate variability, such as the ENSO, is stronger than the SST. The low sea level is linked with the regional scale of warmpool movement from the Indonesian seas to the central Pacific Ocean, while the SST is more likely to link with the fresh water fluxes from the river that struggles the decreasing SST during the El Nino.

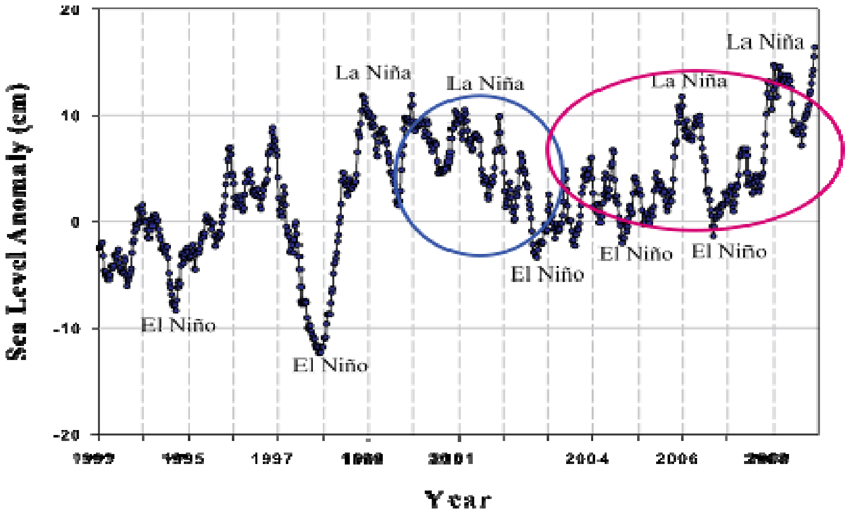


Figure 4.7 Time series of altimeter sea level anomalies (anomaly of SSL,1993 to 2008). SSL anomaly lowers down to 20 cm in strong El Niño period, and increases up 20cm in the strong La Niña period (Sofian, 2009).

4.1.3 Wind and Wind Waves

Generally, wind patterns in the Tarakan areas can be divided into four patterns, based on the existing season, as follows:

- West Monsoon Season (DJF): the wind was blowing predominantly from the north (37.54%), northeast (25.81%), and northwest (15.65%) with dominant velocity of 1-3 m/sec (61.95%), 3-5 m/sec (28.9%), and 5-7 m/sec (1.65%). This occurs because of the influence of the northeast trade winds where the wind comes from the high pressure area, in latitude 30^0 N, to the low pressure region at the equator.
- Transitional Season I (MAM): the influence of the movement of the sun from the south to the north in March, April, and May resulted in changes of the direction from where the wind was coming. In the area of Tarakan, within the transition season, a season domination of the west wind decreases with the composition of the wind, with a direction of northeast (72.07%), north (11.45%), and east (11.79%). In terms of wind speed in the transition season, it also shows that there is a reduction of the season in which the percentage of the west monsoon winds blow at the speed of 3-5 m/sec, decreased from 28.9% to 11.45%, while

the percentage of wind speed in the range of 1-3 m/sec increased to 72.07%, and the range of 5-7 m/sec decreased to 0.44%. Meanwhile the most dominant speed in the range of 1-3 m/sec is 72.07%.

- East Monsoon Season (JJA): changes in the pattern of wind direction from the west monsoon to the transition can be seen in the east monsoon season, where the dominance of the wind coming from the south (21.23%), southwest (14.75%), and southeast (14.09%) exceeded the percentage of wind that comes from the high latitudes. This occurs because of the effect of the southeast trade winds, where the high pressure area formed on the 30^0S latitude. Wind speed was also reduced in the east monsoon season compared with the west monsoon season. For example, the speed range of 3-5 m/sec reaches 10.81% from 09.28%, range of 1-3 m/sec increased to 71.10% from 61.95%, and the range of 5-7 m/sec was reduced to 0.51%.
- Transitional Season 2 (SON): the iinfluence of the movement of the sun from the north to the south in September, October, and November resulted in the changes of the direction where the wind was coming. In Tarakan, within this transitional season, the domination of east monsoon winds are reduced and replaced by winds from the northeast (16.19%), north (15.34%), and southwest (11.25%).

Annual wind-rose pattern for the total wind data during 11 years (Figure 4.8) shows that the northeast wind is the dominant wind, with a frequency of occurrence reaches 19.67%, followed by a second one from the north, with an occurrence frequency of 18.78%, while the north and south wind have frequency of 14.15% and 12.62%, respectively. Dominant speed is in the range of 1-3 m/sec with a frequency of 69.20%. Thus, wind speed in the range of frequencies above only happens in relatively small number, for example the frequency is only 0.84% in the wind speed range of 5-7 m /sec.

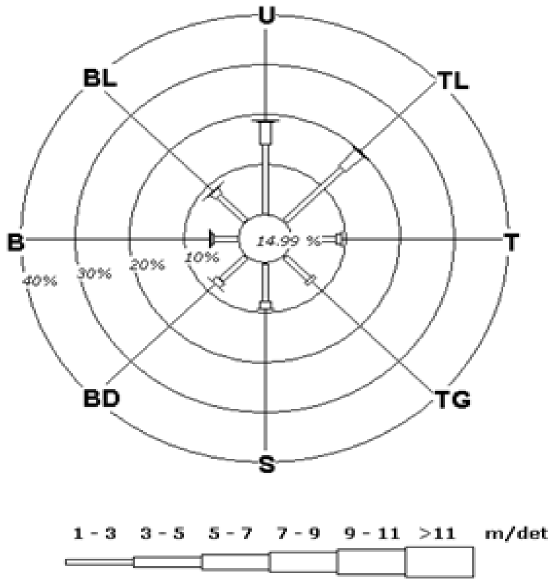


Figure 4.8 Windrose of Tarakan (period of data 1999-2009)

Waves in the surrounding of Tarakan are mainly generated by local winds. Ocean swells moves from the Sulawesi Sea to the Tarakan coast and West Pacific Ocean. The wave pattern in the Tarakan waters and its surrounding area were analyzed based on the wave prediction by using the SMB (Svedrup, Munk and Breitchneider) method.

The pattern of waves can be divided into four conditions regarding to the existing season, such as:

- West Monsoon (DJF): wave mostly dominated from the north by the frequencies of 35.99%, followed by waves from the northeast with 25.63% frequency. Dominant wave heights are 0.2-0.6 m (43.92%), 0.6-1.0 m (19.74%), and 1.0-1.4 m (3.53%). Dominant wave periods are 5-7 seconds (37.47%), 7-9 seconds (26.42%), and 3-5 seconds (7.37%). In this season, wave height on the west monsoon is largest compared to other seasons, with the largest range of incident wave is about 1.4-1.8 m (0.41%).
- Transitional season-1 (MAM): shifting of the dominant wind direction and speed on a transition season causes a slight change of wave direction to northeast (27.17%), north (16.06%), and east (11.28%). While the dominant wave height is not much different with the West Monsoon, i.e.: 0.2-0.6 m (49.58%), 0.6-1.0 m (12:53%), and

1.0-1.4 m (1.54%). Dominant wave periods are 5-7 seconds (40.12%), 7-9 seconds (22.44%), and 3-5 seconds (13.22%).

- East Monsoon (JJA): the dominant wave directions are south (20.07%), southeast (13.85%), and east (10.54%). The dominant wave height are 0.2-0.6 meters (46.52%), followed by the range of 0.6-1.0 meters (9.75%) and 1.0-1.4 m (0.83%). Dominant wave period occurred in the range of 5-7 seconds (39.46%), 7-9 seconds (17.79%), and 3-5 seconds (12.57%).
- Transitional season-2 (SON): shows a condition similar with the Transitional season-1, where the dominant wave height is between 0.2-0.6 m (42.19%) and 0.6-1.0 m (7.93%). Dominant wave period are 5-7 seconds (36.07%), 7-9 seconds (14.20%), and 3-5 seconds (13.44%). Dominant wave directions are from the northeast (15.96%), north (13.09%), and east (8.85%).

Wave-rose pattern in the annual wind data during 11 years (Figure 4.9) shows that the dominant waves come from the northeast, with a frequency of occurrence of about 19.42%. It is followed by the second dominant from the north with an occurrence frequency of 17.04%. While the range of each wave height is 0.2-0.6 meters (45.58%) and 0.6-1.0 meters (12.44%). Dominant period is in the range of 5-7 seconds, with a frequency of 38.29%, and the period of 7-9 seconds reaches 20.17%.

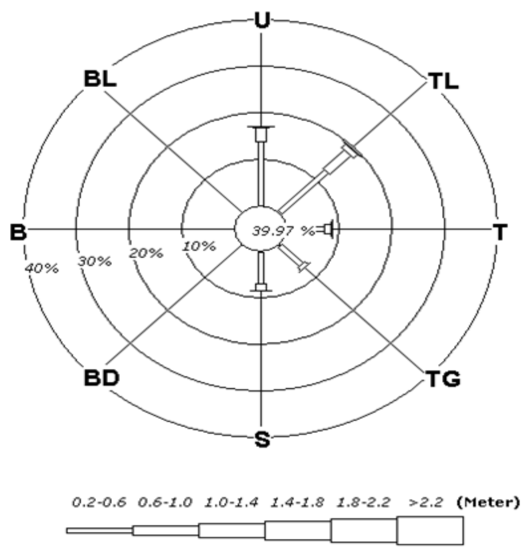


Figure 4.9 Wave rose of Tarakan in the data period of 1999 to 2009

4.1.4 Cyclone and Storm Surges

Tropical cyclone and typhoons generate storm surges and waves, winds, and heavy rains mainly in the regions with latitude of 10º up to 40º. On the sea, the high impact area might be 30 kilometres wide, with extensive damage of lesser impact of over 100 kilometres or more. The incidence of significant tropical cyclones in various regions varies spatially. Because Tarakan is located on latitudes below 10°, it is less affected by tropical cyclones and, in general, wave energy in Tarakan's waters is low (see Figure 4.10). However, waves generated by such disturbances are occasionally transmitted into the Tarakan waters, especially at the east coast of Tarakan, and can produce storm surges of up to 3 meter. Typhoons also generate extreme rainfall, adding to coastal flooding, and wind waves with periods of ten to twenty seconds and heights reaching 4 meter at the sea. The highest waves break as they run into shallow water; smaller waves penetrate the inland with the storm surge, and damage vegetations and structures. Storm surge inundation typically lasts for six to twenty four hours. Figure 4.11 and Figure 4.12 show the number of events, monthly and yearly, in the period of 1945 up to 2009, respectively.

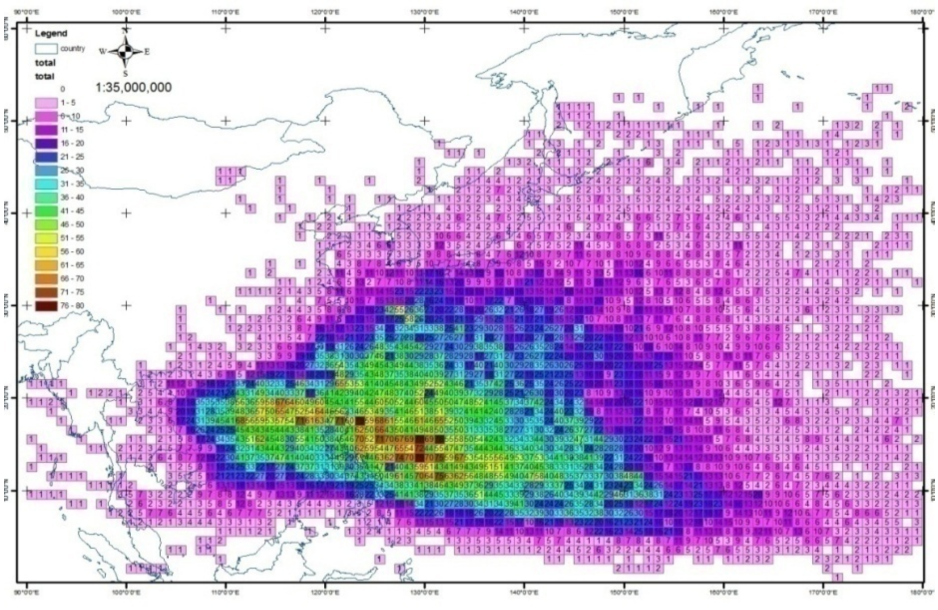


Figure 4.10 Frequencies of tropical cyclone at the west Pacific Ocean
(the period of data is 1945 to 2009)

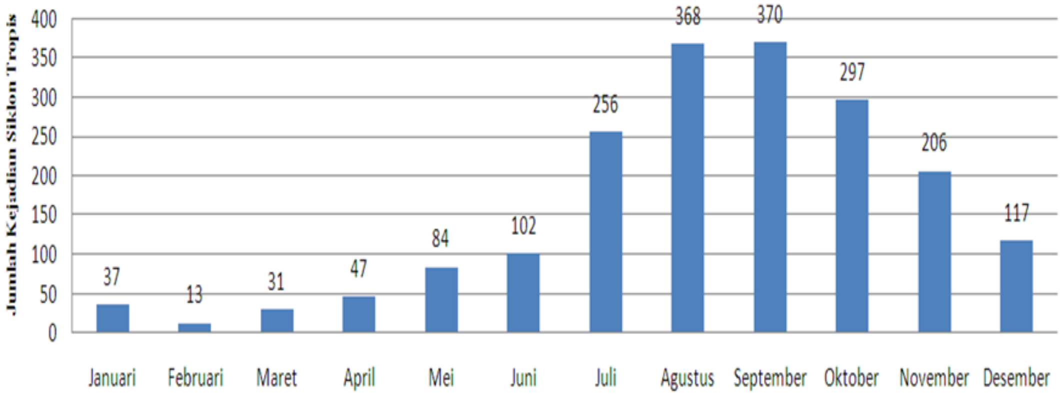


Figure 4.11 Monthly occurrences of Tropical cyclone at the north of west Pacific Ocean (1945-2009).

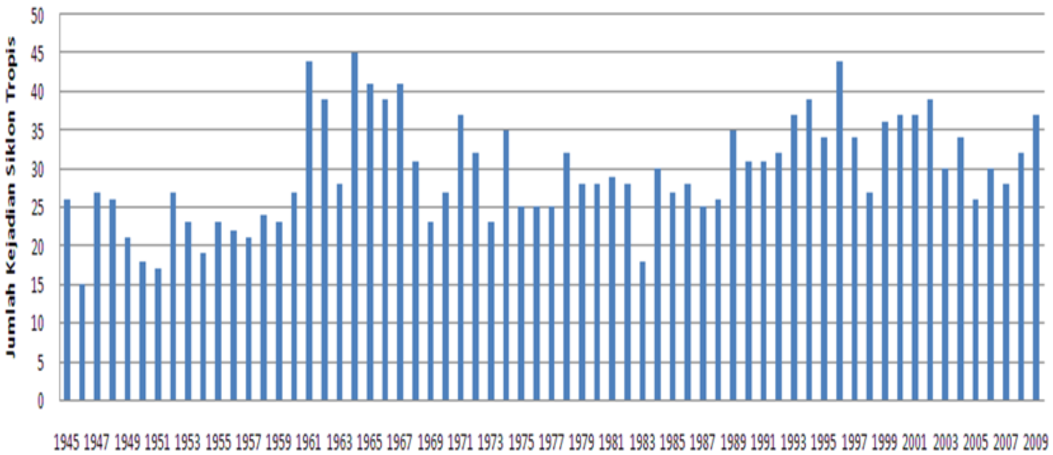


Figure 4.12 Yearly occurrences of tropical cyclone at the north of west Pacific Ocean (1945-2009).

4.1.5 Tsunami

Indonesia is an archipelago formed by the collision of the Indo-Australian, Eurasian, and Pacific Ocean Plates. This causes many earthquakes in Indonesia. Many of the earthquakes that occurred beneath the sea have potential to generate tsunami. In the period of 1600-2100, at least 115 large tsunamis have been occurred in Indonesia (see Figure 4.13).

The pre-calculated tsunami modelling in Figure 4.14, Latief, et.al., 2009 show that the potential of tsunami height that will reach Tarakan Island is about 1-3 meters with reoccurence period of more than 50 years.

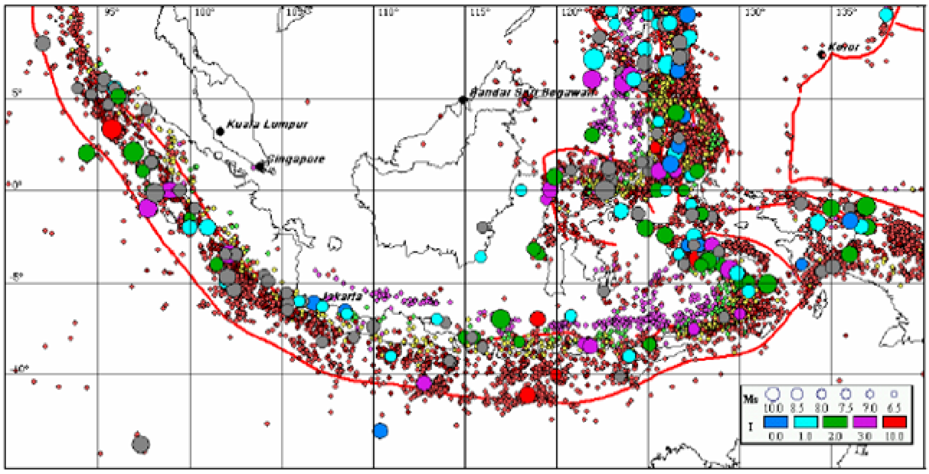


Figure 4.13 Location of earthquake (small squares) and tsunamis (coloured circles) in Indonesian archipelagos and its surrounding areas (Latief and Hadi, 2007)

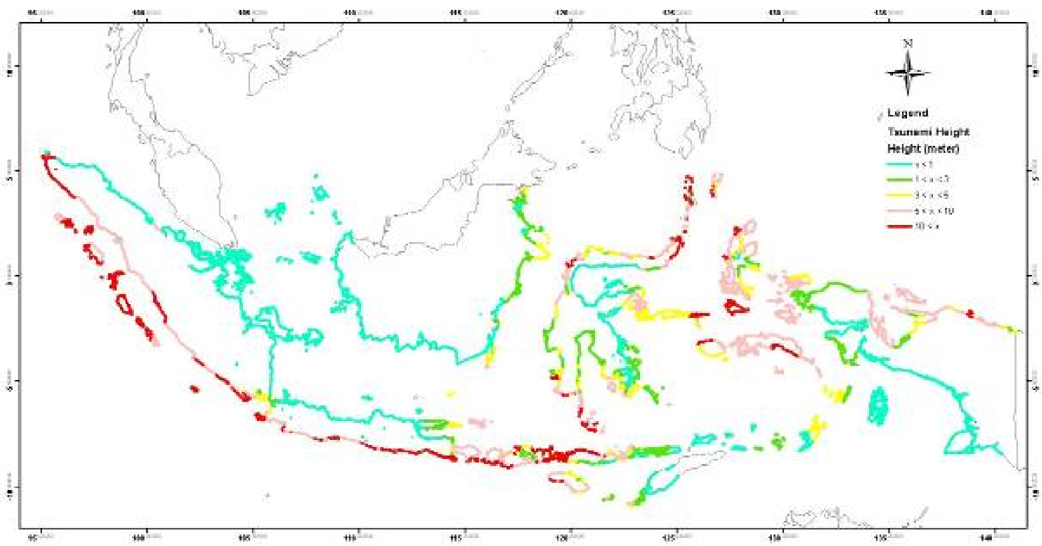


Figure 4.14 Tsunami height along the shoreline based on the pre-calculated tsunami database (Latief, 2009)

4.2 Characteristics of Hazard Elements

Changes in sea surface level are not only caused by the phenomenon of sea level rise but also by other elements such as tidal, wave climate, variability of ENSO/ La Nina, and tsunami. In this study, there are seven hazards elements of sea level change and their characters as listed in Table 4.2.

Table 4. 2 Elements of Hazards Related to Sea Level Changes

Element of Hazards	Hazard code	Frequency	Level of consequence	Return period	Remark
Tidal (HHWL)	1	Frequent	Low	Monthly	Tidal Prediction
Wind waves	2	Frequent	Moderate	Seasonally	Prediction
Global Sea Level Rise	3	Increase	Low	incrementally	Projection
ENSO/La Nina	4	Less frequent	Low	2-3 years	Prediction
Coastal flooding from Inland	5	Frequent	Low	Annual	Statistical
Storms Surges	6	Less frequent	High	Annual	Statistical
Tsunami	7	Rare	High	>50 years	Model

Regarding to the Scientific Basis of Oceanography in Tarakan, which is prepared by Sofian, (2010) as described in sub-chapter 3.4.3 and then accomplished by Latief (2010), the magnitude of each element for SRES A1B, SRES A2, and SRES B1 are listed in Table 4.3, Table 4.4 and Table 4.5 respectively.

Table 4.3 Elements of Hazards Related to Sea Level Changes for SRES A1B

Item/Year	2030	2050	2080	2100
Tidal Range	3.1m/3.5m	3.1m/3.5m	3.1m/3.5m	3.1m/3.5m
Sea Level Rise	14.7 ± 6.25cm	26.0 ±11.0cm	48.0 ±22.0cm	65.5 ±28.5cm
La Nina	15cm	15cm	15cm	15cm
Surges	30 cm	30 cm	30 cm	30 cm
Wind wave	1.3m (estimation)	1.2m	1m	1.m

Note: The wind waves are based on the annual daily maximum wave height, due to the IPCC wind projection that only available for daily.

Table 4.4 Elements of Hazards Related to Sea Level Changes for SRES A2

Item/Year	2030	2050	2080	2100
Tidal Range	3.1m/3.5m	3.1m/3.5m	3.1m/3.5m	3.1m/3.5m
Sea Level Rise	10.0 ± 5.0cm	22.0 ±11.0cm	48.5 ±23.5cm	70.0 ±35.0cm
La Nina	15cm	15cm	15cm	15cm
Surges	30 cm	30 cm	30 cm	30 cm
Wind wave	1.3m (estimation)	1.2m	1m	1.m

Note: The wind waves are based on the annual-daily maximum wave height, due to the IPCC wind projection that only available for daily.

Table 4. 5 Elements of Hazards Related to Sea Level Changes for SRES B1

Item/Year	2030	2050	2080	2100
Tidal Range	3.1m/3.5m	3.1m/3.5m	3.1m/3.5m	3.1m/3.5m
Sea Level Rise	12.0 ± 6.0cm	22.5 ±10.5cm	39.0 ±18.0cm	50.5 ±22.5cm
La Nina	15cm	15cm	15cm	15cm
Surges	30 cm	30 cm	30 cm	30 cm
Wind wave	1.3m (estimation)	1.2m	1m	1.m

Note: The wind waves are based on the annual daily maximum wave height, due to the IPCC wind projection that only available for daily.

4.3 Cumulative Hazards Scenarios

Coastal flooding or inundation as cumulative of all hazards varies along the coastal areas of Tarakan Island according to structures of topography, location and coastal geometry. In areas where the coastline is relatively even, vegetation can buffer the effects of the wave; in areas where there is considerable articulation, wave forces can be considerably higher.

Hazard scenarios are conducted to determine the potential hazards from the accumulation of several elements of the sea level changes that could be occured at the same time in the study area. This assessment considers five elements of climatic hazards: global sea level rise, La Nina, storm surges, and wind waves, beside tsunami, as describe in Figure 3.1.

In this assessment, following six hazards scenarios are proposed, where each scenario is a combination of hazards elements associated with the projected global sea level rise of **14.7 ± 6.25 cm** in 2030.

1. Scenario-1a (significant condition scenario):
   It is the scenario of when hazard combination of wind waves with significant height (SWH) and global sea level rise (SLR) occur in the time of mean highest water level (MHWL) due to tidal fluctuation.
   Typically, Tarakan coastal areas have MHWL of 120 cm and wave setup due to SWH of 38.4 cm, hence, in this significant scenario, baseline and projected hazard

levels are about 158.4 cm and 173.1 cm above recent mean sea-level (MSL), respectively.

2. Scenario-1b (extreme condition scenario):

   This scenario is an extreme one of the scenario-1a above: When maximum height of wind wave and SLR occur in the time of highest high water level (HHWL). Therefore, in this extreme scenario, baseline and projected hazard levels are 210.1 cm and 224.8 cm above recent MSL, respectively.

3. Scenario-2a (scenario of extreme and La-Nina condition)

   This scenario represents condition of above scenario that is further combined by La-Nina hazard so that the sea level rise is 15 cm higher and accordingly coastal inundation is wider than of ones of above scenario both in baseline and projected conditions.

4. Scenario-2b (scenario of extreme and surges condition):

   This scenario is similar to scenario-2a above but La-Nina event is replaced with cyclonic and storm surges condition with typical increase of sea-level of about 30 cm.

5. Scenario-3 (scenario of extreme and La-Nina and surges conditions):

   This scenario represents the condition of when combination of overall climate-related hazards occur in the same time. Baseline and projected hazard level are about 255.1 and 269.8 cm above recent MSL, respectively. This condition will mainly be considered in the assessment of risk induced by climate change.

6. Scenario-4 (scenario of extreme and tsunami condition):

   This scenario represents the condition of when tsunami could occur in the extreme condition scenario. It is interesting to assess the impact of sea level rise in the same time of tsunami occurence, which has highest level of 524.8 cm.

Resume of the overall sea level hazard scenarios can be seen in the following Table 4.6 but only for SRES A1B.

Table 4.6 Scenarios of Cumulative Hazards for SRESA1B Scenario

Elements of Hazard	Hazard code	Projection SRES-A1B		Frequencies
		2010 (cm)	2030 (cm)	
Tide(MHWL)	1a	120	120	520 hours/year (5.93%)
Tide(HHWL)	1b	160	160	46 hours/year (0.52%)
Wind Wave	2a	120	120	18.3days/year (5.01%)
	set-up	38.4	38.4	T=8 sec
	shoreward displacement	7675	7675	
	2b	160	160	9days/year (2.36%)
	set-up	50.1	50.1	T=7 sec
	shoreward displacement	10200	10200	
Sea Level Rise (A1B)	3	0	14.7 ± 6.25	projected
La Nina	4	15	15	1 event/ 2-3 year
Storm Surges and Tidal Surges	5	30	30	3 event/ year (3 days duration)
Tsunami	6	300	300	1 event/100 year
Scenarios	**Cummulative**			
Scenario-1a(Significant)	1a+2a+ (3)	158.4	173.1	2.97E-01
Scenario-1b (Extreme)	1b+2b + (3)	210.1	224.8	1.23E-02
Scenario-2a (Extreme+ La Nina)	1b+2b+4 + (3)	225.1	239.8	6.14E-05
Scenario-2b (Extreme + Surges)	1b+2b+5 + (3)	240.1	254.8	1.23E-04
Scenario-3(Extreme + La Nina+ Surges)	1b+2b+4+5 + (3)	255.1	269.8	6.14E-07
Scenario 4 (Extreme + Tsunami)	1b+2b+6 + (3)	510.1	524.8	1.23E-06

4.4 Cumulative Hazards Maps

A cumulative hazard map is an illustration or information about potential cumulative hazards related to the climate change that could simultaneously be affected the coastal areas of Tarakan Island. The six hazard maps of scenario-1a, scenario-1b, up to Scenario-4 for the year of 2030, can be seen in Figure 4.15, Figure 4.16, up to Figure 4.20, respectively. Occurrence of events in the future represented by each map could pursue related frequency tabulated in Table 4.6 above.

To determine hazard level, we define 2.0 m above MSL (the HHWL and significant wave height) as the threshold between high and very high levels to represent boundary of conformity for community livelihood in Tarakan coastal areas.

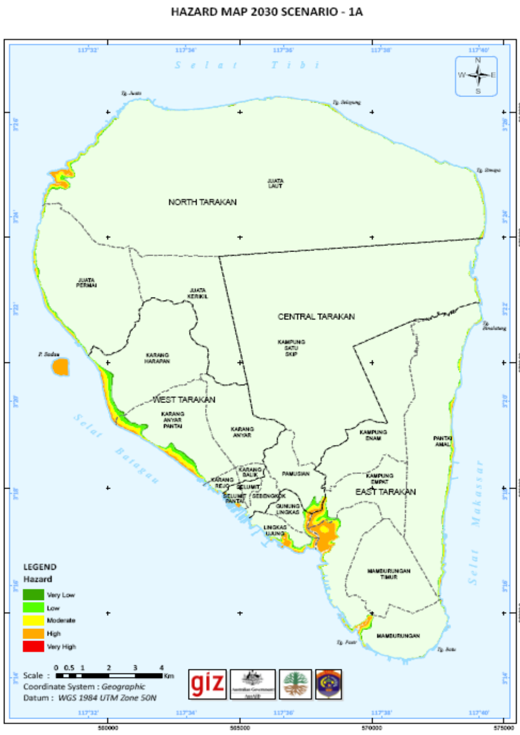


Figure 4.15 Inundation Map of Scenario-1a

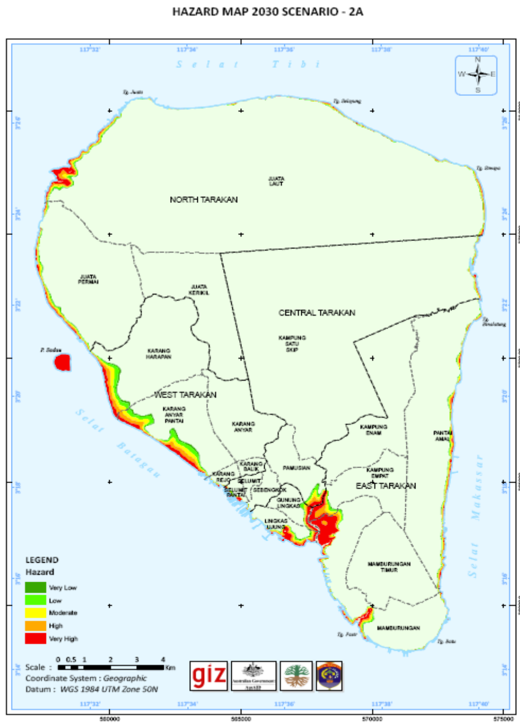


Figure 4.16 Inundation Map of Scenario-2a

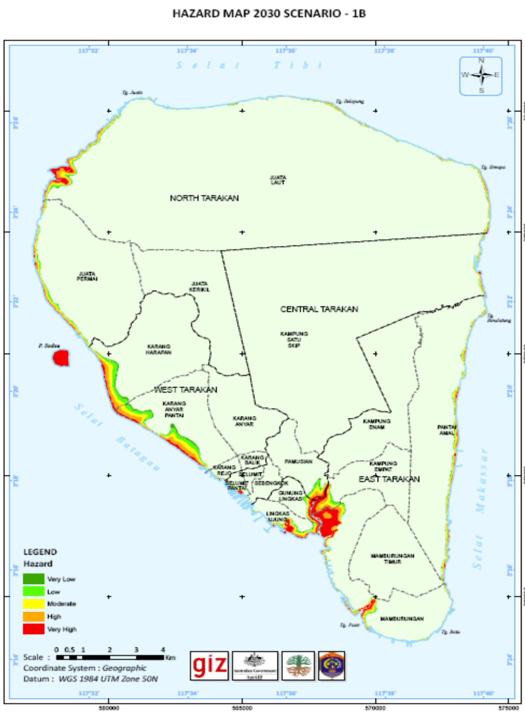


Figure 4.17 Inundation Map of Scenario-2b

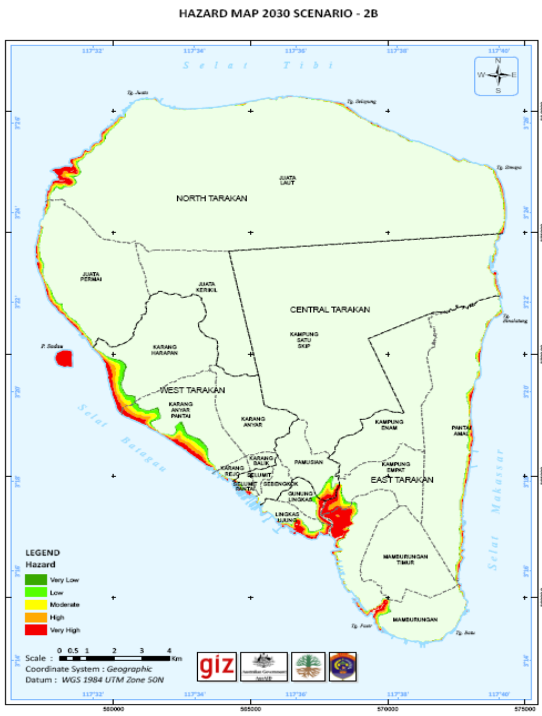


Figure 4.18 Inundation Map of Scenario-2b

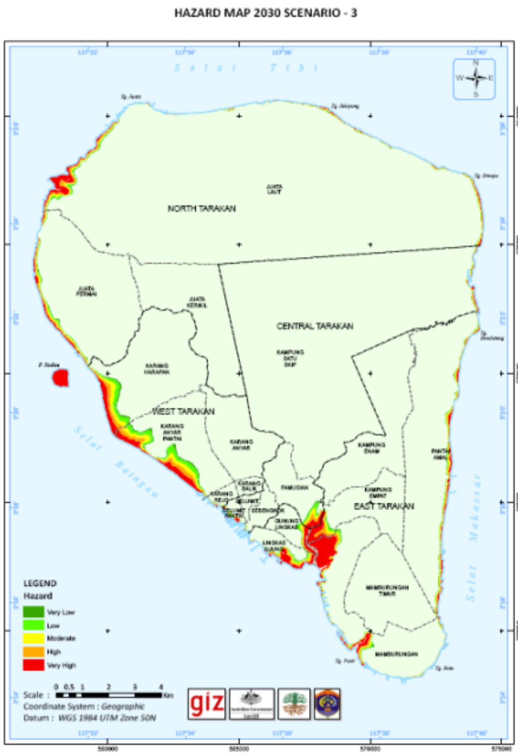


Figure 4.19 Inundation Map of Scenario-3

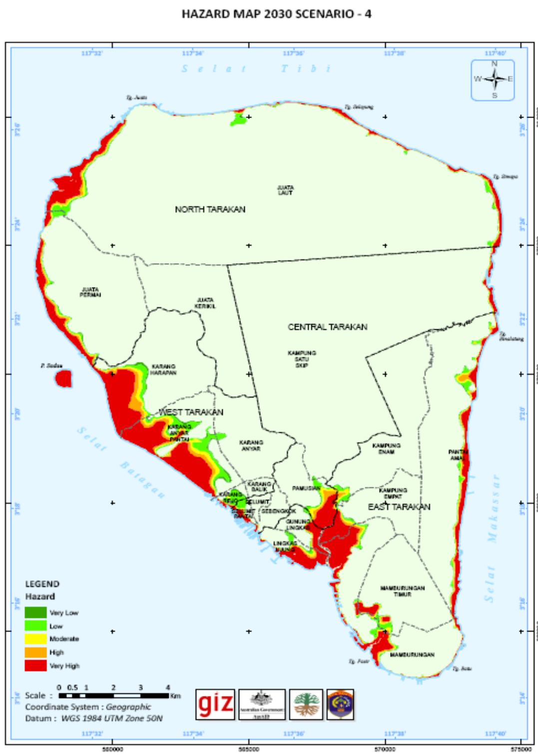


Figure 4.20 Inundation Map of Scenario-4

Further analysis will be focused on the scenario-3 of the year 2030 (Figure 4.19). Because this scenario give extreme condition that will be occurred at least once in 3 years (Table 4.6). Although scenario-4 will produce a very high magnitude of hazard, however the scenario is not considered because the occurrence of Tsunami is very low.

In scenario-3 (see Table 4.7), the flooding or inundation hazard due to sea-level rises give large impacts on both penetration distance from shoreline and inundation area. Large scale impacts could be forced to locations in several coastal sub-districts, especially Juata Laut, Karang Anyar Pantai, Karang Harapan, Mamburungan, dan Pantai Amal, dan Juata Permai.

Table 4.7 Inundated area, distance, and shoreline in 2030

Sub-districts/ Villages	Area (Ha)	Inundation in 2030		
		Distance (km)	Shoreline (km)	Area (Ha)
East Tarakan	**5904**		46.27	
Lingkas Ujung	116	0.719	10.49	62.00
Gunung Lingkas	319	0.573		30.00
Mamburungan	851	1.555	20.99	123.00
Kampung Empat	1139	1.173	-	56.00
Kampung Enam	1121			
Mamburungan Timur	1040	0.113	0.17	1.67
Pantai Amal	1215	0.268	14.62	118.00
Central Tarakan	**5593**		**17.21**	
Selumit Pantai	48	0.467	7.15	17.50
Selumit	43			
Sebengkok	148	0.466	4.98	4.50
Pamusian	254	0.810	-	44.50
Kampung Satu Skip	5061	0.295	5.08	6.50
West Tarakan	**2934**		14.22	
Karang Balik	80			
Karang Rejo	76	0.234	2.33	6.15
Karang Anyar	561			
Karang Anyar Pantai	851	0.983	6.06	222.00
Karang Harapan	1221	0.925	5.83	188.50
North Tarakan	**10649**		40.87	
Juata Permai	1423	0.418	8.48	107.84
Juata Kerikil	1059			
Juata Laut	8454	1.052	32.39	236.84

Chapter V Analysis of Vulnerabilities Related to Climate Change

The objective of vulnerability assessment is to identify features of the vulnerabilities that are susceptible to damage including, the physical feature (topography and slope topography), artificial structures, land use, societal variables (demographic profiles) and sites of potential damage and human mortality.

Vulnerability assessment is done by normalizing of each vulnerability element into the level of vulnerability. Each element of vulnerability is weighted according to the level of sensitivity to the sea-level hazards, in order to get the aggregate of all of vulnerability elements that are considered.

5.1 Topography Data and its Vulnerability Map

Shuttle Radar Topography Mission (SRTM) data were used to represent the surface of the earth in digital form (see Figure 2.16). The SRTM satellite provides the surface elevation data including canopies of tree and surfaces of high-level building, so that the data needs to be corrected. For example: for a settlement, this satellite data take the high roof of a building rather than a land elevation data. Correction process for SRTM data needs land use data in the region. The SRTM elevation data will be compared to the land use data in order to find the actual height of the earth's surface. The SRTM 30m data are taken from the Global Land Cover Facility (GLCF). The topographic map of Tarakan where is generated from SRTM Data.

The topography element is then normalized into the level of elevation vulnerabilities, such as very low, low, moderate, high and very high, which is represented by green, blue, yellow, oranges, and red colours respectively, as shown in

Figure 5.1. The classification and weighting factors are shown in Table 5.1.

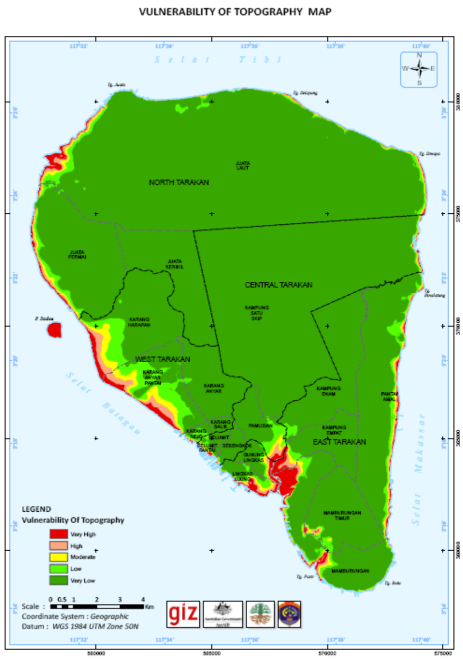


Table 5.1 Weighting and classification of elevation vulnerabilities and their areas.

No	Elevation Class (m)	Rank	Weight	Area (Ha)
1	0 - 1	1	0.33	1424.14
2	1 - 2	2	0.27	451.35
3	2 - 3	3	0.20	423.34
4	3 - 5	4	0.13	1122.33
5	> 5	5	0.07	21819.55

Figure 5.1 Vulnerability Map of Topography

Figure 5.1 showed that several areas has very high level of topography vulnerability (i.e., it has elevation of less than 1 m above mean sea-level) such as Karang Harapan, Karang Anyar Pantai, Lingkas Ujung, Kampung Empat, and Mamburungan.

5.2 Topographic Slope Vulnerability Map

Topographic slope can be derived or generated from topography data (see Figure 2.16) for each pixel. The slope vales are then classified as flat, sloping, slightly sloping, rather steep, steep (Figure 5.2).

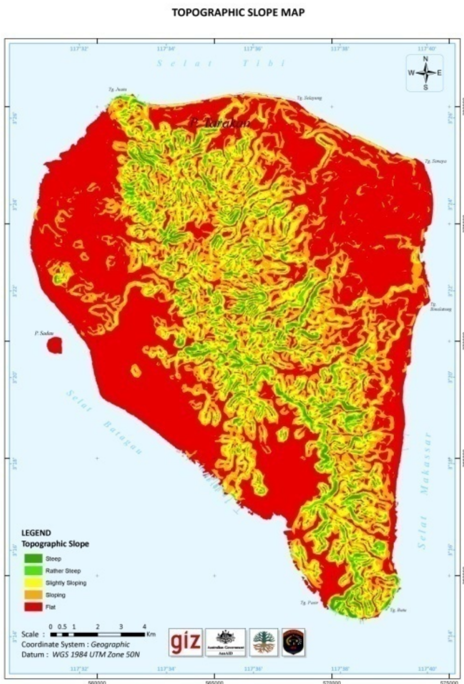


Figure 5.2 Topography slopes map of Tarakan

Normalisation of the topography slope element into the level of topography slope vulnerabilities, such as very low, low, moderate, high and very high, which is represented by green, blue, yellow, oranges, and red colours respectively, as shown in Figure 5.3. The classification and weighting factors are shown in Table 5.2.

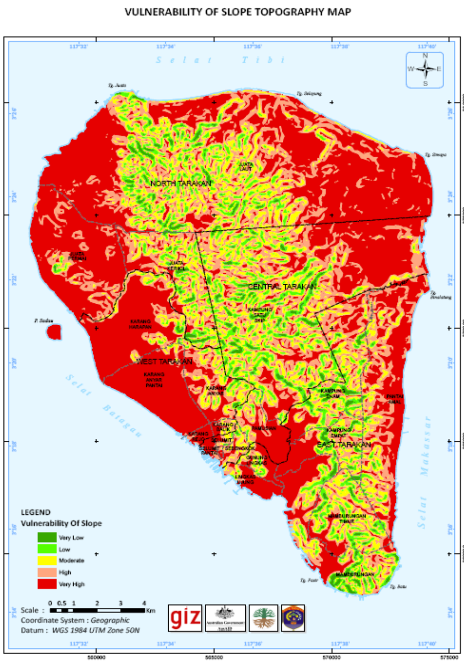


Table 5.2 Weighting and classification of topography slope vulnerabilities and their areas.

No	Slope (degree)	Rank	weight	Area (Ha)
1	0 – 2.5	1	0.33	12825.05
2	2.5-5	2	0.27	6098.10
3	5-7.5	3	0.20	4009.47
4	7.5-10	4	0.13	1783.38
5	>10	5	0.07	524.32

Figure 5.3 Vulnerability Map of Topography Slope

5.3 Land-Use Vulnerability Map

Assessment of both baseline and projected land use vulnerability refer to the data in Figure 2.18 and Figure 2.22, respectively. Normalisation of the land use element into the level of land use vulnerabilities, such as low, moderate, high and very high, which is represented by green, yellow, oranges, and red colors respectively, as can be seen in Figure 5.4 for 2010 and Figure 5.5 for 2030. The classification and weighting factors are shown in Table 5.3 for 2010 and Table 5.4 for 2030.

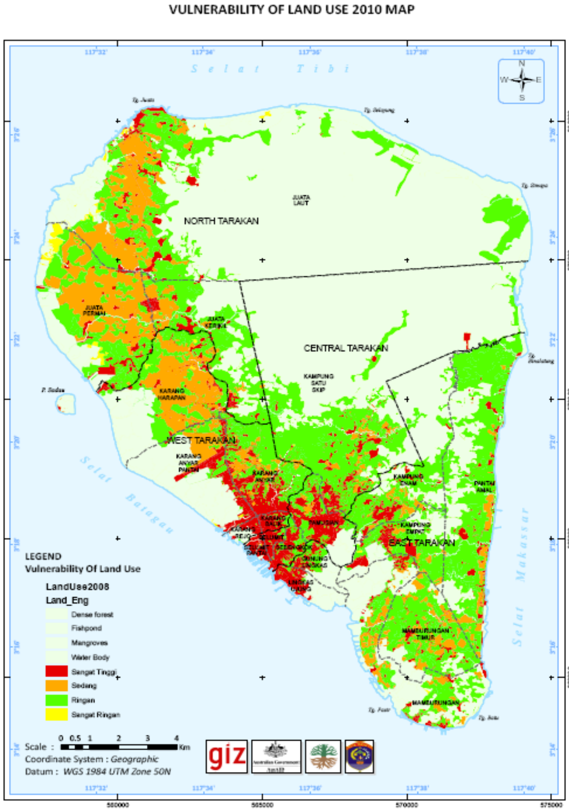


Figure 5.4 Vulnerability Map of Land Use 2010

Figure 5.5 Vulnerability Map of Land Use 2030

Table 5.3 Type and Area of Land Use, Weighting and Classification of Land Use Vulnerabilities (2010)

No	Land Use Type	Area (Ha)	Category of Vulnerability Type	Rank	Weight
1	Built Up Area	1142.5	Built Areas, Important Infrastructure	1	0.4
2	Vacant Land / Moor	705.9			
3	Roads	138.0			
4	Airport	36.0			
5	Beach	35.5			
6	Refinery	21.0			
7	Port / Harbor	4.6			
8	Dryland Agriculture	2375.1	Agriculture	2	0.3
9	Bushes	5364.1	Open Space, Other Utilized Areas	3	0.2
10	Mixed Farm	1878.7			
11	Fishpond	1591.8			
12	Sports Field	10.4			
13	Plantation	3.1			
14	Dense forest	10146.3	Coastal Ecosystem, Conservation Areas	4	0.1
15	Cemetery	3.4			
16	Mangroves	1302.9			
17	Water Body	180.6			
18	Swamp	120.4			
19	Pool	21.6			
20	Water Dam	2.0			

Table 5.4 Type and Area of Land Use as well as Category and Weight of Vulnerability (2030)

No	Land Use Type	Area (Ha)	Category of Vulnerability Type	Rank	Weight
1	Moderate Density Residental	5033.7	Built Areas, Important Infrastructure	1	0.4
2	High Density Residental	2952.0			
3	Industrial Area	1759.1			
4	Service & Trading Area	779.9			
5	Military Area	514.9			
6	Juata Airport	320.2			
7	Governmental Area	255.1			
8	Low Density Residental	223.8			
9	Education Area	53.3			
10	WP	31.3			
11	UPDN Pertamina	21.9			
12	Warehouse Area	13.3			
13	Mining Area	827.2	Other Utilized Areas	2	0.3
14	Tourism Area	792.2			
15	Animal Husbandry Area	158.0			
16	Social & Public Facilities	29.0			
17	Fisheries Area	17.9			
18	Sport Center	20.9	Open Space	3	0.2
19	Water Dam	13.1			
20	Protected Forest	6998.0	Coastal Ecosystem, Conservation Areas	4	0.1
21	City Forest	2492.3			
22	Mangrove Forest	942.8			
23	Green Belt	485.0			
24	Landfill site	93.7			
25	Public Cemetary	69.6			

5.4 Population Density Data and its Vulnerability Map

To describe dynamic vulnerability of population density, the maps in Figure 2.23 and Figure 2.24 were also developed to illustrate population data and population density in 2030. Normalisation of the population density element into the level of vulnerability, such as very low, low, moderate, high and very high, which is represented by the green, blue, yellow, aranges, and red colours respectively, as shown in Figure 5.6 for 2010 and Figure 5.7 for 2030. The classification and weighting factors as shown in Table 5.4

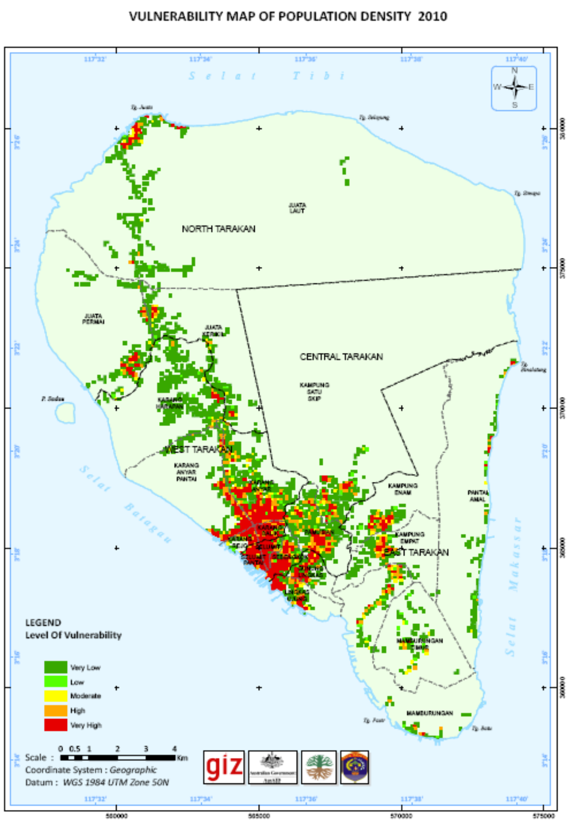


Figure 5.6 Vulnerability Map of Population Density 2010

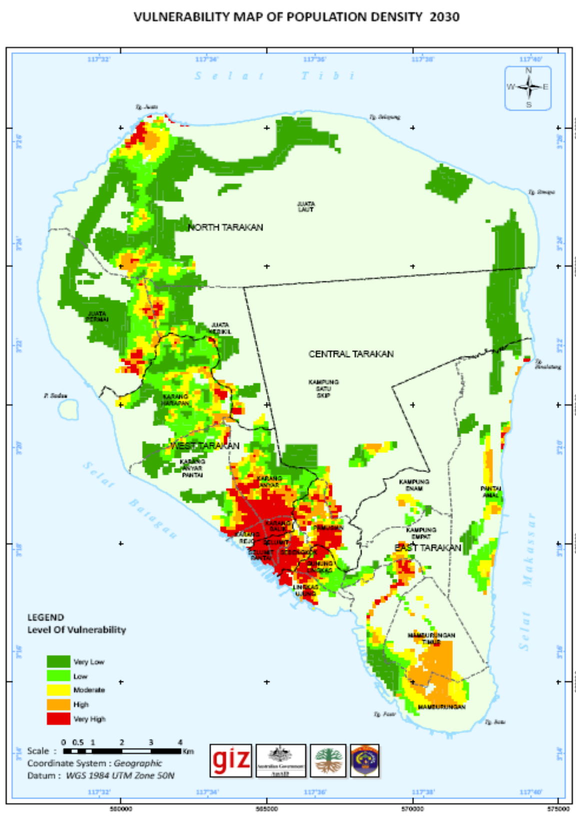


Figure 5.7 Vulnerability Map of Population Density 2030

Table 5.5 Weighting and classification of vulnerabilities of population density.

No	Population	Rank	Weight
1	>4	1	0.33

2	3 – 4	2	0.27
3	2 – 3	3	0.20
4	1 – 2	4	0.13
5	<1	5	0.07

These figures showed that West Tarakan is the most vulnerable sub-districts in Tarakan City, while East Tarakan and North Tarakan will become higher vulnerable in 2030.

5.5 Infrastructures and Critical Facilities Data and its Vulnerability Map

Infrastructures and transportation data (road network) of 2010 and 2030 are shown in Figure 5.8 and Figure 5.9, respectively (Bappeda of Tarakan City). While Figure 5.10 shows the critical facilities such as Juwata airport runway, Pertamina pier, terminal, etc. In the aim to analysis vulnerabilities in term of number of houses/building, infrastructure, facilities, residential areas with more precise and detail so the satellite imagery (Figure 5.11) and zooming in Figure 5.12 are delineated one by one.

INFRASTRUCTURE MAP 2010

Figure 5.8 Map of road network and transportation facilities in 2010

INFRASTRUCTURE MAP 2030

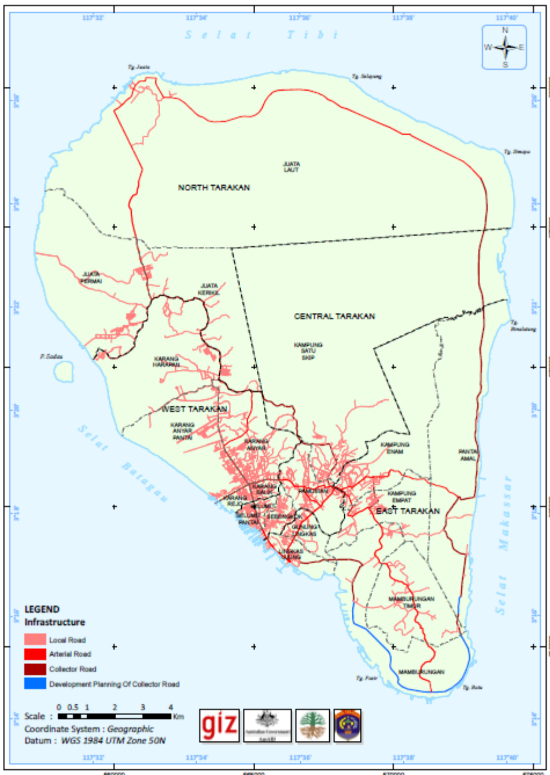


Figure 5.9 Map of road network and transportation facilities in 2030

Figure 5.10 Map of road network and

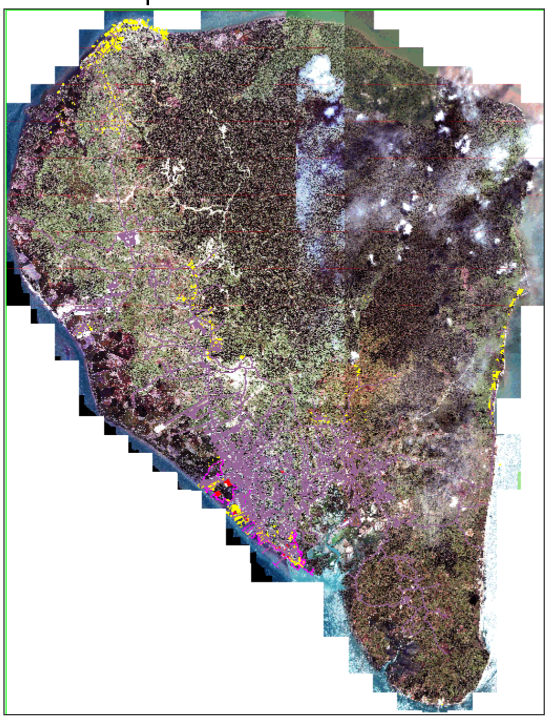


Figure 5.11 Satellite image of Tarakan

transportation facilities

Figure 5.12 Delineation of houses, government buildings and Infrastructures

Artificial features **(**Land-use and infrastructures) patterns are a reflection of changing demographics and settlement trends, for instances, lack of institutional oversight contributes to, or even creates, unsafe conditions by allowing such practices as encroachment into floodplains, inadequate drainage provisions, filling of wetlands and destruction of coastal vegetation, including dune grasses and mangrove forests. All of the above practices may further exacerbate the impacts of natural hazards including slope instability, erosion and siltation which, in turn, lead to increased frequency and losses from small- and medium-size disasters.

Normalisation of the infrastruture element into levels of infrastructure vulnerability, such as very low, low, moderate, high and very high, which are represented by the green, blue, yellow, oranges, and red colours respectively, as can be seen in Figure 5.13 and Figure 5.14 for years of 2010 and 2030 respectively. The classification and weighting factors are shown in Table 5.6.

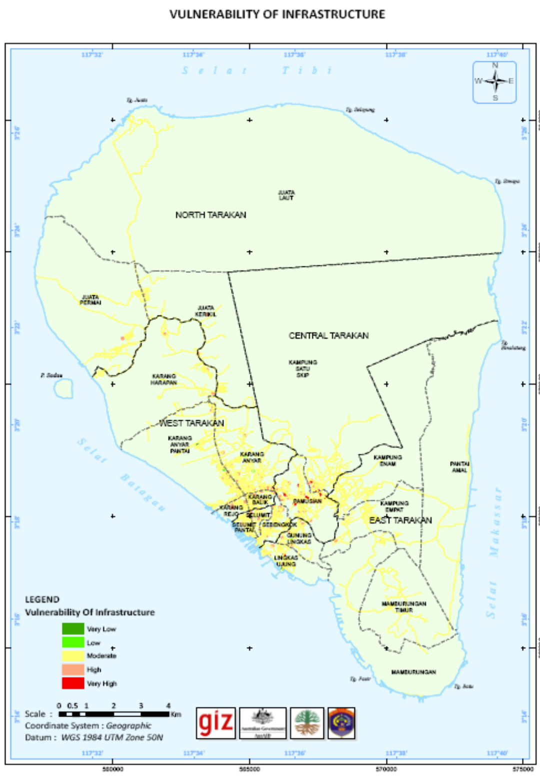


Figure 5.13 Vulnerability Map of infrastructures and critical facilities 2010

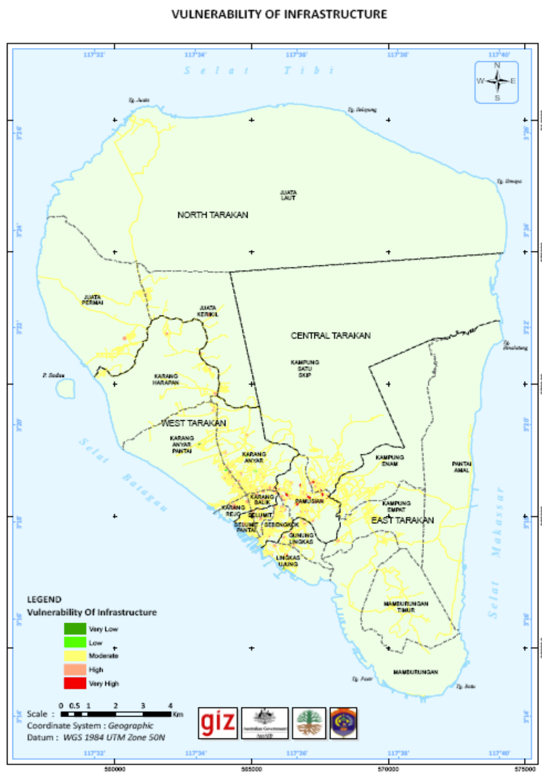


Figure 5.14 Vulnerability Map of infrastructures and critical facilities 2030

Table 5.6 Weight and class of infrastructure vulnerabilities

No	Infrastructure	Rank	Weight
1	Airport	1	0.33
2	Refinery	2	0.27
3	Port	3	0.20
4	Road	4	0.13
5	Navy	5	0.07

5.6 Aggregate Map of All Vulnerability Elements

Aggregate of all vulnerabilty elements is calculated with considering the sensitivity of each elements which is represented by the weight normalisations as shown in

Table **5.7**. These weights were obtained by pairwise comparison between elements that are judged by the expert using the Analitycal Hierarchical Process (AHP) method. The aggregate map of all elements for 2010 and 2030 are shown in Figure 5.15 and Figure 5.16, respectively.

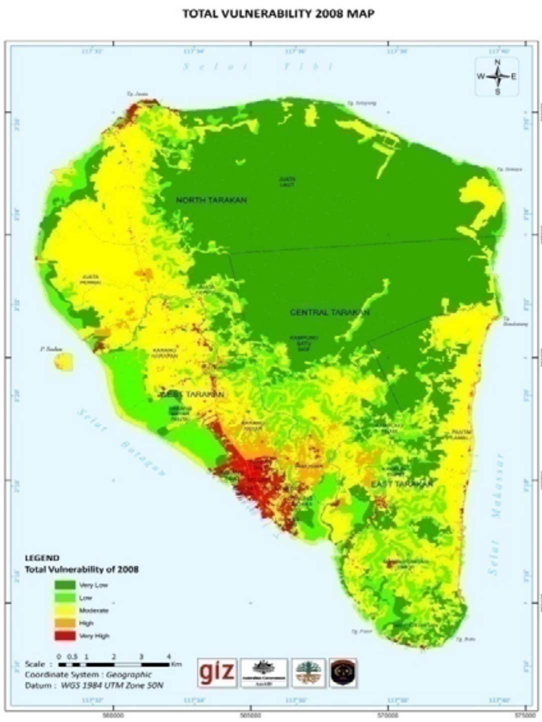


Figure 5.15 Aggregate map of all vulnerability in 2008

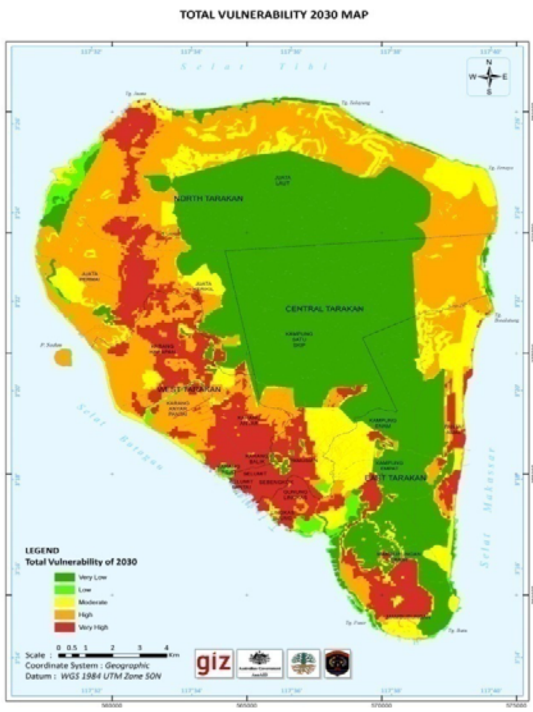


Figure 5.16 Aggregate map of all vulnerability in 2030

Table 5.7 An aggregate and weighting of all vulnerability elements

Vulnerability Elements		Vulnerability Elements					Weight	Weight Normalisation
		LU	P	Inf	E	ST		
Land Use	LU	1.00	1.00	2.00	3.00	4.00	11.00	0.31
Population Number	P	1.00	1.00	2.00	3.00	4.00	11.00	0.31
Infrastructure and Critical Facilities	Inf	0.50	0.50	1.00	2.00	3.00	7.00	0.20
Elevation	E	0.33	0.33	0.50	1.00	2.00	4.17	0.12

Topographic Slope	ST	0.25	0.25	0.33	0.50	1.00	2.33	0.07
	Total						35.50	1.00

Figure 5.15 and Figure 5.16 show that the most vulnerable areas are depicted by red followed by orange colours. In base condition, these areas are merely located at south west of the Tarakan Island, and some in Juata Permai (west) and Juata Laut (north). These areas would broaden along sub-districts in western Tarakan and in Pantai Amal (east). These figures will be used for risk assessment by overlaying with the cumulative hazards scenarios (Figure 4.19).

Chapter VI Risk Analysis

Risk provides the basis for decision-making and institutional acceptance of protective measures and strategic adaptation plan. Risk is calculated by correlating information derived from the Hazard Assessment and the Vulnerability Assessment, i.e. **Hazard x Vulnerability = Risk**. The characteristics of risk are then analyzed in terms of estimated probability of occurrence, magnitude and incidence of losses, which can be calculated both in quantitative or qualitative terms.

6.1 Risk Level Mapping

Risk analysis is important to see how large potential risks would be impacting to the coastal area of Tarakan, therefore we could determine the level of risk that might occur in the region. This assessment performs the estimation of the level of risk in accordance to the levels of hazard and vulnerability by using relation table in Figure 6.1 as follows.

		HAZARD				
		Very Low 0-0.5m	Low 0.5-1.0m	Moderate 1.0-1.5m	High 1.5-2.0m	Very High X>2.0m
VULNERABILITY	Very Low	VL	VL	L	L	M
	Low	VL	L	L	M	H
	Moderate	L	L	M	H	H
	High	L	M	H	H	VH
	Very High	M	H	H	VH	VH

Figure 6.1 Scheme for estimate the risk level

In this analysis, the potential risks are reviewed by developing related risk level map for the year 2030.

Risk level map in the Tarakan coastal areas in 2030 is developed by overlaying the hazards map of scenario-3 (Figure 4.19) and the aggregated vulnerability maps (Figure

5.16) as shown in Figure 6.2. In summary, there are five sub-districts in which having very high level of risk, i.e, Lingkas Ujung, Kampung Empat, and Gunung Lingkas in East Tarakan district as well as Sebengkok and Selumit Pantai in Central Tarakan district. This very high level is mainly caused by high inundated area.

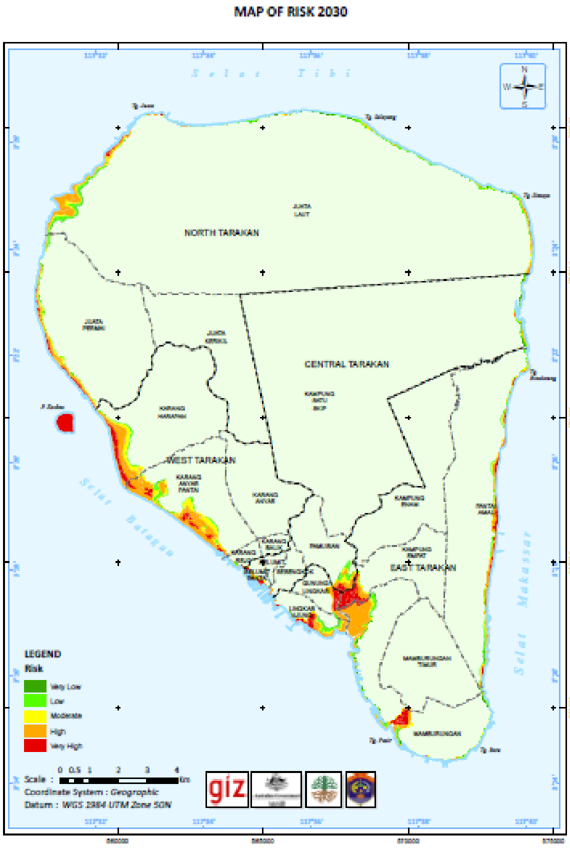


Figure 6.2 Risk Map 2030

6.2 Risk Map in Spatial Planning

In the aim to analyze which types of land use will be inundated in the future, the hazard map of scenario-3 is overlaid with Spatial Pattern Map as a part of Spatial Planning for year 2029 as shown in Figure 6.3. The risk analysis and risk level of each land use element are summarized and listed in Table 6.1.

.

Figure 6.3 Overlaid between Hazard Map of Scenario-3 and Spatial Plan 2029

From these figure and table, it can be seen that all of the five very risky villages comprise settlements with high population density. Some vital infrastructures and facilities are also contained in these areas, such as oil refinery in Lingkas Ujung, mining, military, and industrial areas in Kampung Empat, trade zone and military areas in Sekelumit Pantai and Sebengkok. In aiming of soft protection by vegetation, the mangrove forest located in Lingkas Ujung and Gunung Lingkas, and city forest in Kampung Empat, Selumit Pantai and Sebengkok are most important so that they would be necessary to be maintained and restored.

Table 6.1 Summary of risk map (inundated area, distance, and shoreline; inundated facilities and land uses for each village and its risk level)

Sub-districts/ Villages	Area (Ha)	Number of Population in 2010	Inundation in 2030			Facilities and Land Use Type	Inundated Area (Ha) in 2030	Risk Level
			Distance (km)	Shoreline (km)	Area (Ha)			
East Tarakan	**5904**	42.909		46.27				
Lingkas Ujung	116	10.409	0.719	10.49	62	Oil Refinery, High Pop Density Mangrove Forest	- 23.36 38.85	4.18 (VH)
Gunung Lingkas	319	7.905	0.573		30	High Pop. Density Mangrove Forest	21.92 8.33	4.05 (VH)
Mamburungan	851	7.633	1.555	20.99	123	High Pop Density Tourism Area Warehouse Area, Military Area Industrial Area Mangrove Forest, City forest	6.61 1.72 25.81 3.11 80.33 5.45 -	3.53 (H)
Kampung Empat	1139	4.529	1.173	-	56	Public Facility, Sport Center, High Pop Density Mining Area, Military Area, Industrial Area , City forest, Mangrove Forest	- - 36.54 - 18.58 - 1.43 -	4.18 (VH)
Kampung Enam	1121	5.433				Public Facility, Greenbelt, High Pop Density Mining Area, Trade zone, Education Zone, Protected Forest, City forest		
Mamburungan Timur	1040	2.531	0.113	0.17	1.67	Landfills, Medium Pop Dens. Tourism Area, Military Area, City forest	- - - 0.28 0.92	3.24 (H)
Pantai Amal	1215	4.469	0.268	14.62	118	High Pop Density Tourism Area, Fisheries Zone, Trade Zone, Education Zone, Mangrove Forest, City forest	41.53 69.17 - - - 7.31 0.31	3.69 (H)
Central Tarakan	**5593**	60.397		**17.21**				
Selumit Pantai	48	16.347	0.467	7.15	17.5	High Pop. Density Trade Zone, Military Area, City Forest	17.41 - 0.18 -	4.26 (VH)
Selumit	43	6.490				High Pop. Density , Trade zone		

Sub-districts/ Villages	Area (Ha)	Number of Population in 2010	Inundation in 2030			Facilities and Land Use Type	Inundated Area (Ha) in 2030	Risk Level
			Distance (km)	Shoreline (km)	Area (Ha)			
Sebengkok	148	15.019	0.466	4.98	4.5	High Pop Density Trade Zone, Military Area, City forest	0.79 3.94 - -	4.45 (VH)
Pamusian	254	14.131	0.810		44.5	Public Facility, High Pop Density , Mining Area, Trade Zone, Industrial Area, Mangrove Forest, City forest	10.59 5.72 - 3.83 - 24.24 -	3.25 (H)
Kampung Satu Skip	5061	8.410	0.295	5.08	6.5	Public Facility, Greenbelt, Medium Pop. Dens. Mining Area, Military Area, Mangrove Forest, Conserv. Forest	- - 1.11 - - 5.40 -	2.57 (M)
West Tarakan	**2934**	67.780		14.22				
Karang Balik	80	6.856				High Pop. Density Trade zone, City forest,		
Karang Rejo	76	7.875	0.234	2.33	6.15	High Pop. Density Trade Zone, Industrial Area, City forest Mangrove Forest	1.62 - 1.83 0.22 2.70	3.82 (H)
Karang Anyar	561	27.573				Juata Airport, High Pop. Density Mining Area, Trade Zone, Military Area, Protected Forest, Mangrove Forest, City Forest		
Karang Anyar Pantai	851	17.855	0.983	6.06	222	Juata Airport, High Pop Density Mining Area, Trade Zone, Education Zone, Military Area, Mangrove Forest, City forest	20.30 108.92 - - 10.20 - 62.42 15.27	3.70 (H)
Karang Harapan	1221	7.621	0.925	5.83	188.50	Nursery Barn Medium pop. Dens. Livestock zone, Trade Zone, Industrial Area, Mangrove Forest,	25.71 98.23	3.56 (H)

Sub-districts/ Villages	Area (Ha)	Number of Population in 2010	Inundation in 2030			Facilities and Land Use Type	Inundated Area (Ha) in 2030	Risk Level
			Distance (km)	Shoreline (km)	Area (Ha)			
						City forest Tourism Area	21.95 36.24	
North Tarakan	**10649**	21.983		40.87				
Juata Permai	1423	6.877	0.418	8.48	107.84	Medium Pop. Dens. Livestock zone, Trade Zone, Government zone, Industrial Area, Mangrove Forest, City forest	 66.74 38.91 	3.06 (H)
Juata Kerikil	1059	4.705				Landfills, High Pop Density Mining Area, Trade Zone, Protected Forest, City forest		
Juata laut	8454	10.401	1.052	32.39	236.84	Cemetery, Landfills, Greenbelt, High Pop Density Tourism Area, Mining Area Trade Zone, Govern. zone, Industrial Area, Mangrove Forest, Protected Forest, City forest	- - - 13.54 13.38 - - - 19.45 172.30 - -	2.94 (M)

Chapter VII Adaptation Strategies

This chapter will brief strategies proposed for adapting to plausible climate change impact in Tarakan City. In principle, it is consists of four main substances as follows:

a) adaptation approach, in which explains the general idea of adaptation in coastal
b) adaptation concept for Tarakan City,
c) compatibility description of adaptation and development plan, and
d) adaptation prioritization.

7.1 Adaptation Approach for Coastal Area

Adaptation to climate change is a process through which societies make themselves better able to cope with negative impact of climate change, or it also can be infer as the means to reduce the risk of losses. Adapting to climate change entails taking the right measures to reduce the negative effects of climate change (or exploit the positive ones) by making the appropriate adjustments and changes (UNFCCC, 2008). As a whole, adaptation to climate change will be influence by the large functions that shaped the adaptive capacity; e.g. economic circumstances, institutions, social system, governance, etc. However, in this context, adaptation means taking a comprehensive strategy in which being detailed through a specific adaptation action. In the future as in the past, the success of human adaptation to climate will depend heavily on development options and choices: a higher level of development is likely to produce greater adaptive capacity, but certain patterns of development can undermine these advances by exposing populations to ever-higher levels of climate risk.

Adaptation to climate change in coastal area, can be distinguished into soft and hard measurement. Hard measurement basically is an adaptation that consists of structural construction; e.g. construction of polder, sea wall, sea dykes, elevated housing, etc. The hard measurement can be applied both for protection as well as accommodation effort in adapting to climate change. On the other hand, adaptation also can be done through soft measurement; i.e. basically a non structural construction effort to adapt towards climate change. For instance, enactments of local regulation for coastal area, education, empowerment on coastal livelihood are among this type of adaptation.

Classification of adaptation actions in coastal area also can be based on the combination of time frame, stimulus or motivation, as well as its form; i.e. resulting the classification between reactive adaptation or anticipatory/planned/proactive adaptation. In term of time frame, as well as its stimulus for adapting, reactive refers to adaptation that is based on proven/observed climate impact. On the other hand, planned adaptation refers to adaptation actions that intentional and tends to anticipate future climate impact. In term of form, reactive adaptation aims only to alleviate impacts once they have occurred, as the form of planned adaptation is to reduce exposure to future risk. Decision over adaptation action that being selected probably will relate with the financial ability of particular country or area, for high-income countries and communities, coastal engineering can provide protection against all but the most extreme events, but elsewhere evacuation and retreat may be the only option Nicholls (2004); Nicholls and Lowe (2004). However, the decision about types of adaptation activities will be developed basically must be based on the level of climate risk on particular areas, thus it must inline and should be able to integrate into the development system that being practiced by particular area.

On the other hand, USAID (2009) listed some slightly different measures in adapting to climate change impact in coastal area; in which more comprehensive and did not limit only to the built or physical aspect of coastal area. In general, it was being divided into function and healthy coastal ecosystems, less exposed built environment, diversified livelihood, human safety, and planning and governance measurement. The first measurement, functioning and healthy coastal ecosystems, basically emphasize on the existence and conservation on coastal ecosystems property. For instance wetland protection, thus it would help to create buffer that may helpful in coping against weather events. Second measurement, less exposed built environment, basically emphasize on protection towards human properties and activities through both soft and hard structure. This measurement covers several activities such as beach and dune nourishment installation, practice of building standards, setbacks, living shorelines, and structural shoreline stabilization. The third measurement, diversified livelihoods, more suggests towards empowerment for supporting diversified livelihoods that more robust, even if impacts of climate change are occurring. As for the fourth measurement, it was more emphasize on human safety as its relation to risk reduction towards disastrous event caused by the climate risk. In addition, the fifth measurement was more into cross-cutting as planning and governance may create supporting and vital baseline for other adaptation actions to be a solid adaptation plan.

There were also several suggestions on how adaptation strategies and action should be applied for coastal area. Titus (2000), IPCC CZMS (1999) and UNFCCC (2006) classified three types of adaptation; i.e. protection strategy, retreat/planned strategy, and accommodate strategy. Protection strategy refers to an act to secure or protect people, economic activities, and other built environment at the exact existing location regardless the risk. Mostly it was in a form of building hard and soft structures; e.g. sea-walls, dykes, dune, beach nourishment, etc. The retreat strategy refers to adaptation action to move current built environment, infrastructure, and facilities. As for the accommodation strategy means that the people and built environment may still reside at current location but conduction several actions to cope and live side by side with the risk.

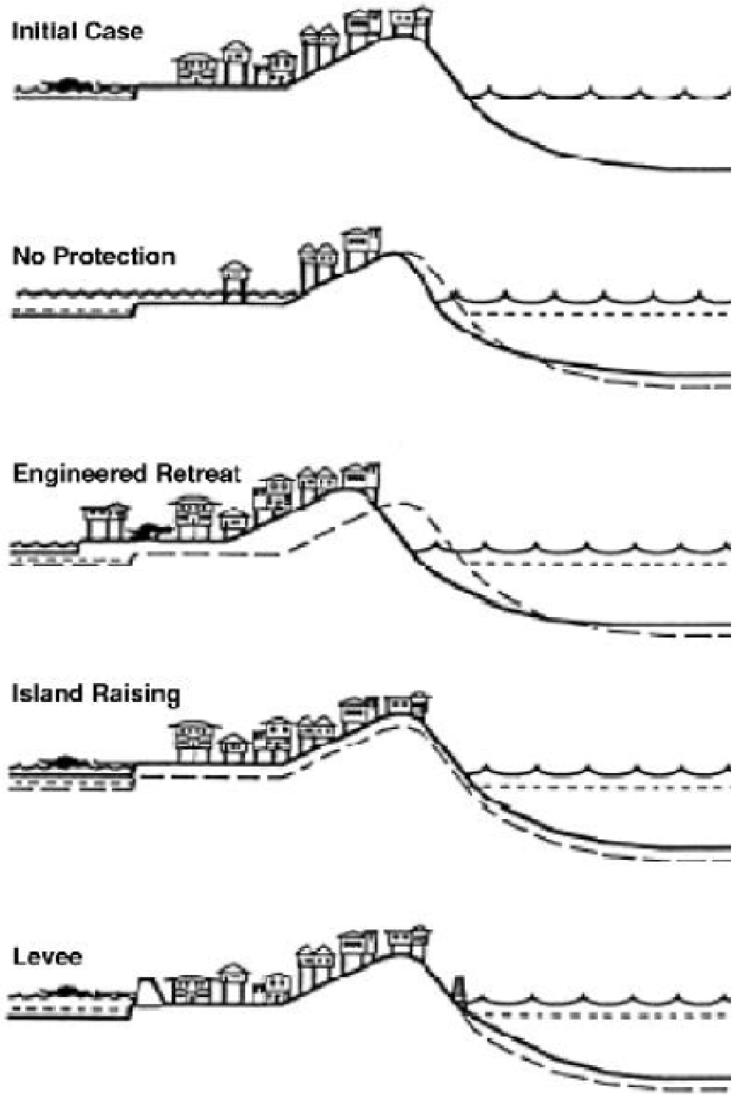


Figure 7.1 Strategies for Coping to Sea-level Rise (Source: J. Titus in NOAA, 2000)

7.1.1 Adaptation Approach: Protection

Protection approach is a form of adaptation to climate change in coastal area generally applied to location which ultimately demanding for protection and cannot be relocate elsewhere or having strategic functions. In this context, there are three types of protection that will be described (based on USAID, 2009); i.e. a) structural shoreline stabilization, b) beach and dune nourishment, and c) living shoreline stabilization. For each approach, explanation about the nature of approach, examples, suitable land use and/or urban activities, as well as supporting population/beneficiaries will be given.

a) Structural Shoreline Stabilization

This approach tries to harden or armouring the shoreline, it may ranges from technically complex structures to placement of construction debris serving as, for instance, bulkheads, revetments and seawalls. In relation to climate change impact, it can gives temporary buffer against the impacts of erosion and flooding caused by both permanent changes condition (e.g. SLR) and episodic events (e.g. storm surge). Structural shoreline stabilization techniques provide property owners with the ability to minimize the destructive effects of flooding, erosion, and land loss to their property that results from sea-level rise or increased storm activity.

Among many alternatives for structural stabilization, the selection should consider the structural design; i.e. environmental impacts and infrastructure performance. Several examples of structural stabilization are sea-wall, sea-dykes, jetty, and detached breakwater; in which use concrete and stone as its material. On the other hand, natural and/or used material also can be used; e.g. *Alat Pemecah Ombak* (APO) using bamboo or used tires.

Detached Breakwater	Jetty
	
Sea Wall	Sea Dykes

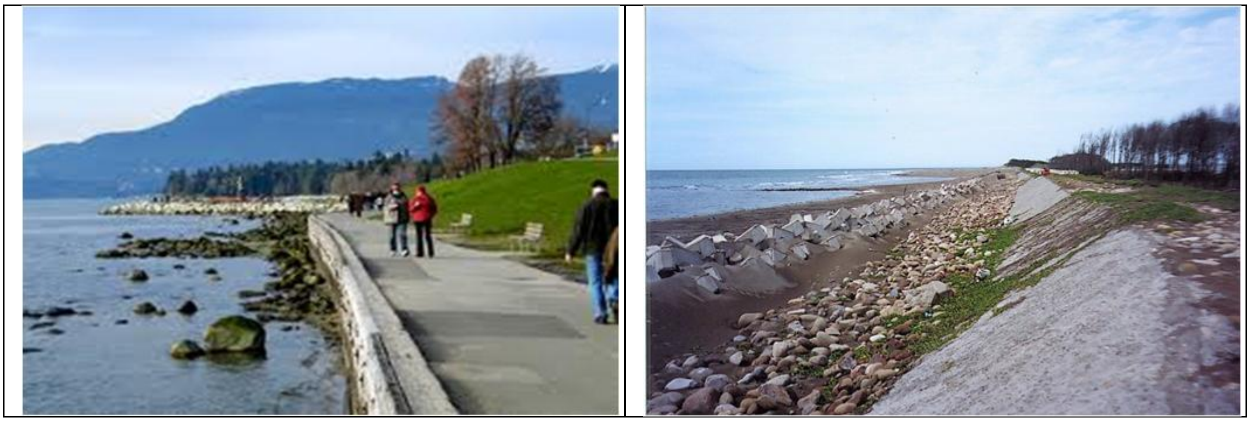


Figure 7.2 Examples on Shoreline Structural Stabilization

Structural shoreline protections are often used to protect property from climate risk in coastal area, especially when infrastructure loss is imminent or where space is limited in urban areas, thus retreat options is unfeasible. Therefore, the construction should assess its performance in protecting the property, potential loss of landscapes, public access, recreational opportunities, and environmental impacts. Implication on how structures might alter the economic, recreational, and esthetical properties of the shoreline and the impact on the public use of and private business activities along valuable shoreline; must be considered in selecting the more definite action. In addition, the construction process needs to be well communicated with the people surrounds. Actors reside and conduct activities within coastal areas that were unable or choose not to retreat should be educated about the designing, decision, implementation, and maintenance of the structural construction. In situation where the people reside or business activities located, they should be invited to participate in the development.

b) Beach Nourishment and Dune stabilization

Beach nourishment and dune stabilization is a process of adding sand to enlarge and enhance coastal beach and dune features, or planting grasses and native vegetation. In relation to climate change impact on coastal area, this effort may protects shores and restores beaches; serves as a “soft” buffer against flooding, erosion, scour and water damage. Beach nourishment may help to overcome the decrease of beach size caused by the SLR or eroded waves and current. This effort is a viable engineering alternative for shore protection and suitable in locations which experienced erosion. Beach nourishment can be more easily implemented in Tarakan since it did not required numbers stones or concrete for its materials, as it was hard to be provided in Tarakan.

Beach Nourishment	Sand Dune
	

Figure 7. 3 Examples on Beach Nourishment and Dune Stabilization

This effort can be applied in several locations in which the built area is still limited. Locations that consist of grasses, as well as native vegetation, are also appropriate to have beach nourishment as their adaptation. To some extent, application of this effort also can be defined as buffer area as well as conservation area, thus it would add the ratio of green open space area within the spatial plan. In addition, community surrounds need to be educated that beach and dune nourishment can provide valuable recreational and habitat area, as well as to be empowered to utilize the area for economic activities as long as it is friendly to preserve the beach and dune nourishment.

c) Living Shoreline Stabilization

Living shoreline stabilization basically is a management practice involving strategic placement of plants, stones, sand fill and other materials to achieve the dual goal of long-term protection/ restoration/ enhancement of shoreline habitats and maintenance of natural processes. This option may mitigate erosion, protect or restore natural functions of coastal area, and also protect people and ecosystems from climate change impacts. In addition to this effort, several supporting actions can be introduced; i.e. developing marine conservation agreements, assigning marine protected areas, as well as introducing payment for environmental services mechanism. The adaptation may provide nursery habitats for fisheries, ecosystems services for communities and their livelihoods; serves as a natural water filter, buffer against coastal ecosystems. In general sense, it may also works for both climate change mitigation and adaptation measure.

Figure 7.4 Coastal shoreline profile and Living Shoreline treatments

Figure 7.5 Soft Protection by using Vegetation

7.1.2 Adaptation Approach: Accommodation

Accommodation to climate change impact in coastal area basically emphasize effort to live alongside the risk of climate change impact, it may be through soft or hard measurement. In hard measurement context, the effort to accommodate was also being known as an effort to create a “flood-proofing” structure; i.e. protecting structures to be resilient enough to maintain its function even during the inundated or flooded period. Flood proofing can be done through alleviation for housing, buildings, roads, and other infrastructure. For housing or buildings, enhancement of basement can be an option. The basement can be used for daily activities, in addition during inundated period it can be flooded.

Accommodation approach will be effectively applied with support of building standard regulation as its soft measurement; e.g. building standards. Building standards should outline technical requirements for design and construction of residential and commercial structure. Technical and safety requirements for the design and construction will reduces risk of climate change impact for residential and commercial structures, promote people health and welfare, as well as increase human safety.

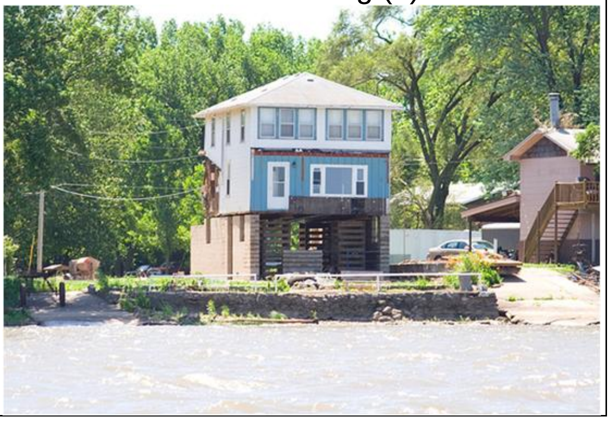
Flood Proofing (1)	Flood Proofing (2)
	

Figure 7.6 Examples on Accommodation Approach: Flood Proofing

Flood proofing will be suitable for dense built area in which its inhabitants or activities unlikely to be removed. As for major infrastructures, for instance main roads, the elevated roads should be constructed only in several sections, thus it will still give space for the water to flow upon and not get trapped within the roads. In addition participatory approach is suggested, in which it may nurture independent flood proofing effort to support government's flood proofing policy from government. This effort also should be sensitive in incorporating local knowledge or pre-existed flood proofing effort done by the community.

7.1.3 Adaptation Approach: Retreat / Coastal Setback

Retreat, or also known as setback action, tries to provide distance between built areas with the coastal feature. It creates buffer zone between shoreline development and the sea, thus providing protection against the destructive effects of erosion or land loss resulted from accelerated sea-level rise or increased storm activity. Setbacks locate new development away from hazards, both seasonal and long term fluctuations in shorelines, or sensitive landforms. In addition, the approach also protects sensitive area from the impacts of development; i.e. includes maintaining natural shore dynamics and shorefront access.

In its application, setbacks for rural and urban shorelines may vary in term of introduced policies. Setbacks in urban areas are especially suitable for public shoreline walkways and landscapes that are designed to filter storm water to remove contaminants. A "no-build" development setback is most effective when implemented on a multi-lot scale, and is commonly used in low density areas without hardened shorelines. USAID (2009) gave indications on how setbacks approach being applied for different types on situation.

Table 7. 1 Evaluation for Coastal Setbacks and Its Adjustment

Coastal Area Situation	Coastal Area Setbacks
Severe shoreline erosion observed beyond setback distance from the shore	Revise setback regulation increase distance
Properties not subject to setback regulations suffer severe damage	Accelerate removal or relocation of buildings the setback distance
New construction observed in violation of setback regulation	Strengthen capacity for permitting, inspection, and enforcement; increase penalties

Source: USAID, 2009

7.1.4 Adaptation Approach: Integrated Coastal Zone Management

Integrated Coastal Zone Management (ICZM) or also sometimes being called as Integrated Coastal Management basically is a continuous and dynamic process of arrangement over sustainable use, development, and protection of coastal and marine areas and resources. This concept basically a multi-purpose oriented strategy that analyze and address implications of development, conflicting uses, and interrelationships between physical process and human activities in which promote linkages and harmonization among sectors and ocean activities (Cicin-Sain and Knecht, 1998). The impact of climate change in the form of sea level rise will require local and state policies to be revisited and adapt new management priorities regarding the sea level rise.

For Indonesian context, the concept of ICZM basically can be implemented as several Laws may support; i.e. Law 24/2007 on Disaster Management, Law 26/2007 on Spatial Planning, Law 27/2007 on Coastal and Small Islands, and Law 32/2009 on Environmental Protection. In relation to spatial planning process and products, ICZM can be used as baseline for deciding spatial structure and pattern (land use arrangement), both in General Spatial Plan (RTRW) level and Detailed Spatial Plan (RDTR). On the other hand, Law 27/2007 mandates government to enact several plans, for instance Action Plan for Coastal Management (*Rencana Aksi Pengelolaan Pesisir*) or Zoning Plan for Coastal Area. In addition, Law 32/2009 also suggests Local Government to conduct Strategic Environment Assessment (KLHS) and Environmental Management and Protection Plan (RPPLH), in which both of them consider impact of climate change.

Since ICZM is a multiple activities, thus the detailed action being taken will be site specific and depends on the current situation as well as future climate risk projection. As follows, USAID (2009) suggest several issues to be addressed in designing a more specific action of ICZM and its type's activities in Table 7.2.

- Compile information on the environmental, social and economic context (boundaries, stakeholders, threats) focusing on key issues in the coastal area

- Assess past events, current natural hazards, and potential future natural hazard risks;
- Analyze existing governance capacities to implement a coastal program. Include an evaluation of vulnerabilities and coping strategies to address natural hazards;
- Obtain climate projections and predictions provided in a way that can be used in impact and adaptation studies;
- Estimate costs, benefits and feasibility of alternative measures for key policy issues; and
- Conduct a range of activities to understand stakeholders' values and their perception on adaptation decisions, and the consequent barriers to adaptation.

Table 7.2 Examples of ICZM Activities

Types of Management	Description	Examples of Activities
Coastal watershed management	Integrated water resources management (IWRM) in the coastal context, which takes into consideration watershed and estuary management. An overarching approach or strategy that can be used to bundle a series of measures.	Preserves estuaries, which act as storm buffers and protect against coastal groundwater salinization.
Integrated coastal management	An overarching management approach or strategy involving planning and decision-making geared to improve economic opportunities and environmental conditions for coastal people. Can be used to bundle a series of measures.	Provides a comprehensive process that defines goals, priorities, and actions to address coastal issues, including the effects of climate change.
Spatial Area Management Planning	An overarching management approach or strategy for a geographic area of critical concern, where there is complex coastal management issues usually within the context of a coastal resources management program. Can be used to bundle and conflicts, including issues related to extreme climate a series of measures.	Improves the management of discreet geographic areas where there are complex coastal management issues and conflicts, including issues related to extreme climate events precipitation change, ocean acidification, sea level rise, and temperature change

Source: USAID, 2009

7.1.5 Monitoring and Evaluation on Climate Change Adaptation

Adaptation approaches, options, and practices can be developed through several elements; i.e. understanding due to the basic facts regarding climate change and how it would affect particular area (Tompkins et al, 2005), hazards information and its communication towards decision maker (Hay, 2009), as well as accurate and up-to-date information for addressing effective adaptation (Klein et al, 2001). Adaptation to climate change itself also should be considered as a multiple time efforts; i.e. a cycle in which each phase may affect decision over adaptation efforts (New Zealand CC Office). USAID (2009) suggest motivation and benefits for evaluating adaptation to climate change based on its types of activity as follows:

Table 7.3 Motivation and Benefit for Adaptation Evaluation

Type of Activity	Motivation for Evaluation	Benefit of Evaluation
One time Project	• Project completion • New or follow-on project	• Gauge project success • Compile lessons learned • Replicate project design
Place-based Plan or Program	• Planned/regular review • Special request from government • Unanticipated (e.g. result of natural disaster)	• Communicate performance • Adjust design of adaptation measures • Adjust implementation strategy • Identify and implement emergency measures • Compile lessons learned • Replicate plan or program
National / Regional Policy	• Planned/regular review • Special request from government • Unanticipated (e.g. result of natural disaster)	• Communicate performance • Guide design and implementation of new policies and adaptation measures • Identify and implement emergency measures • Compile lessons learned

Source: USAID, 2009

7.2 Concept of Adaptation in Coastal Area for Tarakan City

In term of the development of adaptation strategies for Tarakan City, in dealing with the risk caused by negative impact of climate change, basically aimed to be accomplished in an efficient way. Thus, it would be appropriate and avoid mal-adaptation. In doing so, the concept will be developed based on level of the risk and its regionalism (combination of coastal ecosystem and built environment condition), rather than the administrative division of the city itself. Therefore, the concept of adaptation for coastal area in Tarakan City was being divided into three areas; i.e. North Coast, West Coast, and East Coast.

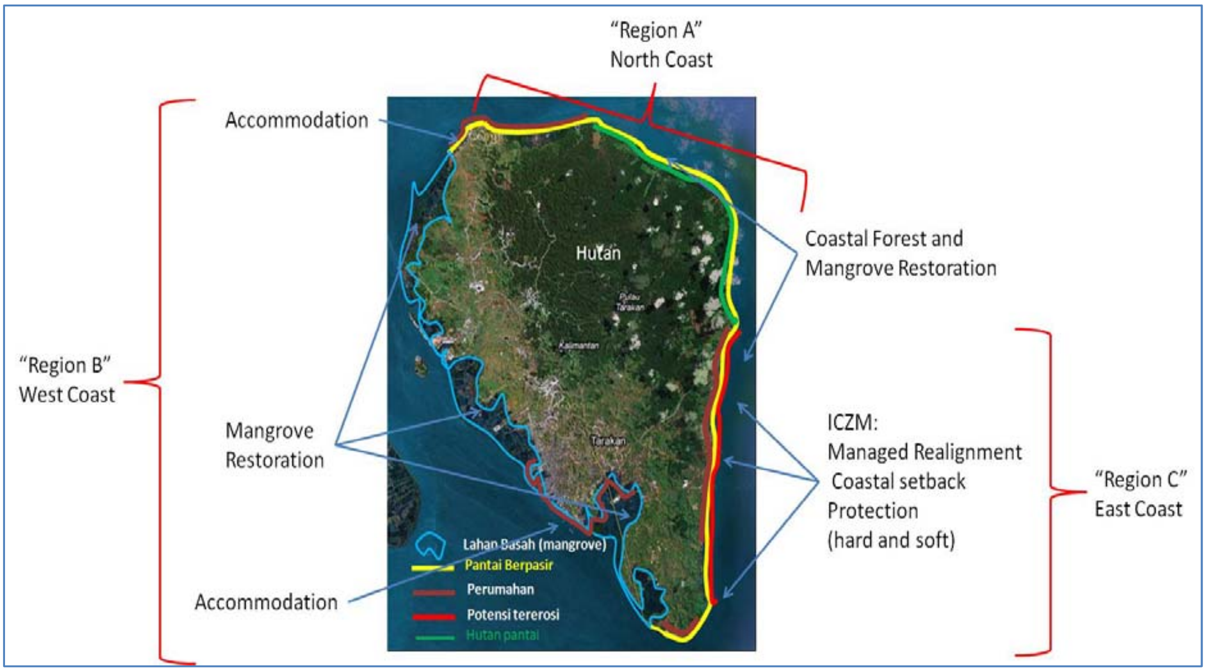


Figure 7.7 Adaptation Regionalism in Coastal Area

7.2.1 Adaptation Concept for North Coast of Tarakan City

This area covered all the shoreline within the Juata Laut Village, North Tarakan Sub-District. The total inundated area in this area by the year 2030 is 236,836 Ha with the level of risk mentioned as moderate. In detail, the inundated area consists of 13.54 Ha of high density settlement, 13.38 Ha of tourism area, and 0.016 Ha trade zone, 19.45 Ha industrial areas, and 172.30 Ha of mangrove area. Based on the situation, suitable adaptation concepts to be proposed to this region are mainly coastal forest and mangrove restoration (living shoreline) followed by accommodation – protection strategy for these settlements in the villages, especially in northeast part of Juata Laut village.

Coastal forest restoration strategy must be applied at the north – east area of Juata Laut Village. Types of plantations can be seed in supporting this strategy are mangrove and coastal pines. Restoration of the coastal forest can be done by the Tarakan City Government solely or through partnership with non-government organization or the community. In addition, such restoration also can be combined with local economic activities that may support community livelihood.

On the other hand, **the accommodation – protection strategy** can be introduced to the built area of Juata Laut Village (i.e., located at the north – west of the area). The accommodative adaptation must be taken into action are flood proofing by elevating the level of housing, industry, harbor, and other buildings within the area. It also should be noted that this effort should be supported by development of green-belt nearby the existing built area, thus it will limit the development.

On the other hand, **coastal forest restoration strategy** must be applied at the north – east area of Juata Laut Village. Types of plantations can be seed in supporting this strategy are mangrove and coastal pines. Restoration of the coastal forest can be done by the Tarakan City Government solely or through partnership with non-government organization or the community. In addition, such restoration also can be combined with local economic activities that may support community livelihood.

7.2.2 Adaptation Concept for West Coast of Tarakan City

The delineation of West Coast stretch from the Juata Permai Village (North Tarakan Sub-District), all of the all villages reside along shoreline in West Tarakan Sub-District and Central Sub-District, and Gunung Lingkas, Lingkas Ujung, and Mamburungan Villages (East Tarakan Sub-District). By the year 2030, from the risk map it may be inferred that this area consists of very high and high risk level of inundated area. In general, it was due to the fact that at present the coastal area already occupied by built environment, high density settlement, as well as important infrastructure, such as Juata Airport. Therefore, one of the main entry points for the adaptation strategy is accommodation and protection. However, there is also still some existed mangrove area along the West Coast area, thus it should be noticed that appropriate mangrove restoration still can be applied.

The Accommodation – Protection Adaptation

The Accommodation – Protection strategy basically should be apply to built area lies within West Coast of Tarakan in which cannot be and inefficient to be relocated. This strategy can be applied in term of flood proofing for buildings, sea-wall, jetty construction, beach nourishment, etc; however the decision over which adaptation action will be taken should be based on the characteristic of the village itself.

The Mangrove Restoration

Mangrove Restoration strategy in West Coast of Tarakan basically proposed to balance the accommodation – protection adaptation, in which this effort commonly known as living shoreline. Usage of living shorelines measures can stabilize shorelines and also help control erosion in estuaries, lagoons, and in riverside areas. In the sense that, it will not be a massive effort on the restoration, but more into land preservation effort that reduce demand to the accommodation – protection adaptation within built area. In practice, mangrove restoration can be also act as green-belt to limit the development of built area. Therefore, the role of local government is urgently required; i.e. Tarakan City Government based on current and planned development should identify each development locus and to purchase its surrounding area to be planned by mangrove.

Implementation of such living shorelines strategy, e.g. mangrove restoration, can be defined as well as vegetative buffer (green belt). Therefore, this strategy can also utilize and enhance current mangrove area. For instance, Karang Rejo has 2.7 Ha of mangrove area and Karang Anyar Pantai has 62.42 Ha; thus, these mangrove area can be assigned to be preserved.

7.2.3 Adaptation Concept for East Coast of Tarakan City

The East Coast area of Tarakan City consists of two villages; i.e. east part of Kampung Satu Skip Village (Central Tarakan Sub-District) as well as Mamburungan and Pantai Amal Village (East Tarakan Sub-District), as well as its surrounding. From the risk map, it can be seen that this area facing very high and high level of risk, even though that the total inundated area still smaller compare to the West Coast. Since the east coast of Tarakan City still un-intensively developed, thus the proposed strategy is Integrated Coastal Zone Management (ICZM). In this sense, the strategy combined both planned adaptation and protection adaptation. However it should be noted that the protection adaptation was being introduced as part of anticipatory effort, rather than a reactive one.

For east coast of Tarakan City, basically there are three major adaptation actions can be taken under the concept of ICZM; i.e. managed realignment, Coastal Setback, and Protection (hard and soft). As follows, here are the brief about each action:

a) Managed realignment

Managed Realignment is an important soft engineering coastal defense technique which aims to achieve sustainable flood defenses by recreating eroded salt marsh and mudflat habitat. This is done by creating new defenses further inland and allowing the existing defenses line to breach and the land to be tidally inundated. Managed realignment is also known as setback and managed retreat.

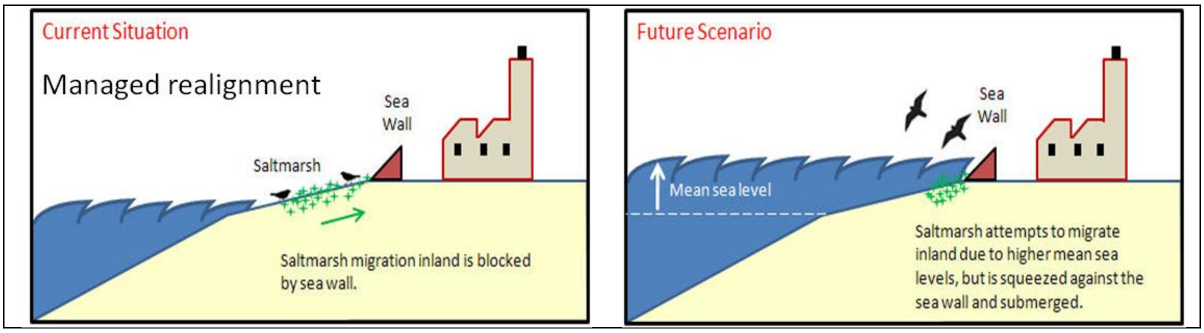


Figure 7.8 Managed Realignment

b) Coastal Setback

Coastal Setback basically more appropriate to be applied for particular specific area in East Coast of Tarakan City which were being planned to be developed as built area in few years time. Therefore, Government and the developer can control the site plan to be built in certain distance from the shoreline as an integrated design, thus basically the distance can be used as open space and the building complex are developed further behind.

Figure 7.9 Coastal Setback Implementation

c) Hard and Soft Protection

For East Coast of Tarakan City, currently some hard structures for shoreline protection have already been installed. However, it is impossible to protect the whole shoreline due to the inefficiency, thus the most appropriate ways is to developed combination of soft and hard protection.

7.3 Adaptation Compatibility

This sub chapter will brief the compatibility between adaptation strategies being proposed with the development system in Tarakan City especially the spatial one. Currently Tarakan City Government has enacted their General Spatial Plan (RTRW) and Detailed Spatial Plan (RDTR) for West Tarakan, however the RDTR for East Tarakan, Central Tarakan, and North Tarakan have not been enacted yet. Therefore, this sub chapter will provide compatibility to the of spatial development system.

Compatibility to the RTRW of Tarakan City being done through identification over spatial development programs defined in the document that located along the coastal area. Afterwards, to each program then being identified which strategy that suitable according to the adaptation concept. From the Table 7.9 below it can be seen that almost all of the programs can be enriched by related strategy. However, the compatibility also suggests that the initiatives to develop sea wall and green belt do not necessarily need to be done; hence it only should be developed in specific location that need protection from sea wall (hard measurement) or green belt. In addition, the program to delineate coastal area that have high level risk towards the climate change impact needs to be improved by introducing ICZM concept; i.e. can be mainstreamed to the enactment of RDTR for all districts.

Table 7.4 Compatibility Measurement between RTRW Tarakan City Development Program and Adaptation Strategy

NO	NAME OF PROGRAM	LOCATION ON COASTAL AREA	LOCATION BASED ON REGIONALISM	COMPATIBILITY WITH ADAPTATION STRATEGY

NO	NAME OF PROGRAM	LOCATION ON COASTAL AREA	LOCATION BASED ON REGIONALISM	COMPATIBILITY WITH ADAPTATION STRATEGY
1	Improvement of International Airport	Karang Anyar Pantai	West Coast	Accommodation and protection
2	Improvement of Local Port	Pantai Amal, Tj. Batu (Tarakan Timur), Tj. Pasir (Tarakan Timur)	East Coast	Hard protection
		Tj. Simaya (Juata Laut), Tj. Selayung (Juata Laut), Tj. Binalatung (Juata Laut), Juata Laut	West Coast	Accommodation and protection
3	Improvement of Local Dock	Mamburungan, Tj, Binalatung (Juata Laut)	West Coast	Accommodation and protection
		Pantai Amal, Tj. Pasir (Tarakan Timur)	East Coast	Hard protection
4	Improvement of Port Malundung and Tengkayu	Malundung (Lingkas Ujung), Tengkayu (Karang Rejo)	West Coast	Accommodation and protection
5	Area with High Risk due to Climate Change Impact Deliniation	Along Tarakan City shoreline	All Area	ICZM
6	Seawall and Green Belt Development	Along Tarakan City shoreline	All Area	***This program should be corrected based on compatibility of each location, and not necessarily need to be developed along the shoreline***
7	Development of Fishermen Housing Complex (Slum upgrading, housing in northern area)	Tj. Batu (Tarakan Timur), Tj. Pasir (Tarakan Timur),	East Coast	Coastal Setback
		Mamburungan	West Coast	Accomodation and protection
8	Development of market and services facilities	Juata Laut	North Coast	Accomodation and protection
		Pamusian, Karang Harapan, Sebengkok, Lingkas Ujung, Karang Rejo, Mamburungan, Kampung Empat, Juata Permai	West Coast	Accomodation and protection
9	Development of Warehouse	Tanjung Selayung (Juata Laut)	North Coast	Accomodation and protection
		Juata Permai, Mamburungan, Lingkas Ujung, Gunung Lingkas	West Coast	Accomodation and protection
10	Development of Timber Industry	Juata Permai, Kampung Empat, Mamburungan	West Coast	Accomodation and protection
11	Development of Shrimp Industry	Tanjung Selayung (Juata Laut)	North Coast	Accomodation and protection
		Pantai Amal	East Coast	Coastal Setback

NO	NAME OF PROGRAM	LOCATION ON COASTAL AREA	LOCATION BASED ON REGIONALISM	COMPATIBILITY WITH ADAPTATION STRATEGY
		Mamburungan	West Coast	Accomodation and protection
12	Development of small and medium industry	Juata Permai, Mamburungan	West Coast	Accomodation and protection
		Juata Laut	North Coast	Accomodation and protection
13	Development of fisheries area (Minapolitan)	Pantai Amal	East Coast	Coastal Setback
		Juata Laut	North Coast	Accomodation and protection
		Mamburungan	West Coast	Accomodation and protection
14	Development of Defense and Security Strategic Area	Mamburungan, East Mamburungan	West Coast	Accomodation and protection
15	Development of revetment	Pantai Amal	East Coast	Hard protection
16	Development of protection structure from abration	East Tarakan	East Coast	Hard protection
17	Protection of mangrove	Mamburungan, Pamusian, Karang Anyar Pantai, Karang Harapan, Juata Permai	West Coast	Mangrove Restoration
		Juata Laut, Kampung Satu Skip	North Coast	Coastal Forest Restoration

*) Note: the list of development programs gained from RTRW of Tarakan City which located along the coastal area

Compatibility assessment also provides several suggestions from the adaptation perspective for preparation of RDTR enactment in Tarakan City. As a coastal city, in general, the concept of ICZM should be looked as main consideration in developing the detailed plan. However, implementation of ICZM may different in each district since there will be difference in term of functions, condition, and main adaptation strategy to be included in RDTR. The level of RDTR plan is a detailed one, which is more physic oriented in implementing the general plan given by RTRW; i.e. contains regulation over zoning, building envelope, and may guide technical specification of spatial allocation. It should be noted that by considering the adaptation concept proposed in this study, thus the RDTR must consider adaptation strategy based on its regionalism in which emphasize on functionality to enrich the substance of RDTR itself. As follows, here is the summary of compatibility between adaptation concept and RDTR in Tarakan City:

Table 7.5 Compatibility of Adaptation Strategy towards RDTR in Tarakan City

Name of RDTR	Location (Sub Districts)	Role and Brief of Location	Compatibility to Adaptation Strategy
RDTR of West Tarakan (Status: in process)	Karang Anyar Pantai, Karang Rejo, Karang Balik*, Karang Anyar*, Karang Harapan	• Current and future city center (PPK Kota Lama) • Main role: trade, services, government, settlement, defense • Main concept in RDTR: development will emphasize on controlling over urban activities through zonation	• Located in West Coast Region • Its ICZM should emphasize on accommodation and protection actions. • Analysis of RDTR should be enriched first by the risk map of SLR in appropriate scale. • Zoning regulation must clearly define which zone will practice accommodation or protection actions. • In Karang Rejo and Karang Anyar Pantai which still have mangrove needs to implement combination of mangrove restoration and living shoreline protection. • Each regulation on building envelope and guidance of infrastructure development must define accommodation or protection action to be included.
RDTR of North Tarakan (Status: have not planned yet)	Juata Permai, Juata Laut, Juata Kerikil*	• Future city center (PPK Kota Baru) in Juata Permai • Main role based on RTRW: trade and service, government, settlement	• Included in both West and North Coast regionalism. • Development of new city center should define detailed accommodation to be taken with possible coastal setback. • Current coastal forest must be restored and preserved, thus have its own zone. • Planned built area, zoning regulation, and building envelope must clearly define accommodation action to be taken based on overlay with SLR risk map.
RDTR of Central Tarakan (Status: have not planned yet)	Selumit Pantai (west), Pamusian (west), Sebengkok (west), Kampung Satu Skip (west – east), Selumit*	• West coast district designated as part of Sub PPK Lama Barat, role: settlement and trade – services area. • East coast district designated as Sub PPK Baru Timur, role: settlement, tourism	• Having two coastal area; i.e. in west coast and east coast. • West coast must designated to practice accommodation – protection strategy • Zoning in east coast must designated to restore coastal forest with possibility to permit tourism activity • Planned built area, zoning regulation, and building envelope must clearly define accommodation action to be taken based on overlay with SLR risk map.
RDTR of East Tarakan (Status: have not planned yet)	Lingkas Ujung, Mamburungan, Mamburungan Timur, Kampung Empat, Kampung Enam*, Pantai Amal	• Some district included in Sub PPK Lama Selatan to play role as military facilities and tourism • Some districts included in Sub PPK Lama Timur to play role as education tourism, and settlement area	• Located in east coast region • Development of new built area must practice coastal setback • RDTR should plan managed coastal realignment • Each regulation on building envelope and guidance of infrastructure development must define hard or soft protection action to be included based on overlay with SLR risk map.

*) Non coastal area

7.4 Adaptation Priority Scenarios

In order to developed appropriate adaptation measurement, aside of consideration over the risk level, prioritization also should consider several more detailed factors came from the vulnerability component of particular area. In other word, adaptation is prioritized in one or more sub-districts in which having very high or high level of risk as well as one or some components of vulnerability with very high or high levels, in attempts of reducing levels of vulnerability and risk accordingly that are attached to these sub-districts.

In this context, risk level information for each sub-district then being short-listed several times using specific additional components; i.e. number of population, vital infrastructure and existence of built area, as well as wetlands and mangrove area. Four scenarios of adaptation priority are then developed based on these criteria and then implemented to each twenty districts in Tarakan City. Detailed assessment on these scenarios is, surely, still needed to provide more exact prioritization, through which adaptation options would be mainstreamed into local development and spatial plans. However, this process is not included in this report.

7.4.1 Pre-Condition Scenario for Prioritization Based on Risk Level Criterion

In this scenario, by sorting the list of sub-districts according to risk level (Table 7.4), there are five villages in which having very high level of risk, i.e., Sebengkok and Selumit Pantai in Central Tarakan sub-district as well as Lingkas Ujung, Kampung Empat, and Gunung Lingkas in East Tarakan sub-district.

From this sorting it can also be resulted that there were five villages in which having non-risk level towards the inundation resulted by the sea level rise; i.e. Kampung Enam, Selumit, Karang Balik, Karang Anyar, and Juata Kerikil. Therefore, all of the five villages – which become non-coastal villages – will not be included for the following short-list. On the other hand, the table below presents the short-list of the remaining fifteen villages with particular risk level to the SLR, thus this table will be used for further short-list activities.

Table 7.4 Sorted Sub-Districts Based on Risk Level

No	Sub-District	Villages	Number of Population	Inundation in 2030			Risk Level	
				Distance (km)	Shoreline (km)	Area (ha)		
1	**Central Tarakan**	Sebengkok	15019	0.466	4.98	5.42	4.45	VH
2	**Central Tarakan**	Selumit Pantai	16347	0.467	7.15	18.89	4.26	VH
3	**East Tarakan**	Lingkas Ujung	10409	0.719	10.49	78.528	4.18	VH
4	**East Tarakan**	Kampung Empat	4529	1.173		56.532	4.18	VH
5	**East Tarakan**	Gunung Lingkas	7905	0.573		30.254	4.05	VH
6	**West Tarakan**	Karang Rejo	7875	0.234	2.33	7.15	3.82	H
7	**West Tarakan**	Karang Anyar Pantai	17855	0.983	6.06	222.78	3.7	H
8	**East Tarakan**	Pantai Amal	4469	0.268	14.62	149.16	3.69	H
9	**West Tarakan**	Karang Harapan	7621	0.925	5.83	188.501	3.56	H
10	**East Tarakan**	Mamburungan	7633	1.555	20.99	200.66	3.53	H
11	**Central Tarakan**	Pamusian	14131	0.81		44.33	3.25	H
12	**East Tarakan**	Mamburungan Timur	2531	0.113	0.17	1.67	3.24	H
13	**North Tarakan**	Juata Permai	6877	0.418	8.48	107.842	3.06	H
14	**North Tarakan**	Juata laut	10401	1.052	32.39	236.836	2.94	M
15	**Central Tarakan**	Kampung Satu Skip	8410	0.295	5.08	29.03	2.57	M

7.4.2 Prioritization Scenario Based on Risk Level and Population Number Criteria

One of the main considerations for prioritizing accommodation and protection adaptation strategy should be based on the population existence. In this sense, the more populated of an area it may require more protection or endorsement towards accommodation, since the setbacks/retreat strategy would be unlikely to be planned.

For Tarakan City, the top-five risky villages sorted from the largest population are Karang Anyar Pantai, Selumit Pantai, Sebengkok, Pamusian, and Lingkas Ujung. Those villages have very high and high level of risk. Therefore, those five villages need to be prioritized for implementation of the accommodation and protection strategy in Tarakan City. In detail, table below give information about the short-list of risk sub-districts based on the number of population.

Table 7.5 Sorted Sub-Districts Based on Number of Population

No	Sub-District	Villages	Number of Population	Inundation in 2030			Risk Level	
				Distance (km)	Shoreline (km)	Area (ha)		
1	**West Tarakan**	Karang Anyar Pantai	17855	0.983	6.06	222.78	3.7	H
2	**Central Tarakan**	Selumit Pantai	16347	0.467	7.15	18.89	4.26	VH
3	**Central Tarakan**	Sebengkok	15019	0.466	4.98	5.42	4.45	VH
4	**Central Tarakan**	Pamusian	14131	0.81		44.33	3.25	H
5	**East Tarakan**	Lingkas Ujung	10409	0.719	10.49	78.528	4.18	VH
6	**North Tarakan**	Juata laut	10401	1.052	32.39	236.836	2.94	M
7	**Central Tarakan**	Kampung Satu Skip	8410	0.295	5.08	29.03	2.57	M
8	**East Tarakan**	Gunung Lingkas	7905	0.573		30.254	4.05	VH
9	**West Tarakan**	Karang Rejo	7875	0.234	2.33	7.15	3.82	H
10	**East Tarakan**	Mamburungan	7633	1.555	20.99	200.66	3.53	H
11	**West Tarakan**	Karang Harapan	7621	0.925	5.83	188.501	3.56	H
12	**North Tarakan**	Juata Permai	6877	0.418	8.48	107.842	3.06	H
13	**East Tarakan**	Kampung Empat	4529	1.173		56.532	4.18	VH
14	**East Tarakan**	Pantai Amal	4469	0.268	14.62	149.16	3.69	H
15	**East Tarakan**	Mamburungan Timur	2531	0.113	0.17	1.67	3.24	H

7.4.3 Prioritization Scenario Based on Risk Level and Vital Infrastructure and Built Area Criteria

Aside of population, the accommodation and protection adaptation strategy also should considers the existence and/or planned vital infrastructure and built area in (it may be settlement, industrial area, military, facilities, mining facilities, etc.) in Tarakan City.

From the sorting based on existence as well as planned vital infrastructure and built area, there are top-five risky villages; i.e. Karang Harapan (with the total area of vital infrastructure and built area reaching 160.18 Ha), Karang Anyar Pantai (139,42 Ha), Mamburungan (117,58 Ha), Pantai Amal (110,7 Ha), and Juata Permai (66,74 Ha).

Karang Harapan, Juata Permai, and Mamburungan villages up until year 2030 will have significant industrial area prone to the inundation, thus protection is needed. On the other hand, villages with significant settlement that are prone to inundation are Karang Anyar Pantai, Kampung Empat, and Pantai Amal need to be prioritized. In addition, Karang Anyar Pantai also required further protection for vital infrastructure, as the Juata Airport is laid within the village. In detail, this table below gives information regarding the sort based on vital infrastructure and built area.

Table 7.6 Sorted Sub-Districts Based on Vital Infrastructure and Built Area

No	Sub-District	Villages	Vital Infrastructure & Land use (Built Area)	Inundation in 2030			Risk Level	
				Distance (km)	Shoreline (km)	Area (ha)		
1	**West Tarakan**	Karang Harapan	160.18	0.925	5.83	188.501	3.56	H
2	**West Tarakan**	Karang Anyar Pantai	139.42	0.983	6.06	222.78	3.7	H
3	**East Tarakan**	Mamburungan	117.58	1.555	20.99	200.66	3.53	H
4	**East Tarakan**	Pantai Amal	110.70	0.268	14.62	149.16	3.69	H
5	**North Tarakan**	Juata Permai	66.74	0.418	8.48	107.842	3.06	H
6	**East Tarakan**	Lingkas Ujung	61.61	0.719	10.49	78.528	4.18	VH
7	**East Tarakan**	Kampung Empat	55.12	1.173		56.532	4.18	VH
8	**North Tarakan**	Juata laut	46.37	1.052	32.39	236.836	2.94	M
9	**East Tarakan**	Gunung Lingkas	21.92	0.573		30.254	4.05	VH
10	**Central Tarakan**	Pamusian	20.14	0.81		44.33	3.25	H
11	**Central Tarakan**	Selumit Pantai	17.73	0.467	7.15	18.89	4.26	VH
12	**Central Tarakan**	Sebengkok	4.73	0.466	4.98	5.42	4.45	VH
13	**West Tarakan**	Karang Rejo	3.45	0.234	2.33	7.15	3.82	H
14	**Central Tarakan**	Kampung Satu Skip	1.11	0.295	5.08	29.03	2.57	M
15	**East Tarakan**	Mamburungan Timur	0.28	0.113	0.17	1.67	3.24	H

7.4.4 Prioritization Scenario Based on Risk Level and Size of Wetland and Mangrove Area Criteria

As for living shoreline and environmental protection adaptation strategy, basically it will be suitable to be implemented for sub-districts which have a big amount of wetlands and/or mangrove area. Therefore, the priority may come from the sort based on size of wetlands and mangrove area. In this context, the top-five villages of Tarakan City are Juata Laut, Karang Anyar Pantai, Juata Permai, Lingkas Ujung, and Pamusian. In detail, it can be seen from the table below:

Table 7.7 Sorted Sub-Districts Based on Wetlands and Mangrove Area

No	Sub-District	Villages	Size of	Inundation in 2030	Risk

			Wetlands & Mangrove Area	Distance (km)	Shoreline (km)	Area (ha)	Level	
1	**North Tarakan**	Juata laut	172.30	1.052	32.39	236.836	2.94	M
2	**West Tarakan**	Karang Anyar Pantai	62.42	0.983	6.06	222.78	3.7	H
3	**North Tarakan**	Juata Permai	38.91	0.418	8.48	107.842	3.06	H
4	**East Tarakan**	Lingkas Ujung	38.85	0.719	10.49	78.528	4.18	VH
5	**Central Tarakan**	Pamusian	24.24	0.81		44.33	3.25	H
6	**West Tarakan**	Karang Harapan	21.95	0.925	5.83	188.501	3.56	H
7	**East Tarakan**	Gunung Lingkas	8.33	0.573		30.254	4.05	VH
8	**East Tarakan**	Pantai Amal	7.31	0.268	14.62	149.16	3.69	H
9	**East Tarakan**	Mamburungan	5.45	1.555	20.99	200.66	3.53	H
10	**Central Tarakan**	Kampung Satu Skip	5.40	0.295	5.08	29.03	2.57	M
11	**West Tarakan**	Karang Rejo	2.70	0.234	2.33	7.15	3.82	H
12	**East Tarakan**	Kampung Empat	1.43	1.173		56.532	4.18	VH
13	**Central Tarakan**	Sebengkok	0.00	0.466	4.98	5.42	4.45	VH
14	**Central Tarakan**	Selumit Pantai	0.00	0.467	7.15	18.89	4.26	VH
15	**East Tarakan**	Mamburungan Timur	0.00	0.113	0.17	1.67	3.24	H

Chapter VIII Conclusions

As a typical small island, Tarakan is strongly exposed to some coastal hazards due to climate change stimuli such as sea-level rise, La-Nina, surges, and wind waves, especially in the extreme tidal condition of highest high water level.

Interestingly, Tarakan is also a representative area that is vulnerable to climate change due to its administrative status as a city which has quite dense population and high economic activities. Almost 80% of total population and some vital infrastructures such as airport, harbors, oil refineries, government, business and industrial areas are mostly vulnerable living to the coastal hazards. Among 20 villages, only five ones have no shoreline or contact with saline water through estuaries, i.e. Juata Kerikil in North Tarakan district, Karang Balik and Karang Anyar in West Tarakan district, Selumit in Central Tarakan district, and Kampung Enam in East Tarakan district; therefore, they are called as non-coastal sub-districts

This risk assessment showed that the Tarakan coastal areas could be divided into three regions due to typological characteristics. As consequences, three types of concept of adaptation options are recommended from this assessment to the Tarakan City Government. Characteristics and related adaptation options. These regions are:

- Region A (north coast), which typically comprises dense forests, wetlands, and mangroves along Juata Permai and Juata Laut villages. As a result, adaptation concepts to be proposed to this region are mainly coastal forest and mangrove restoration (living shoreline) followed by accommodation – protection strategy for these settlements in the villages.
- Region B (west coast), which has typical dense population (settlements) and economic activities, and also containing some wetlands and mangroves. Concepts of adaptation proposed in this region are accommodation – protection strategy followed by mangrove restoration (living shoreline).
- Region C (east coast), which will mainly be developed as coastal tourism areas (Pantai Amal) in the future as it has benefit of sandy beach. However, development in this region is constrained by potentially high abrasion or

erosion as it is exposed to daily high wind waves coming from the Makassar Strait. Therefore, concept of integrated coastal zone management (ICZM) is proposed to be implemented in this region, especially by managed realignment, coastal setback, and hard and soft coastal protection.

In term of implementation of those adaptation options, there are four scenarios of adaptation prioritization according to criteria of risk level, number of population, vital infrastructure and existence of built area, as well as wetlands and mangrove area.

- There are five villages in which having very high level of risk towards the coastal inundation hazard, i.e., Sebengkok and Selumit Pantai in Central Tarakan district as well as Lingkas Ujung, Kampung Empat, and Gunung Lingkas in East Tarakan district.
- The top-five risky villages with largest population are Karang Anyar Pantai, Selumit Pantai, Sebengkok, Pamusian, and Lingkas Ujung. They need to be prioritized for implementation of the accommodation and protection strategy
- The top-five risky villages with largest vital infrastructure and built areas require either soft or hard protection strategy to be prioritized, i.e. Karang Harapan, Karang Anyar Pantai, Mamburungan, Pantai Amal, and Juata Permai.

  Other reasons for prioritizing the coastal protection strategy are that: Karang Harapan, Juata Permai, and Mamburungan villages up until year 2030 will have significant industrial area, while Karang Anyar Pantai, Kampung Empat, and Pantai Amal have significant settlements, especially Juata Airport in Karang Anyar Pantai.
- Forest and mangrove restoration, living shoreline and environmental protection adaptation strategies become most priority in the top-five villages with largest sizes of forest, wetlands and mangrove areas, i.e. Juata Laut, Karang Anyar Pantai, Juata Permai, Lingkas Ujung, and Pamusian.

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