CIA2009-04-GAOL

PROCEEDINGS OF WORKSHOP

INCREASING CAPACITY OF LOCAL SCIENTISTS FOR CLIMATE CHANGE IMPACT & VULNERABILITY ASSESSMENT ON INDONESIA ARCHIPELAGO:

WORKSHOP IN IN-SITU/SATELLITE SEALEVEL MEASUREMENT

DELAMER HOTEL, PUNCAK INDONESIA.

10-12 NOVEMBER 2010

ASIA PACIFIC NETWORK FOR GLOBAL CHANGE RESEARCH (APN)

DEPARTMENT OF MARINE SCIENCE AND TECHNOLOGY
BOGOR AGRICULTURAL UNIVERSITY
2010

PREFACE

This Proceedings is a collection of workshop of In situ/satellite sea level measurement have done in Delamer Hotel, Puncak, Indonesia on November 10-12, 2010. A task as this would have been impossible without the untiring effort of Ms Aninda, Fina, Hanum, Mr Riza and Windra. Many people have also involved. Our thanks to all of them.

Editorial

(Jonson Lumban Gaol)

CONTENTS

IMPACTS AND ADAPTATION OF SEA LEVEL RISE IN COASTAL AND SMALL ISLANDS

Dr. Subandono Diposaptono
Director of Coastal and Marine, Ministry of Marine Affair and Fisheries, Indonesia.

1. Background

Based on a study of the IPCC - Inter-Governmental Panel on Climate Change - (2007) showed that the rising world temperatures especially during the period 1990 to 2006. The records show an increase in global temperatures to 0.76 degrees C since the 1800s. The mean sea level was also increased by an average of 1.8 mm per year in global the period 1961 until 2003. Therefore, is predicted that sea level will rise up to 0.17 m in the 20th century.

The climate change impact on human life and basically human activities had a role in global warming since the mid-20th century. Global warming will continue to increase with a higher acceleration in the 21st century if no effort to reduce them. Global warming is caused climate change and increase in frequency and intensity of extreme climate.

Coastal regions and small islands is one of the areas potentially affected significantly of climate change. It is generally agreed that climate change will exacerbate problems of synergy that currently exist in coastal regions and small islands such as the degradation of ecosystems, pollution, erosion, water supply, and biodiversity. The IPCC also states that global warming could cause significant changes in physical and biological systems. Coastal communities, and small islands which generally have limited resources, living as fishermen or fish farmers, limited education, and infrastructure, will suffer a great impact.

Policies and programs need to be done to significantly reduce vulnerability and increase community capacity (human system) and the ecosystems of coastal areas and small islands in anticipation of the negative impacts of climate change.

2. Vulnerability and Impacts on Coastal Areas

In general, the impact of global warming for coastal and small islands as in Figure 1. These impacts include:

2.1. Sea Level Rise

Global warming is not the only causing factor of sea levels rising. In general. the cause factors of rising sea levels rise can be classified into 3 factors: (i) global. (ii) regional and (iii) local. Changes in sea level due to the global factor is the main factor that very concern in the 21st century because it can cause coastal inundation. Regional factors are generally caused by tectonic activity in a region. While local factors occurs mainly by the process of subsidence due to changes in the soil and underground fluid changes. The follow-up impact of sea level rise include;

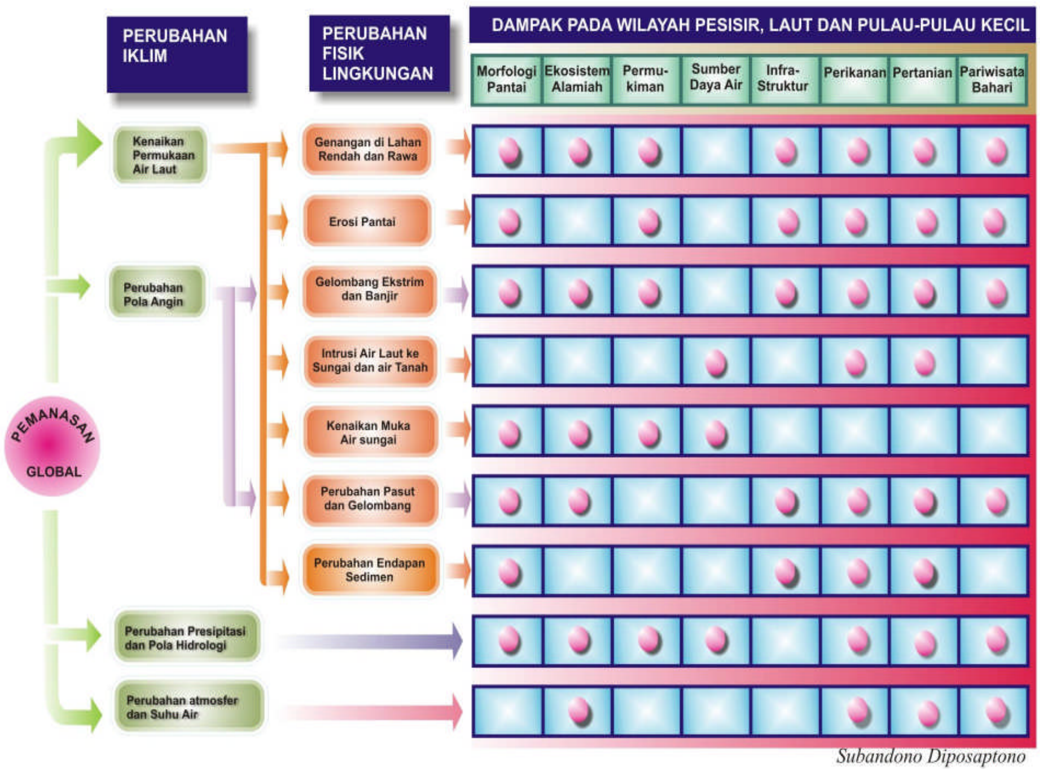


Figure 1. The impact of global warming on the coastal environment and small islands.

2.1.1 Exposure of coastal zones

- Influence the form of land and ecosystem such as sandy beaches, rocky beaches, cliffs the tidal plains, coral reefs, and mangroves.
- Increase the inundation of residential areas, Ports, industries, power plants, tourist facilities, and other facilities in the coastal region.
- Assuming the Indonesia coastline is 81.000 km, coastal inundation due to SLR 1m average is 50 m wide, it means that coastal land (including small islands) are flooded in 100 years to reach 405,000 ha or 4,050 ha / year.
- Hydraulic regime changes that affect the mangrove ecosystem.

2.1.2 Coastal Erosion

The impact of climate change and sea level rise is superposition with erosion trend that has happened now. so that later Indonesia will require effort and huge cost to overcome erosion.

2.1.3 Floods

Increasing the frequency, and intensity of flooding due to the effects of damming by the SLR which reduces water flow velocity, and increase the rate of sedimentation in the estuary. Coastal city like Jakarta will face increasingly severe floods in the future.

2.1.4 Sea Water Intrusion

SLR also resulted in the volume of sea water coming into the mainland through the river will be even greater. Sea water is pushed deep into this land is a problem for coastal towns that rely raw water from rivers.

2.1.5 Impact on infrastructure in coastal areas

SLR also affects the function of some facilities such as ports, fishing ports, an artificial island (man made islands), hoarding of land, coastal protective structures, drainage systems and others infrastructure.

2.1.6. Vulnerability and Impact on Fisheries Activities

Aquaculture

Fishing activity is very vulnerable to the impacts of climate change because its location is in the lowland (low lying area). For aquaculture activities, the main impact of the cultivation area of inundation, loss of economic assets and infrastructure, fisheries, increased erosion and destruction of cultural soil in coastal areas and biodiversity of coastal and small islands.

Losses will be suffered by the coastal communities and fishing gear and fish farmers in the form:

- Environmental degradation of coastal and small islands due to coastal erosion. sea water intrusion, and pollution
- Reduced productivity of fisheries due to the destruction of mangrove ecosystems and coral reefs from rising sea surface temperatures and changes in groundwater regime.
- Damage to land due to inundation by aquaculture and sea water flooding caused by rising sea water faces
- Damage to homes and the potential loss of life due to extreme events such as tropical storms and high waves.

To calculate the economic losses still require more detailed studies related to the economic value of resources, productive land, economic activity, and infrastructure in coastal areas. Indonesia has 400.000 ha of aquaculture land and fisheries infrastructure. Inundation of land, of course, would disrupt production, especially shrimp which is a strategic export commodity. In addition, the impact of climate change will also exacerbate the coastal villages ± 8.000 with socio-economic conditions of population of 16 million with the poverty index reached 32%.

3. Vulnerability and Impacts on Small Islands

From all these potential impacts, communities, and ecosystems of small islands has vulnerability and the greatest risk to climate change. This is due to the small islands:

* The capacity of adaptation to society in small islands is relatively weak due to lack of supporting infrastructure, education level, far from the reach of administrative and social services so that their vulnerability is higher.

* Projected sea level rise will face increasing erosion of small islands; loss of productive land is relatively limited, increasing the risk of storms, sea water intrusion which would disrupt water supply on the island.

The sectors most vulnerable to climate change impacts are:
a. Water Resources,
b. Resources of small islands,
c. Agriculture, fisheries and food security,
d. Biodiversity,
e. Settlement,
f. The economy and social life of society,
g. Infrastructure and transport,

Without any real effort, then the predicted impacts of climate change will further enhance socio-economic problems of society, particularly the level of poverty of small islands (Fig. 2.).

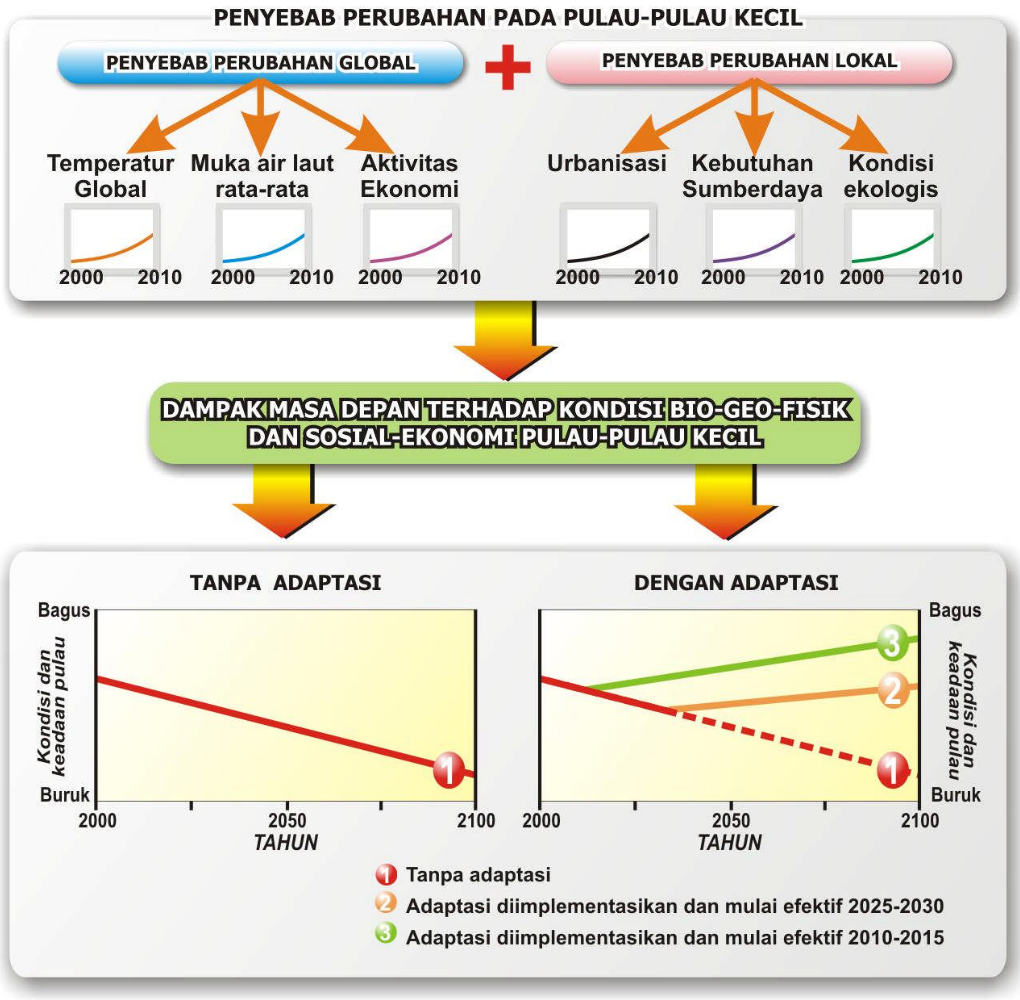


Figure 2. Climate change and its impact on the system of small islands (source IPCC 2007).

For small islands located and serves as a base point or a territorial boundary. global warming with all its impact will be a threat in the form:

- The physical form of the loss and / or sinking of the island.
- Socially, existence of dislocation / relocation of the island communities due to environmental conditions are not suitable to sustain life.
- Reduce resistance and national security in these areas so prone to actions that harm the national interest, such as smuggling, drug distribution, piracy, and so forth.

IV. Case Study of Central Java and in particular the City Semarang and Pekalongan Regency

Sea Level Rise (SLR) has been felt by almost all regions in Indonesia waters, this can be seen from some tidal data in some areas that show such phenomena. SLR occurs among others in the area of Semarang during 1985-2008 (23 years) of 7.74 mm / year. Jakarta was 8.5 mm / year and Jepara of 8.9 mm / year.

To check or change the dynamics in the coastal area of Semarang, carried out simulations using satellite image data that has been equipped with a high point. The simulation scenarios used using sandstone rising sea water by an average of 7.74 mm/year, and combined with land subsidence (land subsidence) in the region. The total area of the flooded area of the simulation results of 746.45 ha (year 10) and 968.62 (year 20).

Rob inundation scenario is then performed with spatial modeling based on the existing ground surface elevation and the SLR without considering the parameters of land subsidence. In these conditions, the distance landward inundation rob for Semarang region ranged from 0.63 to 4.49 km. while for the Pekalongan area ranged from 2.40 to 3.78 Km.

Scenario faces rising sea water for the next 100 years is estimated as high as 0.775 meters based on analysis of tidal data. In these conditions, the distance landward inundation rob between 0.63 km to 4.49 km. Rob inundation scenario is the result of spatial modeling based on the existing ground surface elevation and the SLR without considering the parameters of land subsidence. Rob inundation scenarios in the study area in the next 100 years based on the results of this modeling are presented in the
Figure 3.

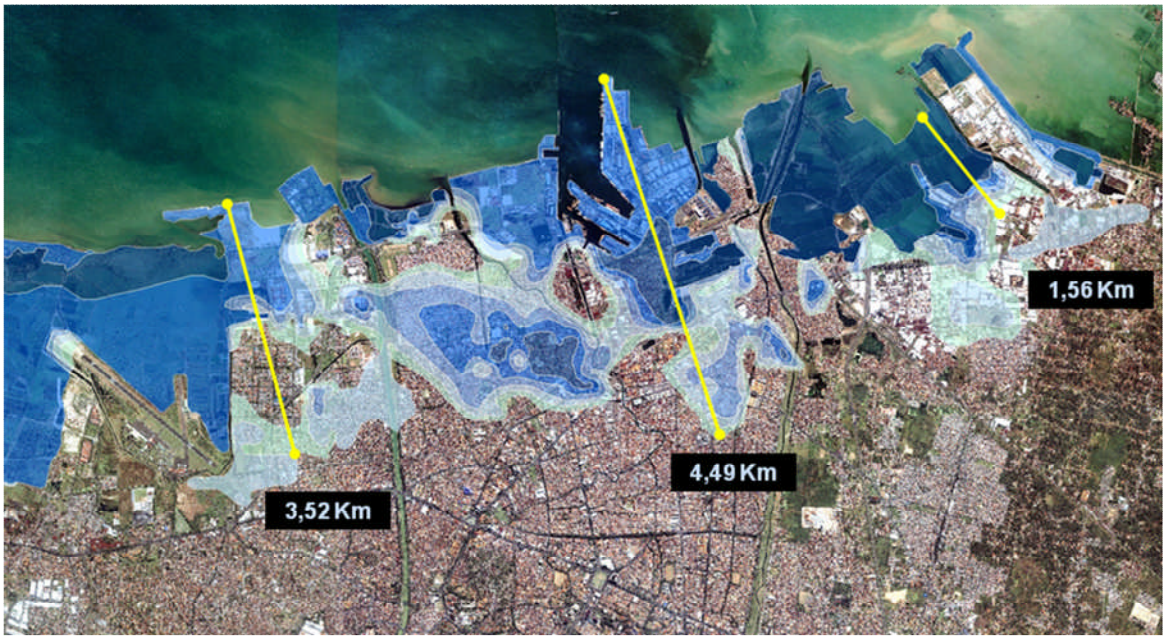


Figure 3. Rob inundation area in the city of Semarang in the next 100 years based on the tidal parameters, the existing ground surface elevation and the scenario of rising sea levels of 0.775 m

This study also generates spatial information inundation depth at each position in the SLR 100 such scenarios. Spatial depth of inundation depth information is presented in the form of a pool of depth contour lines. Inundation depth data integration and Ikonos satellite images of 2007 are presented in the figure below. The Figure 4 shows the shape and depth of inundation of land use which will be experienced in scenario SLR 100 years.

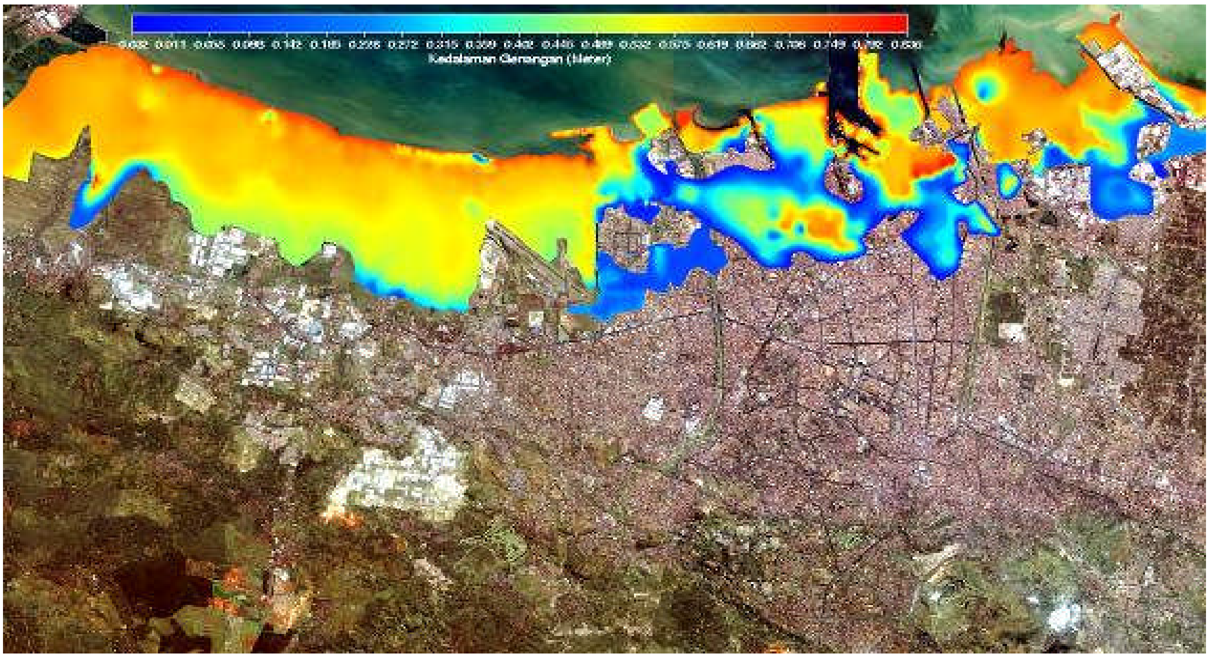


Figure 4. Spatial Data on the depth of inundation SLR 100 years (0.775 m) future. Color difference above a portrait of inundation depth difference in meters in the coastal city of Semarang.

Rob inundation area for Semarang can be seen in the following Table 1.

Table 1. Land area flooded due to the influence of SLR in the city of Semarang in the next 20-100 years

Next- Years	**Flooded Area of SLR (Ha)**			
	Settlement	**Rice Field**	**Fond**	**Industry**
20	66.29	39.47	1.302.83	27.33
40	175.93	79.44	2.334.58	329.90
60	343.54	95.19	2.379.12	405.34
80	610.65	12..95	2.474.59	554.65
100	790.63	146.47	2.534.81	667.18

In addition to the city of Semarang. rob also occurs in Pekalongan Regency. Rob Condition in Pekalongan only caused by SLR, while for land subsidence does not occur in Regency Pekalongan.

Scenario SLR used in Pekalongan Regency same as those used in Semarang city for 100 years is estimated as high as 0.775 meters based on analysis of data on the tidal waters of the city of Semarang. The use of tidal data Semarang city is due to the lack of tidal observation stations in the district of Pekalongan and nearby tidal observation stations exist only in the city of Semarang. On the condition scenario of SLR, the distance landward inundation rob between 2.40 km to 3.78 km. Rob inundation scenario is the result of spatial modeling based on the existing ground surface elevation and the SLR without considering the parameters of land subsidence. Rob inundation scenarios in the study area in the next 100 years based on the results of this modeling are presented in the figure below.

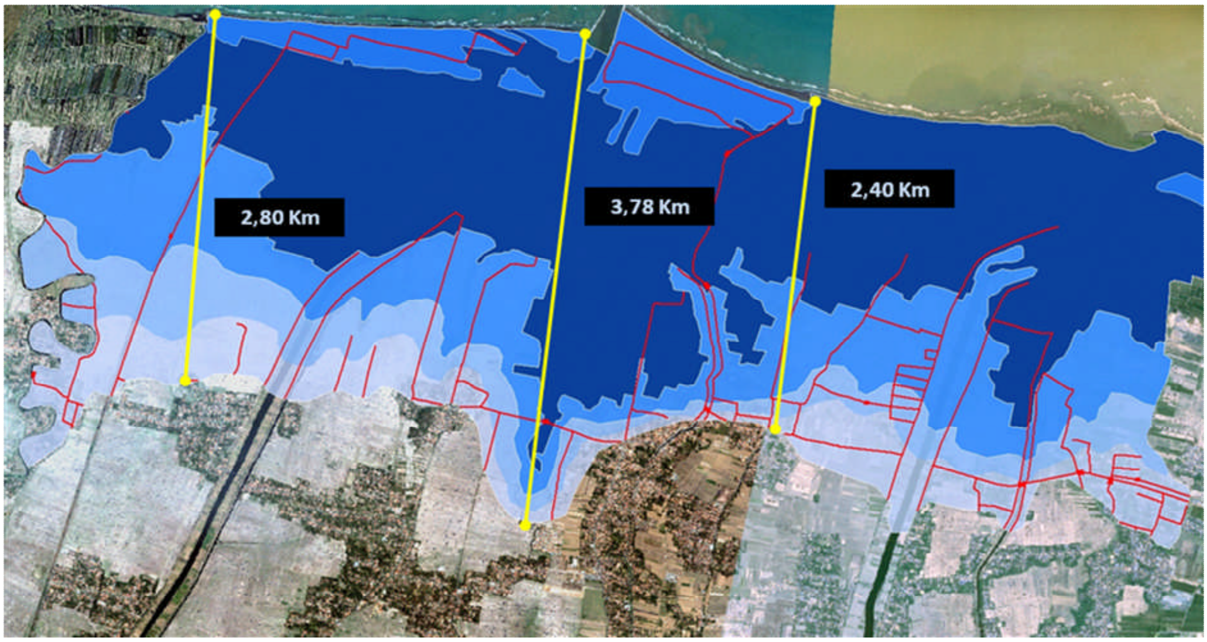


Figure 5. Rob inundation area in Pekalongan District in the next 100 years based on the tidal parameters elevation. Rob area of Pekalongan Regency can be seen in the following Table 2.

Table 2 Area of land were flooded due to the influence of SLR in the district Pekalongan in the next 20-100 years

Next-year	**Flooded Area (Ha)**			
	Sattelment	**Rice Field**	**Fond**	**Industry**
20	0.97	151.66	954.02	0
40	4.41	161.42	964.16	0
60	54.23	601.17	986.8	0
80	100.86	800.15	986.91	0.11
100	201.39	969.95	986.91	0.11

In general, the level of hazard, vulnerability and risk some of Central Java coast are presented in Table 3. The Methods used to analyze the potential dangers of using the method published by USGS (2007), whereas to calculate the level of coastal vulnerability refers to the Guidelines analysis of disaster prone areas and climate change issued by the Ministry for Environment - New Zealand Government (2008). As for calculating the risk of disaster is a product of Potential Coastal Hazards and Vulnerability.

Table 3. The number of coastal hazards in Central Java

No	Location	Geomor phology	Erosion/ acresion Coast line	Slope of Coast	Elevation change relative Sea level	Mean wave heigh	Mean Tide	Avera ge
		Score	Score	Score	Score	Score	Score	
1	Ds Temperak, Rembang	3	3	1	3	1	3	2,3
2	Ds Gegunung Kulon, Rembang	3	2	1	3	1	3	2,2
3	Ds Tanjung Sari, Pati	3	2	1	3	1	3	2,2
4	Ds Bedono, Demak	3	3	2	3	1	3	2,5
5	P. Maron, Semarang	3	2	2	3	1	3	2,3
6	P. Depok, Pekalongan	3	2	1	3	1	3	2,2
7	P. Krematorium, Pekalongan	3	3	1	3	1	3	2,3
8	P. Widuri, Pemalang	3	2	1	3	1	3	2,2
9.	Ds Sugih Waras, Pamalang	3	2	2	3	1	3	2,3

0.1 - 1.0	Low
1.1 - 2.0	Moderate
2.1 - 3.0	High

5. Mitigation and Adaptation to Climate Change

Mitigation of climate change is the effort made to reduce emissions of greenhouse gases from the source or by increasing the natural ability to absorb these emissions. While adaptation to climate change is an effort to address climate change impacts that are either reactive or anticipatory.

For example in the case of smoke impact to shortness of breath due to forest fires in Indonesia. Efforts to mitigate the impact of smoke made with fire-fighting so as to reduce or eliminate the effects of breathing smoke from forest fires. While adaptation is done by using a mask covering the nose so that the impact of forest fire smoke on the shortness of breath can be reduced or even eliminated.

One of the other examples to make it easier to understand and differentiate in terms of mitigation and adaptation to climate change is when someone is in a cold room due to air conditioner use (air conditioner or air conditioning). Efforts to reduce the risk of the impact of cold can be done with mitigation and adaptation.

Mitigation efforts can be done by raising the temperature of air conditioning so the room becomes warmer and comfortable. Meanwhile, the effort of adaptation can be done using body warmer clothes (jackets). Both activities are equally intended to reduce the impact / risk to the chill caused by the AC.

The term mitigation of climate change in terminology is slightly different with the term "mitigation" in the terminology of disaster. "Mitigation" in the terminology of disaster is defined as efforts taken to reduce risk/impact caused both by natural disasters and human. So the term "mitigation" in disaster mitigation and adaptation has been included in climate change. Mitigation and adaptation to climate change are both intended to reduce the impacts/risks due to climate change.

The examples in terms of climate change mitigation by Indonesia is to ratify the Convention on Climate Change (UNFCCC) in 1994 and the Kyoto Protocol in 2004 which was adopted by Law No. 17/2004. The seriousness was marked among others by the formation of the National Council on Climate Change in 2008 to manage the Clean Development Mechanism (CDM). Based on the National Strategy Study (2001/2002), if the only CDM can be used effectively it can reduce emissions of these countries amounted to 23-24 tons per year.

Nothing, Indonesia's contribution in emissions of greenhouse gases in the atmosphere was recorded fairly large. which is ranked world's 15th largest. Especially if it is associated with emissions from deforestation, including peat and forest land conversion and forest fires. If all the disasters that included in, the calculations that produce greenhouse gas emissions. Indonesia claimed as greenhouse gas emitters is the third largest in the world.

In the mitigation, Indonesia needs to urge developed countries to cut their greenhouse gas emissions if the global community wants to remain under the air temperature rise an average of 2 °C. Therefore, the earth was still able to adapt to increases in air temperature that big.

Working Group III of the IPCC states, Gross Domestic Product (GDP) will be cut by 0.12% for CO2 levels over the world can survive under the lowest level until 2030. By the way, the overall that can be pressed to reach around 3% in the same year.

The next step is to prioritize adaptation strategies for development and development planning in both the local and national. Without a plan like this, Indonesia will fail in development due to environmental disasters due to climate change. Indonesia needs to do the assessment and mapping of vulnerability and adaptation to climate change in order to create an effective treatment.

UNFCCC explain the importance of response strategies as the needs of developing countries to take immediate action in a flexible based on clear priorities. This is the first step towards comprehensive response strategies at the global, national, and regional, which takes into account all greenhouse gases, with consideration of their relative contribution to the greenhouse effect.

Mitigation means the reduction of GHG emissions and increase the absorption of CO2. Adaptation involves adjustments to enhance the viability of social and economic activities and to reduce their vulnerability to climate change.

In regard to the mitigation of climate change, some things to do include energy conservation, elimination of chlorofluorocarbons (CFCs), exchange of fossil fuels with environmentally friendly fuel.,reducing emissions of methane and nitrous oxide. the use of biomass fuels and cooking stoves. the use of technology renewable energy, prevent deforestation and forest fires, reforestation, and planting vegetation.

Climate change is a certainty that when this has been is, and will happen if humans do not make many efforts in order to put the brakes on global warming. Therefore, the adaptation activities are a necessity and urgent priorities for coastal communities and small islands in Indonesia.

Given the complexity of coastal areas and small islands, then mitigation and adaptation efforts should be made to approach the management of coastal areas and small islands integrated. To be able to coexist harmoniously with the environment, the wise management of coastal areas must be supported. By adapting (IPCC. 1990), the management of coastal areas (coastal management) aims:

- Avoid development in areas prone and vulnerable ecosystems

- Ensuring that the natural protection system still works fine

- Protecting human safety, property, and economic activity from danger by taking into account aspects of ecology, culture, history, aesthetics, and human needs of safety and welfare.

Process of Adaptation to Climate Change

Since climate change is considered as one of the serious problems in the 1980s, the main focus handling when it lies only in mitigation efforts (i.e. reduction of greenhouse gas emissions in the atmosphere) and not on adaptation efforts. Climate change adaptation efforts began to develop along with the increasing understanding that some climate change can not be done by simply relying solely on mitigation efforts.

Klein et al. (1999) show that coastal adaptation to climate change can be done with the stages and iterative process that involves four basic steps:

* Development of information and awareness;
* Planning and design;
* Implementation;
* Monitoring and evaluation.

Here is a framework for preparing the concept of adaptation that considers changes in climatic conditions. This concept is in accordance with that proposed by Klein et al, (1999) (Fig. 6.).

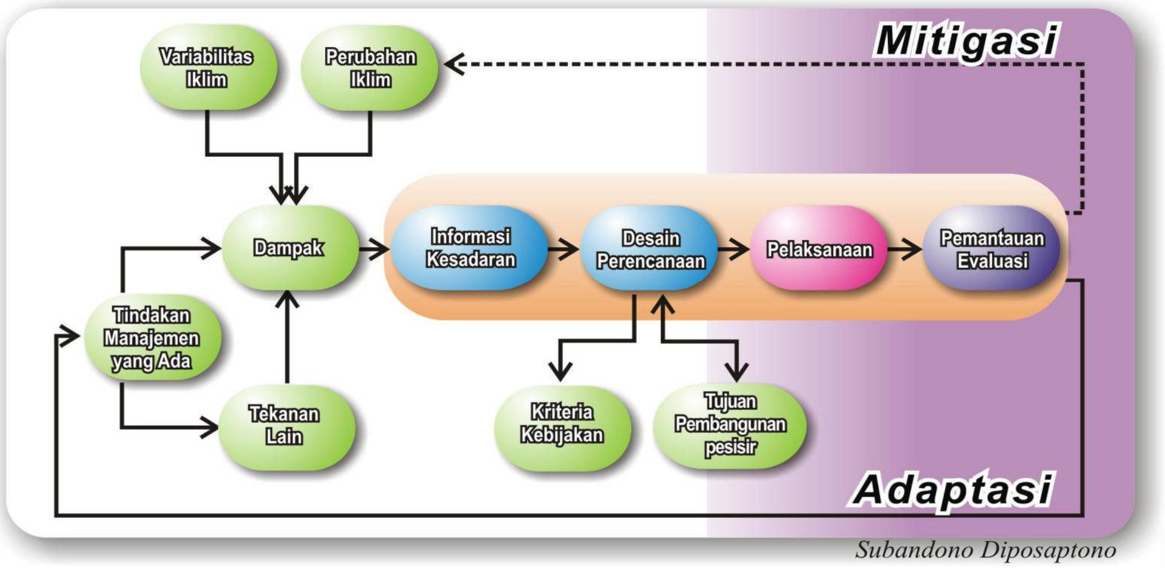


Figure 6. The framework of mitigation and adaptation in coastal areas (Source: Subandono D. et al. 2009).

Development of Information and Awareness Rising

Data collection and development of information is an important prerequisite for the adaptation of coastal and small islands, especially to identify priorities and needs of adaptation. The available information and data accurately will be increasingly relevant for the managers of coastal and small islands if, so it will get targets and adaptation strategies are more effective. Adaptation of coastal and small islands is required data and information will be the characteristics and dynamics of coastal and small islands. the pattern of human behavior to understand the potential consequences of climate change. Also it is important that there is an awareness of the community, managers and decision makers of the consequences and the need to take appropriate action. The availability of data and information is very useful because of coastal adaptation to climate change will require more detailed information.

Planning and Design

The next step is to decide what the best course of action can be taken and how best to implement it. This depends on general criteria such as general guidelines, the preparation of national or regional policies, as well as the presence of the development and management plans that form the broader context of adaptation initiatives. Important criteria that can influence policy decision-making adaptations include cost effectiveness, environmental sustainability, cultural appropriateness and social acceptability.

The coastal planner will always face an uncertainty, not only due to the uncertainty in the future but also because knowledge of natural processes and socio-economic coast is not controlled properly.

Given these uncertainties, the planning to assess the impact of climate change on environment and society both with and without adaptation is necessary. The information obtained is used to assist the determination of optimal adaptation strategies (actions which one?), and time of implementation (when?). The quality and effectiveness of the design process and planning required in making decisions. Planning should be done comprehensive by considering various scenarios of climate change adaptation strategy following options.

Implementation

After all coastal adaptation options considered and the best strategy is selected and determined, we then carried out the implementation of plans and designs have been prepared. Adaptation can be either reactive or anticipatory, in accordance with time. purpose and motive of its implementation. Reactive adaptation done when the impacts of climate change has occurred, while anticipative adaptation (or proactive) is done before its effects appear. Anticipatory adaptation (planned) need information and strategic action. Almost all of adaptation options require a strategic plan. Furthermore, the pattern of adaptation options protective (protection) against sea level rise can be implemented either reactive or proactive. While almost all of the options with the pattern of retreat and accommodating only be implemented with anticipatory approach. Until now, adaptation strategies are carried out mostly focused on the pattern of protective (protection).

Monitoring and Evaluation

The next step is to conduct field tests at every level of policy implementation is periodically or continuously assessed against the original target (although unfortunate. this step is often ignored in practice). Such evaluations can provide insight and new information that can improve the suitability of an appropriate strategy. Evaluation of implementation of this must be distinguished from the evaluation is conducted to identify the appropriate technology. Later evaluation before implementation can be used as part of the planning and design stage.

Effective evaluation requires data or reliable indicators, which were collected during regular time intervals through an appropriate monitoring system. Indicator is a tool for reporting and communicating with decision makers and the public. Indicators should be able to meet various needs including (i) the relationship with functional concepts; (ii) representative and responsive to changes in relevant conditions, and (iii) can be easily integrated into a broader evaluation framework. Evaluation is a continuous process and monitoring should be planned to conform to the evaluation.

In principle, mitigation and adaptation aimed to reduce negative impacts. Maximize opportunities, and anticipate the consequences that arise from global climate change. Adaptation options will be effective when synergized with development planning, both national and local levels.

In planning this is summarized in the overall coastal management planning documents and small islands under Article 7 of Law No.27/2007 which consists of a strategic plan, zoning plan, management plan, and action plans. Meanwhile, in Article 4 of Law No.27/2007 states that the management of coastal areas and small islands held with the aim of protecting. Conservation, rehabilitates, and enhances coastal resources and small islands and the ecological system.

Thus, efforts must be made in protecting the climate change impacts are potentially damaging to the preservation and sustainability of ecosystem functions and benefits of coastal and small islands. These efforts need to be poured in integrated coastal management planning documents including strategic plans, zoning plans, management plans, and action plans. In particular, mitigation and adaptation to climate change also needs to be set forth in the plan strategy and action plan on climate change.

In general, climate change mitigation and adaptation can be done through physical (structural) and non-physical (non-structural) as presented in Table 6.

Table 6. Mitigation and adaptation to climate change as a whole.

NO	Physical	Non-Physical
1. 2.	Natural Coral reefs, sand dunes, mangrove planting, coastal vegetation/forest beach Made Make a breakwater, sea wall, embankment, shelter houses, friendly home disasters, creation of reservoirs, channels gatherer, ditches, etc.	Making maps vulnerable. Vulnerability, and risks of climate change. Law Early warning system Relocation, spatial planning, zoning, land use Awareness community Training or counseling Transfer of livelihood Changes in cultivated varieties of agricultural or fisheries Poverty alleviation ICZM (Integrated coastal zone management)

6. **Adaptive Technology Increase Sea Level Rise**

Although there are various impacts and potential impacts of climate change and rising sea levels as mentioned above. has not pursued many concrete activities to its anticipation. This is understandable given that some things such as:(i) the relative impact of climate change have not felt included certainty of the scenario, (ii) awareness and knowledge society that is still lacking, and (iii) there is no strategy and program development activities are accommodated in both sectors and regions . At the national level too there is currently no specific policies or strategies such national action plans (national action plan/NAP) in relation to climate change issues.

However, the Government ought to take the initiative to do the adaptation and mitigation efforts. Under Article 18 of Law no. 32 of 2004 local governments have authority in the exploration, exploitation, conservation, natural resource management. and responsibility to preserve it. Thus, local governments are also responsible in conserving coastal areas including the impacts of climate change. Regional authority in the management of coastal areas and small islands now increasingly apparent and obvious to have been the enactment of Law no. 27 of 2007 on the Management of Coastal and Small Islands.

Technology adaptation faces rising sea water in coastal regions and small islands aimed at reducing the vulnerability of society and increase the capacity of coastal ecosystems and Small Island in carbon sequestration and natural function for adaptation to climate change. In this intervention will be conducted involving human systems (human systems) ranging from development planning, and arrangement of space and natural system with the rehabilitation and conservation of ecosystems. Figure 7, shows how the impacts of climate change and human and natural systems related thereto.

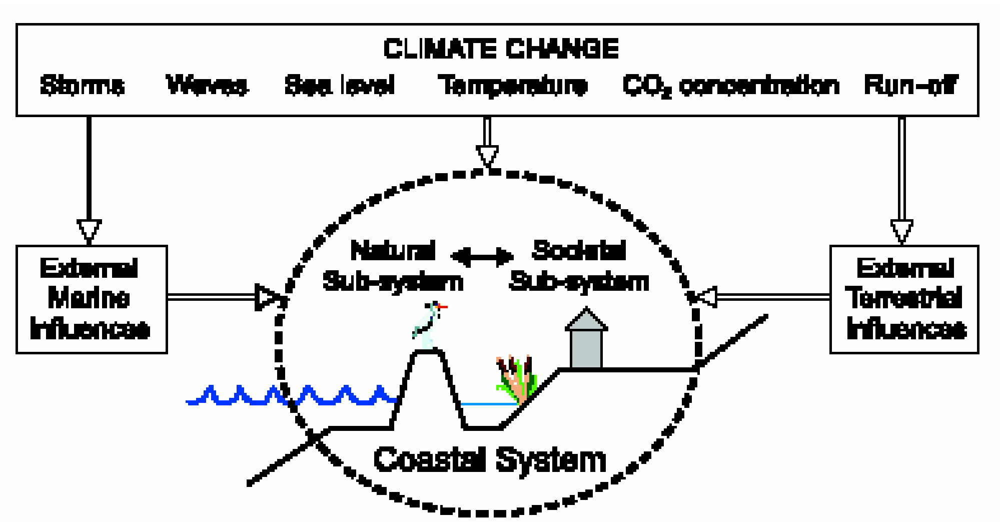


Figure 7. Climate change and its impact on natural and human systems (source IPCC 2007).

Philosophically, the handling of sandstone rising sea levels in coastal areas can be reached by several strategies. First, the pattern by creating a protective coastal structures being able to prevent the flooding of sea water so as not to rush to the ground. This pattern is intended to protect the settlements, tourism industry, roads, agricultural areas. and others from a pool of sea water. Tangggul and coastal structures are not only designed on the face of high tides and sea waves at the moment, but also must take into account land subsidence. SLR, HHWL, and ocean waves due to wind in extreme conditions.

Other protective patterns that can be achieved are by conducting restoration through the rejuvenation of the beach (beach nourishment) and mangrove rehabilitation. This process involves taking material from places that are not dangerous and filled into where it is needed. Land fill results are then planted with mangroves in order to reduce flooding rob pushed to the ground. Mangrove forests also serve as a carbon sink to reduce global warming.

Second, adaptive patterns adjust to sea levels rise. The houses on the beach made for a stage model of safe from inundation of sea water, especially during flood tide. For agricultural areas inundated by sea water due to rising sea levels rise can be converted into land allotment aquaculture.

Third, the pattern of retreat (retreat) aims to avoid inundation by way of relocating residential, industrial, agricultural areas, and others landward sea water so as not affordable due to sea levels rise.

Other efforts are no less important is to control the utilization of ground water recharge and make wells to inhibit the rate of land subsidence.

In addition to the physical nature should also be carried intangible efforts such as risk mapping faces rising sea water, education, and public awareness. Community, both in areas prone to flooding due to rising sea water sandstone, and outside the region is very large role. They demanded to know, care, and love for the environment and the discipline of rules and norms that exist.

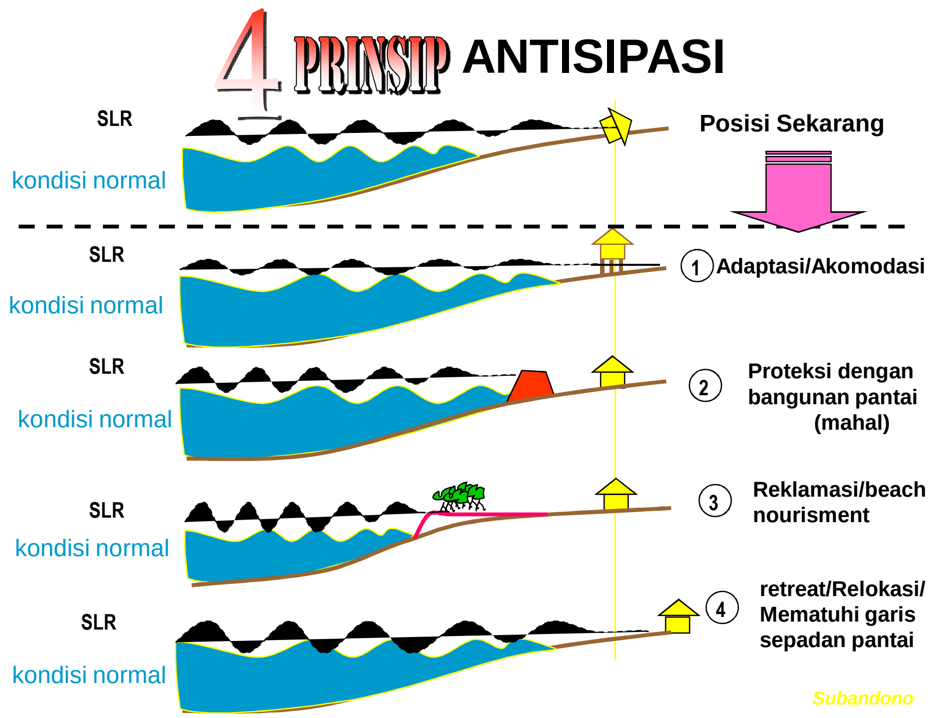


Figure 8. Adaptation strategy faces rising sea water

Table 7. Options technology anticipation adaptation faces rising sea water.

Application	Technology
A. Protective	
With hard structures	Dam, levee, flood barrier (floodwalls) With hard structures Seawall, revetment Groin Separate wave-breaking Doors and retaining tidal water (tidal barriers) Retaining seawater intrusion maintenance of the beach (beach nourishment) periodically
With a soft structure	Repair and manufacture of Sand Dunes Repair and wetland creation
With natural ways (indigenous)	Reforestation Planting of coconut, hibiscus, mangrove Retaining walls of wood Retaining wall of stone
B. Retreat	
- Increase or set the region back (set back)	It takes a bit of technology
- Move the threatened buildings	Consumes a lot of technology
- Eliminate or negate the risk of development in the region	Requires little technology
- Estimating the movement	Takes a little technology
- Set Realignment	Requires various technologies according to the location
- Creating a buffer in the Upland area	Requires less technology
C. Accommodative	
- Emergency Planning	Early warning system Evacuation System
- Disaster Protection	Requires little technological
- Changes in land use and agricultural practices	Requires a variety of technologies
- Setting strict to disaster areas	requires little technology
- Improve drainage system	increase the diameter of the pipe improve drainage system

7. Summary

Global climate change has raised the impact on natural systems and human life. Coastal regions and small islands is one of the areas that have significantly negative impacts of climate change. These impacts will increasingly exacerbate the pressures and problems that exist in coastal regions and small islands ranging from the availability of water, lack of infrastructures, transport, and health and food security. Efforts to adapt to rising sea level looks to be done and integrated into overall development planning process of economic and social activities of society. Strengthening the capacity and vulnerability reduction should be carried out on natural systems (habitat) and human systems (development, social life economic).

Reference

Barth. M.C and Titus. J.G. 1984. Greenhouse Effect and Sea Level Rise. A Challenge for This Generation. Van Nostrand Reinhold Company.

Bruun. P. 1962. Sea Level Rise as a Cause of Erosion. J. Waterway. Port Coastal & Ocean Eng. ASCE. No. WWI February 1962.

Dean. R.G. 1992. Beach Response to Sea Level Change in The Sea. John Wiley & Sons. London.

IPCC. 1990. Strategies for Adaptation to Sea Level Rise. Rijkswaterstaat. Netherland. IPPC-Response Strategies Working Group. 1992. Global Climate Change and the Rising Challenge Of the Sea. Rijkswatertaat. Netherlands.

Klein. RJT. Jansen. HMA. Verbruggen. H.. Tol. 1996. Some considerations on the Economic Importance of Proactive Integrated Coastal Zone Management. Ocean Coastal Management 32. pp 39-55.

Subandono. D. et al.. 2009. Deal with Climate Change in the Coastal and Small Islands. PT. Means of Communication.

THE IMPACT OF INCREASE IN SEA WATER INTERFACE IN SEMARANG

Aris Ismanto
Diponegoro University Oceanographic Studies Program
Jl. Prof. SH Sudharto Tembalang-Semarang
Email: aris.ismanto@gmail.com

1. Background

Semarang is a city located in the northern coast of Central Java. Approximately, for the last 30 years, the city has been subjected to flood. This flood has inundated several places in the coastal areas in Semarang, which occurred when the tide is high. It was noted that in May 2005, there were at least 14 villages, which were inundated and the area reached 2418 hectares.

Flood was caused by the rise of sea level, where the rate of sea level rise recorded in the Tidal Observation Station at Tanjung Emas Port in Semarang was 5.43 cm per year (Wirasatriya, 2005). Other than that, high tides and land subsidence was a major threat in Semarang (Marfai *et al.* 2005). The condition of land elevation, which was lower than the sea level caused greater rate of land subsidence. Flood in Semarang caused damage in the infrastructure and residential areas. It also affected the livelihoods of communities, households and individuals simultaneously (Marfai *et al*. 2007).

2. The Objectives

This study has to be done immediately remembering that for the last 30 years, Semarang has been the capital city of Central Java with a population that reaches approximately 1.4 million people. In spite of the fact that Semarang still cannot be separated from the issue of flood, that is due to the rise of sea level, which had caused many damages to the infrastructures, health disturbances, transportations and the population's activities. The handling of flood problems had only been done partially and self-reliance by the public and private parties, such as disposal or land elevation and pumping that was proved ineffective and did not solve the problems. The handling of flood should be conducted in accordance, where the Government in Semarang should create policies, which embraced all parties in the response to flood in the coastal areas in Semarang. To make this policy, data and information on the causes of flood are needed so that the solution or the policy that is offered could successfully ward off flood problems in the coastal areas in Semarang. Therefore, the study of sea level rise in the coastal areas in Semarang is needed.

3. Data

The data used in this study was the sea surface high anomaly data from satellite altimeter from the year 1993-2009. It is gained from the database of the University of Colorado, USA. Global Mapper software is use to visualize the Aster DEM data whereas ArcGIS software is use to analyze coastal inundation areas due to sea level rise.

4. Results and Discussions

At this moment, inundation has occurred in the coastal areas in Semarang due to flood and rain. The results due to flood could reach the level from 20 cm to 60 cm. According to Sarbidi (2002), flood in Semarang is caused by several factors, such as:

• Changes in land use in the coastal areas: Land fishponds, swamps and rice fields that could naturally accommodate the tide had been turned into residential areas, industrial areas and for other uses. As a result, tidal water could not be accommodated and eventually lower areas are inundated. Approximately, 790.5 hectares in the district of North Semarang, there are no more fishponds and about 585 hectares in the district of West Semarang, there are only 126.5 hectares used as fishponds (Bappeda Semarang, 2000).

Table 1. The Change in Fishpond Areas and Mangrove Swamps in the District of North

years	Area (Ha)		capacity m3	Y (m) Increase in river
	Pond	Mangrove		
1975	187.0	56.10	935000	0
1979	160.0	48.00	800000	0.072
1982	150.0	45.00	750000	0.108
1984	145.0	43.50	725000	0.144
1988	130.0	39.00	650000	0.216
1990	120.0	36.00	600000	0.324
1992	100.0	30.00	500000	0.504
1996	80.0	0.00	400000	0.738
1998	30.0	0.00	150000	0.918
1999	1.0	0.00	5000	1.026

Source: Widiasmadi (1999)

• Land subsidence: According to Sutanta and Hobma (2002), land subsidence is a process whereby the elevation of an area is lower than the previous elevation. Furthermore, Hobma and Sutanta explained that the land subsidence could be caused by natural factors, the influence of human activities or a combination of both. Factors that could cause land subsidence included consolidation of clay layers, pumping of underground water, earth tremors, building load, etc. Meanwhile, according to Muhrozi *et. al* (1997) and Suripin (2002), land subsidence that occurred in Semarang was caused by factors of consolidation and retrieval of underground water.

• Sea level rise due to global warming: Sea level rise due to global warming is the difference between the values of the total sea level rise with the values of the land subsidence at tidal stations.

The flood caused inundations in North Semarang about 27.2 km^2 and in West Semarang about 12.4 km^2. Based on the data from two drainage areas, it was estimated that inundation areas will cover approximately about 32.6 km^2 (BAPPEDA, 2000). For more details about the distribution of flood areas in Semarang, it can be seen in Figure 1.

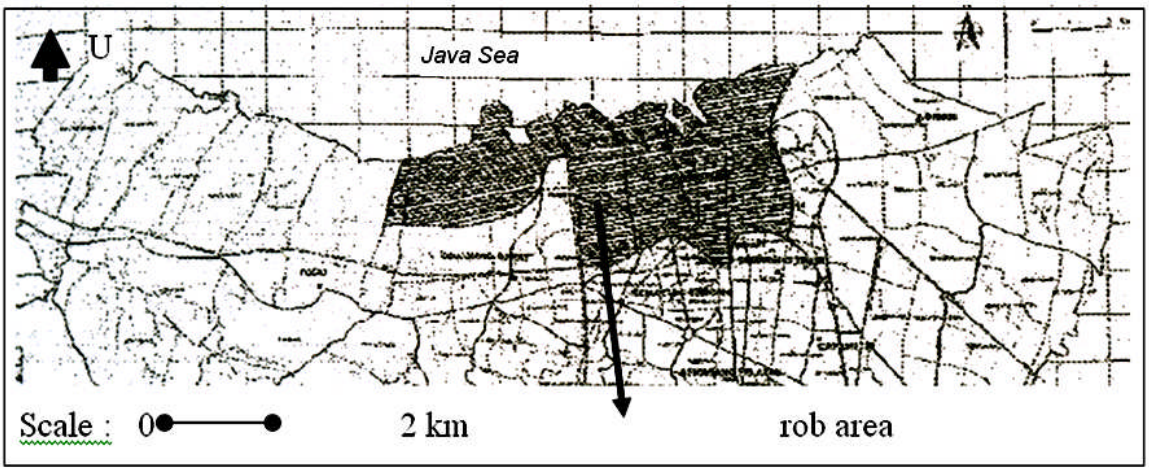


Figure 1. Regional Distribution Map of Rob in Semarang (BAPPEDA, 2000)

Starting from 1993 to 2009, the sea surface high anomaly data around Semarang is shown in Figure 1. The data showed a 4.1 mm increase in the sea surface per year.

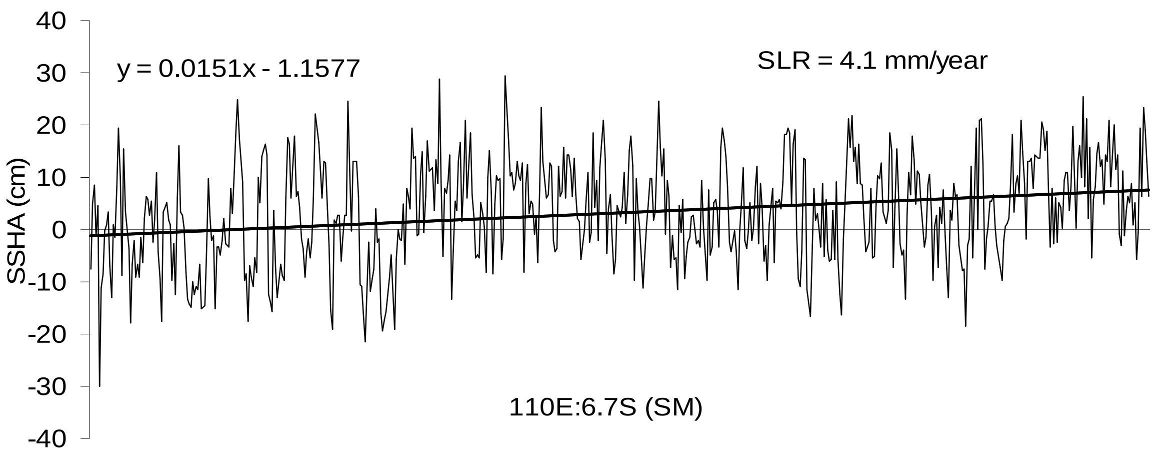


Figure 2. Trend of the Sea Surface Anomaly around the Waters of Semarang (1993-2009)

The results in the simulation of coastal areas due to sea level rise in the next 20 years are listed in Figure 3. The results show that in the next 20 years, there will be additional inundation areas in the coastal areas of approximately about 57.22 ha.

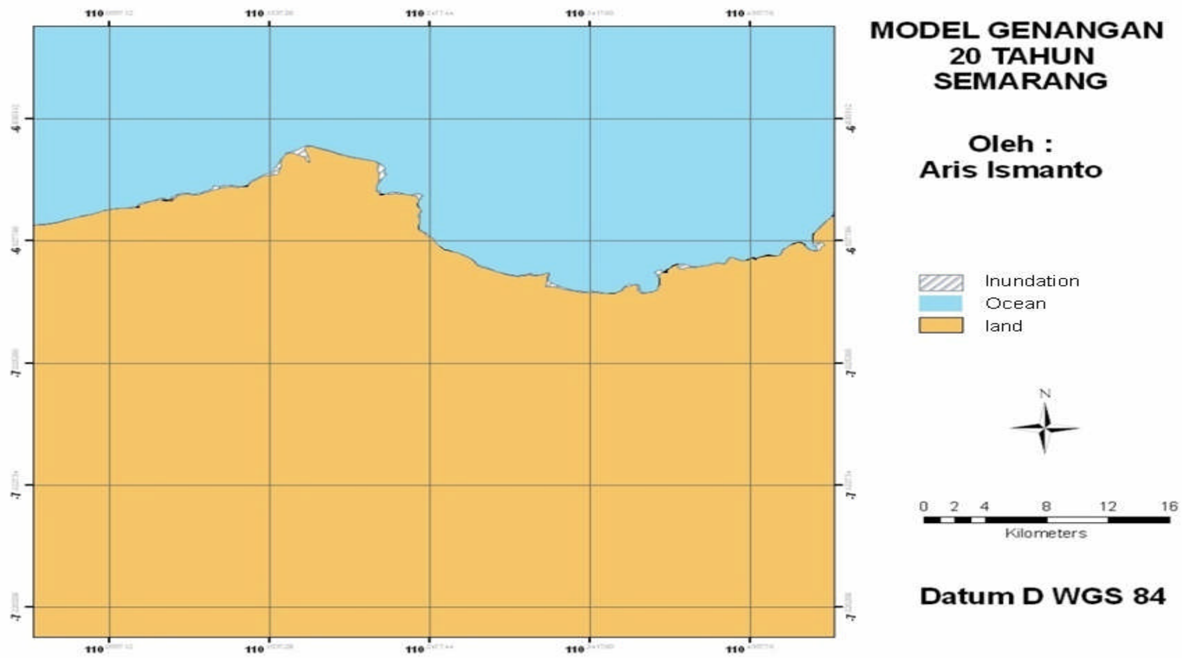


Figure 3. The Simulation of Inundation in the Coastal Areas in the Next 20 Years

In Figure 4 shows the results in the simulation of coastal areas due to sea level rise in the next 50 years. In the year 2060, it is estimated that inundations in the coastal areas will increase up to 272.75 ha.

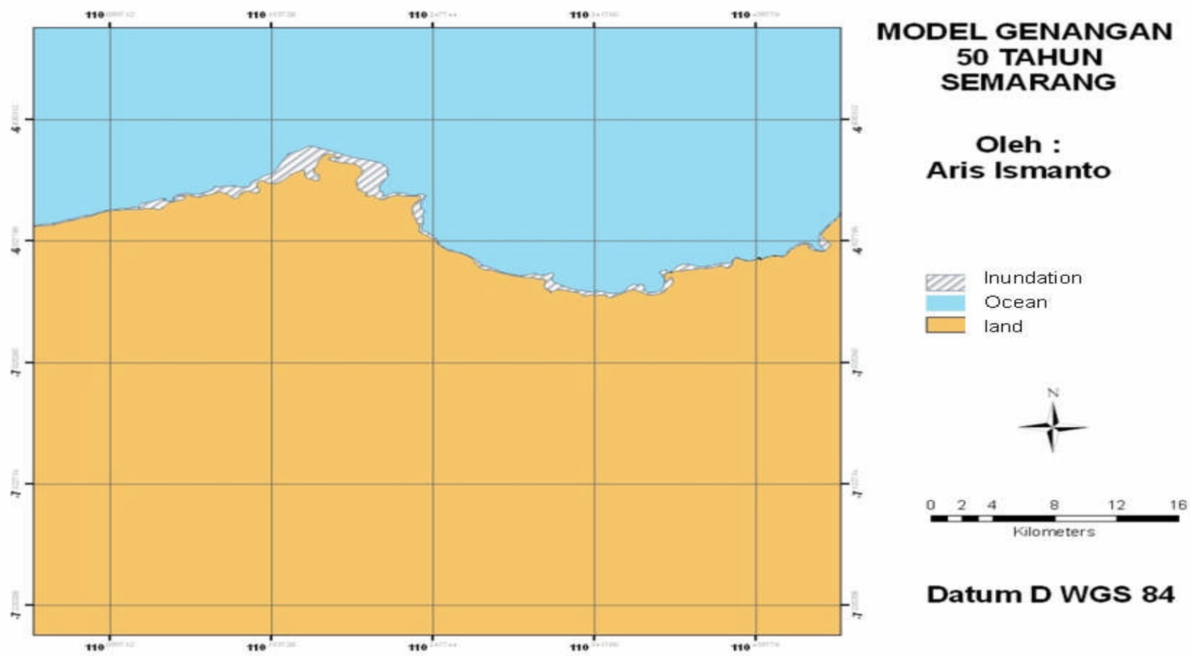


Figure 4. The Simulation of Inundations in the Coastal Areas in the Next 50 yars

The flood, which attacked the coastal areas of Semarang, gave bad impact to the lives in Semarang. According to Sarbidi (2002), the flood that attacked Semarang adversely affected the urban areas, houses and buildings, facilities and infrastructures as well as the environmental health.

The flood caused inundation regularly. The depths of floods varied and the lowest could reach more than 60 cm. The duration could reach one day up to one week. In general, houses or buildings that are inundated with water were often found abandoned or not occupied by the owner. The effects are on the infrastructures and muddy roads that were always inundated with water, negative effects on clean water and the disturbance in the environmental health.

By looking at the factors that caused floods, such as the global sea level rise, land subsidence, the changes in land use, therefore, the efforts that are needed to be done to solve the problems are to tighten the permits, supervise the retrieval of underground water, stop the activities of accumulation or disposal swamps, fishponds and mangrove forests, improve the drainage system through the normalization and revitalization of rivers and channels, improve the area of land use and the most important is to protect the absorbance areas as well as to expand the storage areas as a place where seawater can ascend to land. Therefore, the study of geometric mapping with the surface contour data (data space shuttle or SRTM) that can accurately calculate and model the flow patterns, lowlands that are sensitive to flood, is needed to be done immediately (Hartoko, 2005).

Polders Development at Tawang station is one way to expand the storage areas. Based on field observations at Station Tawang and the Old City, it was proven that with the construction of polders, inundation during high tide do not happen anymore. However, on one side, the constructions of polders have weaknesses such as the high cost in manufactures and the lack of economic values obtained from these polders.

The effective and efficient ways to expand the water storage areas is to empower back fishponds and open new fishponds that have less environmental benefits such as vacant lands, fields, rice fields, etc., as well as taking the advantage of swamps or fishponds for tourist attractions, such as fishing, floating restaurants and others. This business will be very useful in overcoming floods. Other than that, by involving the communities, they will also feel the economic benefits from the fishponds and they will maintain the continuity of the fishponds.

Along the shoreline, reforestations of mangrove are also needed. According to Bruun *in* Aditya (2003), sea level rise of 1 cm will cause the land to retreat as far as 1 m, which means that the sea level rise causes erosion in the coastal areas. With the mangrove forests along the coasts, it will restrain the erosion in the coastal areas or in other words, the mangrove forests serve as a natural dike beach. Then, through its function as a sediment trap, the erosion will be confronted with the sediment and as a result, it is expected that seawater will not rise to the mainland but instead, the mainland moves forward to the sea. The mangrove forests along the coasts will also be beneficial to the fishponds behind it.

However, in doing these efforts, the study about the kinds of fishponds and the cultivar mangrove species, the appropriate ways in mangrove planting to overcome abrasion, where fishponds and mangrove areas are required, any areas that will be use as fishponds and mangrove forests, public perception is needed to be done.

Figure 5. Disposal on Arterial Roads that Causes Overflow onto the Highway

Figure 6. Inundation in the Port of Tanjung Mas

5. Conclusions

The flood in Semarang is caused by the global sea level rise, land subsidence, changes in land use and the poor condition of the drainage system. Global sea level rise is not a dominant influence on sea level rise in Semarang. Subsidence in land is the dominant factor leading to the rise of seawater in Semarang.

The total area that will be flooded in the next 50 years is estimated will be about 27,274,570.49 m^2, which includes 4 sub-districts and 14 districts, that is the district of Genuk: Trimulyo, Terboyo Wetan, Terboyo Kulon and Muktiharjo Lor; the district of Gayam Sari: Tambak Rejo; the district of East Semarang: Mlatiharjo, Mlati Baru, Kemijen and Rejomulyo; and the district of North Semarang: Tanjung Mas, Bandar Harjo, Kuningan, Panggung Lor and Panggung Kidul.

References

Adhitya, F.W. 2003. *Analisis Banjir Rob di Kecamatan Semarang Utara dan Kecamatan Semarang Timur pada Saat Pasang Tertinggi*. Skripsi Jurusan Ilmu Kelautan FPIK. UNDIP. Semarang (Indonesia)

BAPPEDA Semarang. 2000. *Profil Wilayah Pantai Dan Laut Kota Semarang*. BAPPEDA. Semarang

Hartoko, A. 2005. *Supply of Thematic Coastal Zone Data Sets for Province of North Sumatra*. BAPPEDA SUMUT; DKP-RI dan ADB (Indonesia)

Marfai, M. A., Sudrajat, S., Budiani, S. R., & Sartohadi, J. 2005. *Tidal flood risk assessment using iteration model and Geographic Information System, (In Indonesian)*. The competitive research grants scheme no ID: UGM/PHB/2004, Gadjah Mada University, Yogyakarta, Indonesia.

Marfai, M. A., & King, L. 2007a. *Monitoring land subsidence in Semarang, Indonesia. Environmental Geology*. doi:10.1007/ s00254-007-0680-3.

Muhrozi; S Pranoto dan Nasrullah. 1997 *Studi Penentuan Penurunan Permukaan Tanah di semarang bagian Bawah.* Fakultas Teknik Sipil Universitas Diponegoro. Semarang. (Indoensia)

Sarbidi. 2002. *Pengaruh Rob Pada Permukiman Pantai (kasus Semarang*). Prosisding Kerugian pada Bangunan dan Kawasan Akibat Kenaikan Muka Air Laut pada Kota-kota Pantai di Indonesia.

Suripin, 2002. *Model Development of Ground Water Abstraction and Land Subsidence Potential Maps at The North Coast of Semarang Based On GIS*. Civil Engineriing Study Program. Engineriing Faculty Diponegoro University. Semarang. 32 p.

Sutanta, H dan TW Hobma. 2002. *Preliminary Assessment of The Impact of Land Subsidence and Sea Level Rise in Semarang, Central Java, Indonesia*. Proceeding PORSEC. Bali

Widiasmadi,N. 1999. *Peran Tambak sebagai Penyangga Kawasan Terhadap Pengaruh Eksternal Eksploitasi Dataran Alluvial.* PEMKOT Semarang dan Universitas Ki Ageng Pandanaran. Semarang (Indonesia)

Wirasatriya, A. 2005. *Kajian Kenaikan Muka Laut sebagai Landasan Penanggulangan Rob di Pesisir Kota Semarang*. Tesis Program Studi Magister Manajemen Sumber Daya Pantai. Universitas Diponegoro. (Indionesia)

SEA LEVEL RISE TREND AND ITS IMPACT ON THE COASTAL AREA OF BANGKALAN DISTRIC, MADURA

Achmad Fachruddin Syah
Lecturer of Department Marine Sciences University Trunojoyo
E-mail:fahrudin_unijoyo@yahoo.com

Abstract

Every change in the earth's surface such as climate change will have an impact on human survival. Study which is currently mostly done related to the global warming issue is the sea level rise (SLR). Assessment of SLR and its impact on coastal region has an important role. This is because of a lot of number of people who live and take advantages of the coastal region. Bangkalan District is one district that most of its territory lies on the coast directly opposite the waters. With a thin mangrove forest condition, land slope, elevation from sea level is low and the activities that can reduce the resilience of coastal inundation will affect the sea water both in the land and that happened outside the coastline. It will certainly affect the quality of life for coastal communities in Bangkalan.

Key words: global warming, rising sea level, impact, coastal

1. INTRODUCTION

1.2 Background

The increasing of sea level as the effects of global warming is one of the biggest challenges to be faced in environmental issues for the long term. Some of the issues mentioned that there has been a significant increasing of sea level. The study impact of sea level rise is an important to know the impacts especially in areas directly adjacent to the sea.

The level of damage caused in each area may be different depending on the carrying capacity of the area or the capacity of coastal and marine ecosystems. This difference is because of an addition to agro-ecological conditions between different islands so that use of different coastal areas, as well as the implementation of policies and the concentration of development in each region is very diverse.

Bangkalan District is one district that most of its territory located in the coastal region of East Java, is assumed as one area that receive the impact of SLR. It is because of that there are several areas that directly deal with the waters, low altitude and at least a layer of natural protective coastal mangroves.

1.2 Objective

The objective of study is to monitor the SLR trend from satellite Figurery as well as from the data *in situ*, and to assess the impact and vulnerability of coastal areas due to SLR.

2. DATA

Data used in this study is the sea surface high anomaly satellite altimeter from the year 1993-2009 derived from the database University of Colorado, USA. We use DEM ASTER data to produce coastal slope map. We use Global Mapper software for processing ASTER DEM data and for analyzing the coastal inundation areas due to SLR using ArcGIS software. Field study conducted to analysis of coastal condition such land use, coastal erosions, and others.

3. **RESULTS AND DISCUSSION**

3.1 General Condition of Bangkalan District

One district that has a region located in coastal areas is Bangkalan District of Madura Island. Bangkalan Regency is geographically located between 112° 40'06 "-113 ° 08'04" east longitude and 6 ° 51'39 "-7 ° 11'39" south latitude with an area of 1260.24 km^2.(Figure 1). With an area of the state of local topography consists of gently sloping area of 68,454 ha (54.25%), choppy areas covering 45,236 ha (35.85%), corrugated area covering 11,773 ha (9.33%) and hilly areas covering 719 ha (0.57%). Administratively Bangkalan district bordering are: (1) North side: Java Sea, (2) East: Sampang Regency, (3) te South: Madura Strait (Surabaya), and (4) West: Madura Strait.

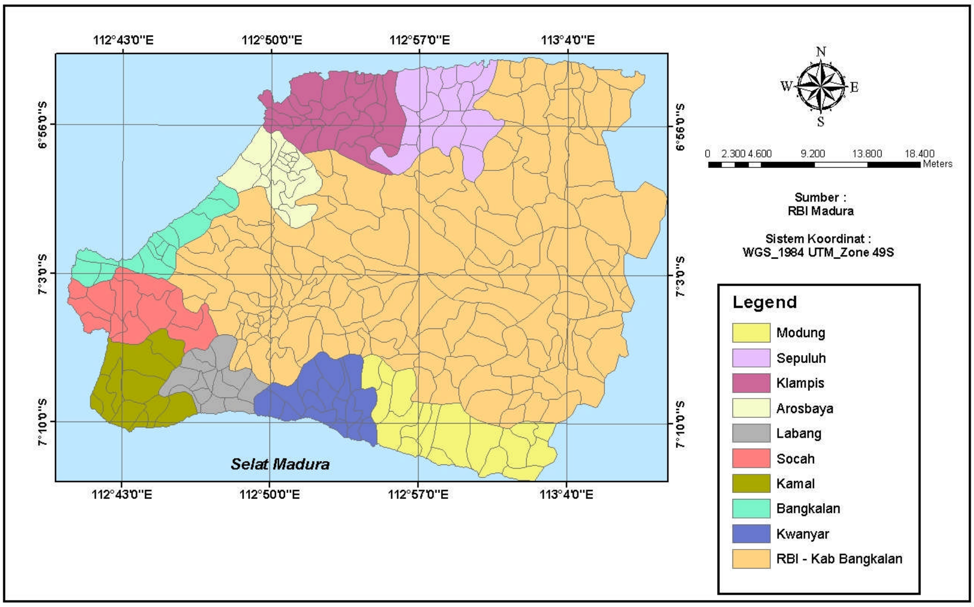


Figure 1. Coastal District of Bangkalan

Bangkalan District consists of 18 districts, divided in to over 273 villages and 8 wards. Based on the state of topography, the area of Bangkalan located at an altitude 200-100 m above sea level. By looking at high value of sea surface, high impact directly face the sea water is expected to affect the low-lying area which is located in coastal areas.

Areas in the District of Bangkalan located in coastal areas such as Sub Sepulu, Bangkalan, Socah, Kamal, Modung, Kwanyar, Arosbaya, Klampis, Tanjung Bumi, and Labang have a height between 20-10 m above sea level. While the region that is located in the middle has a height of between 19-100 m above sea level, the highest is Geger district with an altitude of 100 m above sea level.

In the Spatial Plan Document 2007, Bangkalan regionally is one of regencies in East Java province which has a relative rapid growth rate, both in the agriculture sector, plantation, animal husbandry, trading and services and industry sectors where it has been triggered the land changes and developments that affect the conditions of cultivation areas and protected areas. Bordering areas Bangkalan capital of East Java Province is predicted to grow rapidly as the impact of the Bridge construction, especially the southern coastal region of Bangkalan. Livelihoods of residents on the southern coast are largely aquaculture sector, agriculture, plantations, livestock, trade, services and industrial activities.

The total area of sub-districts located in coastal areas of Bangkalan is around 9,431 km^2 with an average population density 1,047 inhabitants per km^2. While the number and density of population in coastal areas Bangkalan can be seen in Table 1.

Table 1. Number and Density Population of Bangkalan Coastal

No	Sub-district	Population	Area (km^2)	Density per
1	Kamal	48101	41,4	1161
2	Labang	37159	35,23	1054
3	Kwanyar	46699	47,81	976
4	Modung	50415	78,79	639
5	Socah	58328	53,82	1083
6	Bangkalan	72914	35,01	2082
7	Arosbaya	43241	42,46	1018
8	Sepulu	45226	73,25	617
9	Klampis	53428	67,10	796

Source: Bangkalan in Figures 2008

Based on Table 1, can be seen that the level of population density in coastal areas of Bangkalan is quite high, especially in Sub Bangkalan which serves as a center of government and also Kamal as the central port district and transportation.

The ability of land in the District Bangkalan when it is viewed from the slope is then much has the value of the slope of 2-15% which is about 50,45% or 63,002 Ha, and slope of 0-2%, approximately 45,43% or 56,738 Ha. When it is viewed from the soil texture then most textured medium that is an area of 116,267 Ha or about 93.10% while the depth of the soil spektip the largest percentage of land ≥ 90 cm depth is about 64,131 hectares or 51.35%.

Average rainfall in the District Bangkalan in 2007 of 5,35 mm, much larger than in 2006 which reached 2,281, a rise of 57.36 percent. In the same period the average number of rainy days per year also increased ie from 127 days in 2006 to 183 days in 2007. Thus the increased rainfall along with the increasing number of rainy days.

Potential Fisheries Sector

Fishery potential of both sea and land in the District Bangkalan is very big because it has a wide sea area. It is also supported by centers of fishing (fishermen) and aquaculture are scattered along the shoreline Bangkalan. Marine fishery products are the mainstay of Bangkalan: Shrimp, Squid, Tuna, Layang Fish, Snapper, Crab and Ray. While the aquaculture products are: Mas Fish, Tilapiar, Milkfish, Tawes and Windu Shrimp. Overlooks the sea and shore fisheries are good opportunities for investment and trade. Because of the availability of a continuous supply throughout the year according to the season. The main location of fisheries are: District of Klampis, Sepulu, Bangkalan, Kwanyar.

The area of land aquaculture owned by Bangkalan is about 2.327 Ha. Aquaculture is as a whole of District Bangkalan covers 2.210 Ha pond area, pond area of 2 Ha, and wetland pond area of 115 Ha. Brackish pond fish production averaged 1.529,2 tons per year, as much as 7.76 tonnes of fisheries ponds and public fishing waters fisheries production of 133.50 tons per year. Marine fisheries as a whole in the District Bangkalan reach 23,204.10 tons per year with the largest production of marine fisheries is the District Klampis (3,619.80 tons) and Bangkalan (3,062.90 tons) while the lowest is in District Kamal (92.80 tons). Production of fish in public waters average of 133.50 tons per year with the largest production in Sub Bangkalan (34.30 tons) while the lowest is located in District Kwanyar, Modung and District Klampis with the same fish production of 4,30 tons.

Height of Sea Level

During 2007 the entire area of Bangkalan that experiencing periodic inundation and always get flooded covering approximately 5.38% (Table 2). Inundation that occurred caused the rising tide of sea water and river water overflow due to heavy rainfall. Based on discussions with one of the officials of the Department of Marine and Fisheries Bangkalan, when the high tide and heavy rains occur simultaneously then the pool becomes more widespread and reflux time becomes longer. There's even one of the areas in which adequate Bangkalan often experience rob.

Table 2. Coastal inundation

No	Pool	Area (ha)	%
1	Never get flooded	118170	94,62
2	Periodically get flooded	2082	1,67
3	Flooded continuously	4636	3,71

Source: Bangkalan in Figures 2008

Generally, area located in coastal almost in bordering areas the coastline. This conditions indicate that the tidal influence on coastal areas is quite dominant. One possible cause is the coastal region is an area of sloping and partly territory under the highest tide point.

To know the development of future inundation areas is used sea surface height anomaly (SSH) data derived from satellite from 1993 - 2009. SSH anomaly data at Western Madura Strait from 1993 to 2009 shown in Figure 2. The Sea level trend around Madura Strait is 3.4 mm /year.

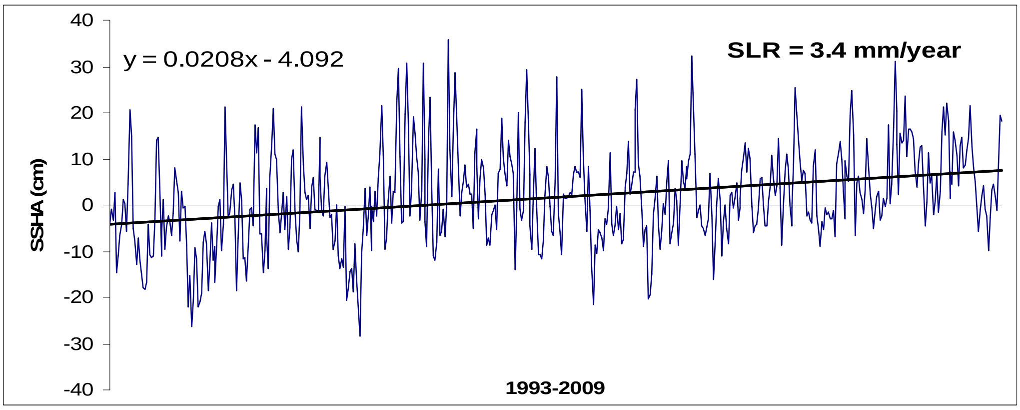


Figure 2. SLR trend in Western Madura Strait (1993-2009)

Based on the trend of SLR, the simulation was made coastal inundation due to SLR 20 and 50 years later. The simulation results coastal inundation due to SLR 20 years later shown in Figure 3. The results showed that 20 years later is predicted will occur inundation area about 188.84 ha.

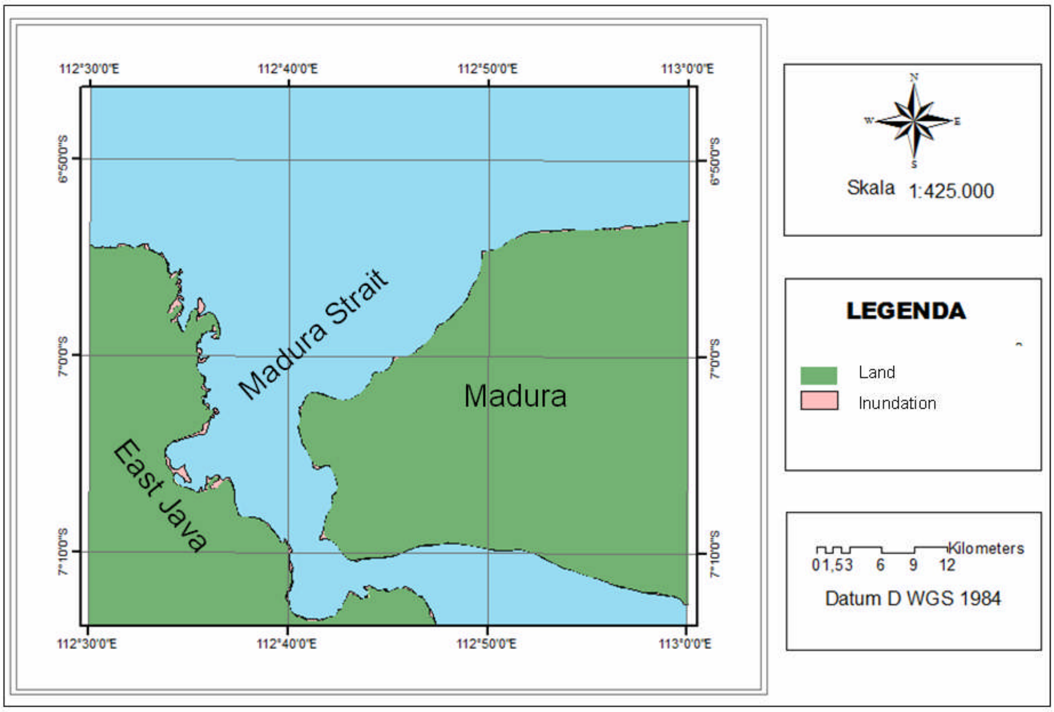


Figure 3. Simulation of Inundation in East Java and West Madura 20 years later

Figure 3 shows that the territories in Bangkalan the first time will inundated compare to Districts Kamal, Socah, Bangkalan and Klampis. It is possible to happen, given the four districts are located in coastal areas that deal directly with the waters and also the many activities undertaken by the society in areas such as aquaculture, agriculture, plantations, livestock, trade, services and industrial activities which can increase susceptibility to the occurrence of inundation. The following pictures shown the location in the district Socah and Kamal are predicted to experience inundation of sea water.

Figure 4. Coastal area in District of Kamal

Figure 5. Locations in District of Socah

Based on Figure 4 and Figure 5 above can be found that in coastal areas Socah District and Kamal, the condition of mangroves as a natural protective beach is very thin. This certainly slow the sea will cause abrasion that occurs will be more severe so that the mainland will be increasingly eroded by sea water. It can not be avoided that the existing roads along the coast, ponds, residential and other facilities and infrastructure will also be eroded by sea water which will eventually be getting damaged.

However, on the other side, especially in a densely populated area that is very close to the beach, seawall built a wall and a portion of the stacked stone construction. This aims are to prevent erosion and rising sea water onto land in order to protect the existing facilities and infrastructure on land. The examples of revetment have been built can be seen in Figure 6.

Figure 6. Locations in District of Labang

Coastal inundation for 50 years later due to SLR is shown in Figure 7. Predicted total land inundation is 953.04 ha. Based on the figure 7, there is some sub-district suffer such as Kwanyar, Arosbaya, and Seppuku District. It is also very possible to happen considering the 3 sub-district also have many activities undertaken by the coastal communities that can increase vulnerability to the high level of sea water looks like ponds, gently sloping ground and thin as a protective coastal mangroves in the region.

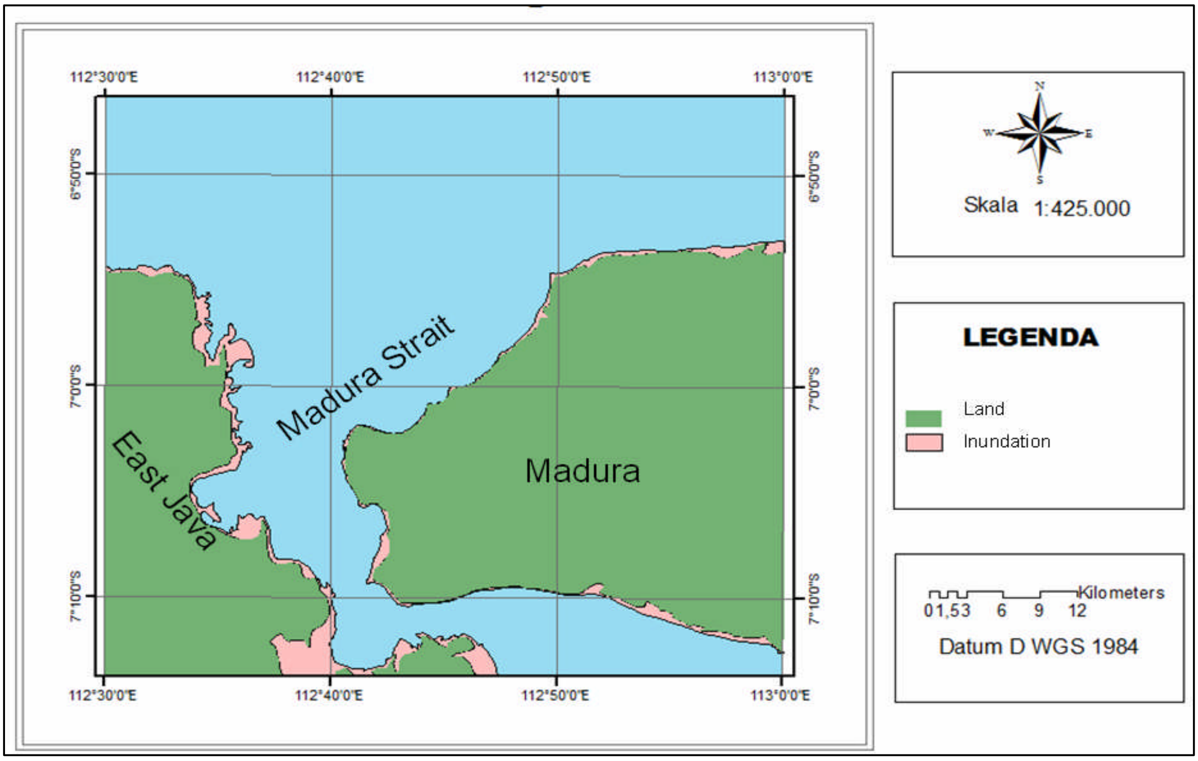


Figure 7. Simulation of Inundation in East Java and West Madura 50 years later

The larger range is certainly make inundation will increasingly and the land affected by the greater influence. It is predicted to increasingly add inundation. The settlements, roads and facilities that exist in the surrounding working paper that will be damaged due to eroded by the existence of a pool of water.

Shoreline changes are also expected to lead to the increasing indundation of sea water to land. Shoreline changes can occur by various causes, including erosion and sedimentation caused by currents, winds, waves, and tides. Although it is not very significant, there has been erosion, especially in Kamal harbor areas and around Suramadu. Based on the calculation and analysis of refraction, field observations, analysis of Landsat Figures, and the results of analysis of shoreline change, allegedly the main cause of erosion is the transformation of waves due to changes in shoreline contour bathimetery parallel, especially in environments with low bearing capacity due to damage to natural protective, thickness of the depletion of mangrove plants (Aries, 2010). The thickness of the mangrove plants correlated to the stability of the shoreline (Pratiwi, 2002).

Figure 8. Locations in District of Klampis

Weighing pressure exploitation of coastal resources and rapid rate of pollution, gradually influenced by the input of domestic waste or from the local population and industry, resulting in decreased physical quality of aquatic environment and ecosystem productivity can go down to the lowest point. Impacts that may arise are the decline of social-economic conditions of local communities which rely on natural resources in the surrounding of waters.

There are several aspects or variables that will be affected by the inundation. On the physical aspect of variable environmental conditions strongly influenced by the settlement of flood inundation, namely the condition of roads, drainage conditions, water conditions, physical condition of buildings, and health conditions. In social aspect, variable environmental conditions are strongly influenced by settlement floodwaters, namely the condition of comfort, while the economic aspect, variable environmental conditions are strongly influenced by settlement floodwaters, namely the condition of the home improvement spending, state spending on health, the condition of the public revenue. In general, the above conditions given can be seen that flooding due to tidal inundation of sea water provides a significant negative impact on the physical aspects of the residential environment. It impact causes to the existing environmental quality decreases.

CONCLUSION

One of result that is important to be observed as the effects of global warming is the occurrence of sea level rise. This situation will certainly affect the activity of residing in coastal areas. Associated with coastal areas in Bangkalan, sea level rise will add to the area of sea water inundation that occurr in the land area that occur outside of the coastline. This occurrence due to the vulnerability of coastal areas on the activities of undertaken and man-existing natural conditions in these coastal areas.

REFERENCES

Bangkalan Dalam Angka Tahun 2008. Badan Pusat Statistik Kabupaten Bangkalan.

Nicholls, Robert J and de la Vega-Leinert, Anne. 2002. Overview of The SURVAS Projet, Makalah pada Proceeding of APN/SURVAS/LOICZ Joint Conference on Coastal Impacts of Climate Change and Adaptation in The Asia-Pasific Region, Kobe Japan 14 – 16 November 2000

Pratiwi, A. 2002. Pengaruh Wilayah Bakau Terhadap Laju Sedimentasi di Desa Tengket, Kecamatan Arosbaya, Kabupaten Bangkalan, Tesis Magister, Institut Teknologi Sepuluh Nopember Surabaya.

Rencana Tata Ruang Wilayah Kabupaten Bangkalan 2007-2017. Bappeda Kabupaten Bangkalan

Revisi Rencana Tata Ruang Wilayah Kabupaten Bangkalan 2005. Bappeda Kabupaten Bangkalan

Siswanto, A. D. 2010. Analisa Stabilitas Garis Pantai di Kabupaten Bangkalan. Tesis. Surabaya. Pascasarjana ITS.

Suprijanto, I. 2003. Kerentanan Wilayah Tepi Air terhadap Kenaikan Permukaan Air Laut, Kasus Wilayah Tepi Air Kota Surabaya. Jurnal Dimensi teknik Arsitektur Vol 31. No 1. Juli 2003: 28 – 37.

Suprijanto, I. 2002. Model Pengembangan Wilayah Kota tepi Air, Makalah pada Kolokium Hasil Litbang PUSKIM, Puslitbang Pemukiman, Balitbang, Departemen Kimpraswil

SEA LEVEL RISE AND ITS IMPACTS ON COAST AREA OF KABUPATEN JEMBRANA, BALI

Teja Arief * dan Yoke Hanny Restianingsih*
*** Balai Riset dan Observasi Kelautan, Prancak, Bali**

1. INTRODUCTION

People activities in usage of fossil fuel and forest destruction have become irrefutable causes of the concentration acceleration of carbon dioxide (CO_2) and other gases with glass house effects in atmosphere (IPCC,2007). They are all affecting rise of average global temperature assessed of around 1.1 – 6.4°C before this century end. This global warming can happen if all countries keep on depending on fuels derived from fossil (IPCC, 2007), because it has effect on changing precipitation pattern, dryness, flood, hurricane, and warm waves will more frequently happen (National Wildlife Federation, 2007) .

Global warming will influence on sea level rise around the world. The cause is combination between spread of warm wave in seas and liquefaction of ice layer quicker on pole part. At present, average rise of sea level in the world is around 0.17 meters, this rise is 10 time quicker than the average of sea level rise of 3000 years before (IPCC, 2007).

Sea level rise will directly influence event of inundation on coast area. The inundation will cause increase in salinity on ground water. Various species in coast, whether it is flora or fauna, have optimum range salinity for their survival. Inundation will cause change of species community structure in coast (National Wildlife Federation, 2007). Sea level rise will also cause seashore erosion and coast area will be invulnerable toward storm. Indonesia is an archipelago consisting big and small islands. Thousands of small islands are most invulnerable for phenomena of sea level phenomena (Nunn, 2004).

To make as model the vast inundation caused by sea level rise for the coming 20 years and 50 years on entire subdistricts in Kabupaten Jembrana area, as well as to know the most invulnerable to the sea level rise on seashore areas of Kabupaten Jembrana, Bali.

2. RESEARCH METHODOLOGY

Location of study is Jembrana District, Bali Propince (Figure 1). Data used in this study is anomaly data of sea level height from altimetry satellite from years of 1993-2009 obtained from data base of University of Colorado, USA. For visualizing DEM Aster data, Global Mapper software is used, whereas ArcGIS software is used for analyzing inundated coast area caused by sea level rise.

Figure 1. Topography condition in Kabupaten Jembrana

4. RESULTS AND DISCUSSIONS

Jembrana District is one of districts in Bali Province located at west part of Bali Island. Kabupaten Jembrana has territory of 841,800 km^2 width stretching out 8°09'30" LS (south latitude) – 8°28'02" LS and 114°25'53" BT (east longitude) – 114°25'53" BT. Administratively, Kabupaten Jembrana consists of 4 subdistricts (Kecamatan), i.e. Melaya, Negara, Mendoyo, and Pakutatan. Those 4 subdistricts have sea borders. Amongst those 4 subdistricts, Kecamatan Negara has the widest seashore area compared to other subdistricts. Around 20 village of 4 subdistricts in Kecamatan Jembrana are seashore area (Table 1).

Table 1. Subdistricts and villages of Kabupaten Jembrana which are on the seashore.

No	Sub-district	Villages
1	Melaya	Candikusuma, Gilimanuk, Tukadaya,Tuwed
2	Mendoyo	Delodberawah, Penyaringan, Sumbul, Yeh Embang, Yeh Embang Kauh
3	Negara	Baluk, Cupel, Pengambengan, Air Kuning, Perancak Yeh Kuning
4	Pekutatan	Medewi, Pangyangan, Pekutatatan, Pengeragoan Pulukan

To detect the vulnerability of Kecamatan Jembrana area toward sea level rise, a deep study is required to observe the impacts. The study results are expected to be use as input in developing mitigation and adaptation system on climate change in Kabupaten Jembrana.

Four subdistricts available in Kabupaten Jembrana, all have seashore areas, and along seashore area of Jembrana, the topography is in low category and sloping level is around 0-2% (Figure 2). Therefore, the four subdistricts topographically and also the sloping level have invulnerability toward sea level rise.

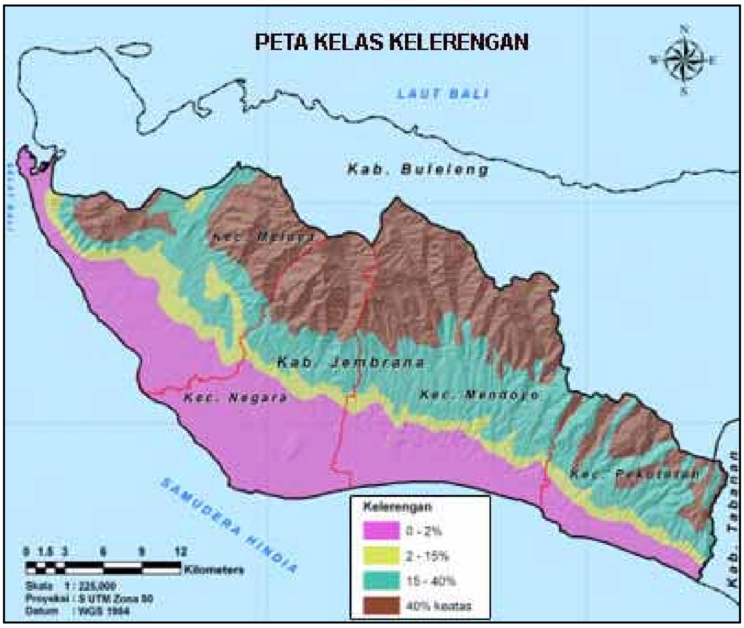


Figure 2. Slope levels of Kabupaten Jembrana

For the entire Bali Province, analyses results of sea level height from altimetry satellite for periods of 1993-2009, show that there are TPL rise trends amounting to 3.2 mm/year (Figure 3).

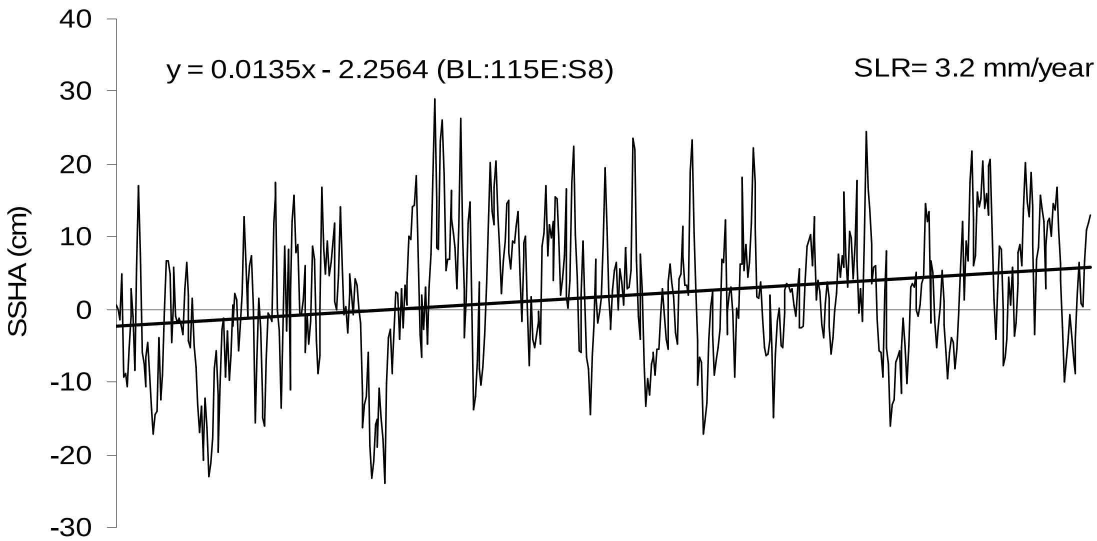


Figure 3. Sea Level Trend of Bali Province (1993-2009).

Based on the above analyses results, the model is made on inundation caused by sea level rise for the coming 20 years and 50 years. Results of inundation model in four subdistricts of Kabupaten Jembrana for 20 years and 50 years later (Tabel 2).

Table 2. Prediction coastal inundation for 20 years later.

No	Kecamatan	Luas Genangan (km^2)
1	Melaya	0.3230
2	Negara	0.2024
3	Mendoyo	0.1488
4	Pekutatan	0.3329

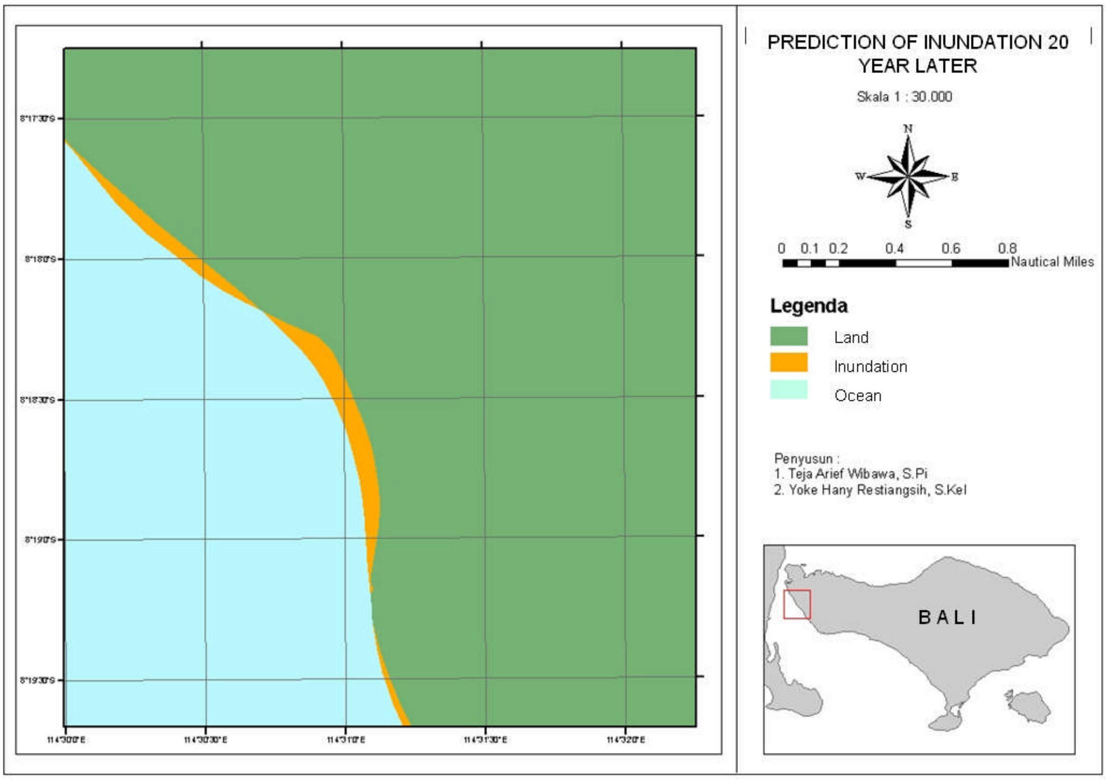


Figure 4. Inundation Model for 20 years to come in Kecamatan Melaya, Jembrana

Tabel 3. Prediction coastal inundation for 50 years later.

No	Kecamatan	Genangan di Darat (km^2)	Genangan di Luar Garis Pantai (km^2)
1	Melaya	0.1553	0.1600
2	Negara	0.0189	1.1067
3	Mendoyo	0.0069	1.5952
4	Pekutatan	0.0099	0.9340

Results of the inundation model for the coming 20 years and 50 years show that there are two subdistricts of Kabupaten Jembrana which are invulnerable to sea level rise, i.e. Kecamatan Melaya and Kecamatan Pekutatan. Kecamatan Pekutatan is a subdistrict that will undergo vast inundation as in the scenario sea level rise in 20 years and 50 years to come, to follow is Kecamatan Melaya.

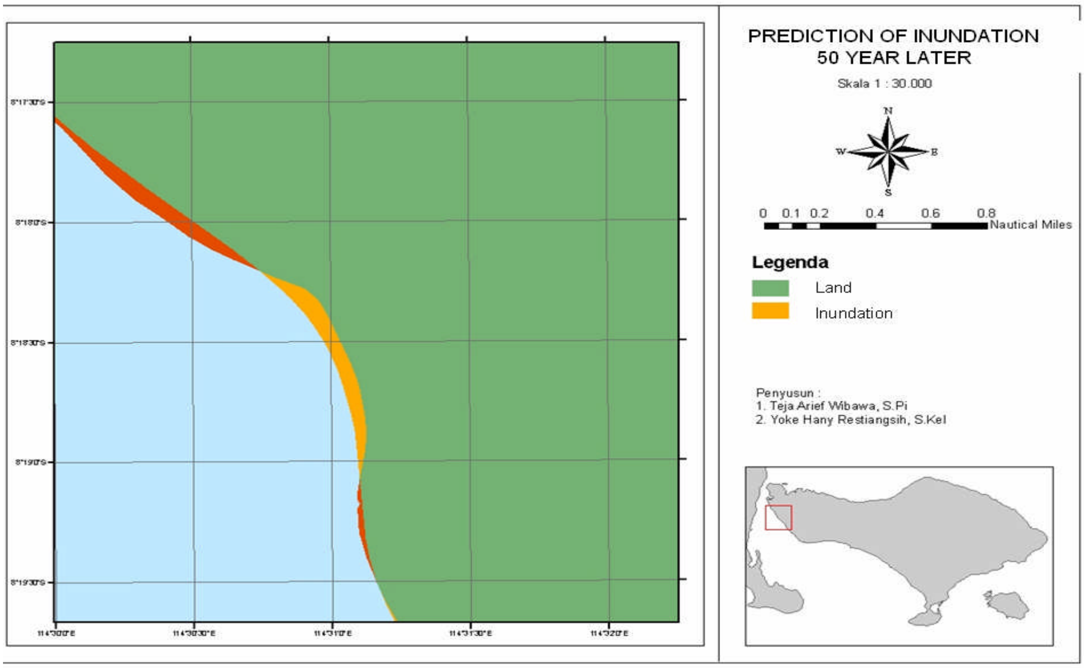


Figure 5. Prediction of coastal inundation 50 yeera later

One of seashore villages in Kecamatan Melaya has so far undergone problem of seashore abrasion. Some years ago, it is assessed change of seashore line in Desa Candikusuma. Facts on the field show that there are ex-trees felt down along the seashore of Candikusuma village (Figure 6). That condition, however, need to be further studied, whether abrasion on the seashore of Candikusumo is caused by sea level rise as the impact of climate change, or it is caused wave pattern change as result of development of fishery harbour of Nusantara Pengambengan.

Figure 6. State of Beach in Candikusuma village

Whereas seashore area of Kecamatan Pakutatan, it is mostly known as tourism area in Kabupaten Jembrana. One of seashore areas in Kecamatan Pakutatan, i.e. Medewi is one of surfing location for foreign tourists in Bali (Figure 7).

Figure 7. Surfing activities in Medewi Beach

In addition of tourism area, beach on west side of Pantai Medewi is utilised by traditional fishermen to put ashore their boats. This situation of Pantai Medewi is arranged of sand and stones (Figure 8). With this condition so far, Pantai Medewi tends to be escaped from abrasion process.

Figure 8. Medewi Beach

REFERENCES

Intergovernmental Panel on Climate Change (IPCC). 2007. *Climate Change 2007: The Physical Science Basis; Summary for Policymakers. Fourth Assesment Report*, Intergovernmental Panel on Climatic Change, Geneva Switzerland.

National Wildlife Federation. 2007. *Sea-level Rise and Coastal Habitats in the Pacific Northwest; An Analysis for Puget Sound, Southwestern Washington and Northwestern Oregon*.

Nunn, Patrick D. 2004. *Understanding and Adapting to Sea-Level Change*. In Harris, F (eds.). *Global Environmental Issues*. John Wiley and Sons.

ASSESMENT OF COASTAL INUNDATION IN SELECTED COASTAL AREAS OF INDRAMAYU DUE TO SEA LEVEL RISE

Aninda W. Rudiastuti, Risti Endryani Arhatin, Jonson Lumban Gaol
Department of Marine Science and Technology
Bogor Agricultural University

ABSTRACT

Climate change and anticipates impacts of sea level rise (SLR) such as increased coastal erosion, inundation, and salt water intrusion will affect all countries but mostly small island countries of oceans and low lying lands along coastlines. Indonesia as an archipelago country will also received this impact. Thus, a coastal vulnerability assessment of Indonesia to sea level rise is needed as a part of coastal zone management. Indramayu, one of Indonesia's coastal regions, which has 114.1 km of coastline, has been dealing with coastal erosion and its vulnerability will more by SLR. Prediction to inundation at Indramayu coastal region for next 20 and 50 years show that area of inundation will increase especially at several subdistricts such Cantigi, Indramayu and Sukra.

Keyword: sea-level, inundation, coastal, climate change

1. INTRODUCTION

Coastal regions are very vulnerable toward impact of reidents' activities and the nature condition, especially by rise of sea level. This condition can cause serius vulnerability to the rise of sea level height by global warming. The rise of global warming causes rise of seal level height, and this, of course, will threaten the existence of small islands and of small areas with slopiness. The slopiness causes every resident who lives in coast must be on the alert for degradation of living in coast area as the effect of SLR. Air temperature increase since early 1990s on the global temperature reaching 1°/century, has triggered temperature increase of sea surface on the same pattern (Folland *et al*.,2001).

District Indramayu locating on the north coast of Java Island has coast line of 114.1 kms length. It has 11 kecamatan (subdistricts) (Bapeda Indramayu, 2006). There are 7 out of 11 subdistricts spreading on coast and being research area for this study, i.e. Kecamatan Sukro, Patrol, Kadunghaur, Losarang, Pasekan, Cantigi and Indramayu.

Land-usages in Indramayu are varied, mainly as rice cultivation field, shrimp or bandeng breeding in coastal ponds or salt-making location. Kabupaten Indramayu has areal of 204,011 Hectares consisting of 110,548 hectares of rice field (54.19%) wich technical irrigation of 73,600 hectares, half technical irrigation of 11,734 hectares and PU simple irrigation of 2,978 hectares as well as PU median irrigation of 18,275 hectares, a.o. are Rain-receptacle rice-fields.

Fussel and Klein (2006) in Ozyurt and Ergin (2009), stated that there are a lot of different stages in estimating coast vulnerability that can clearly be differed quantatively to semiquantatively, non-adaptively to perfect adaptively based on scientific interests upto interests of the decision maker, simple upto complex. Every estimate calls for differently carefull and accurate data.

This study is designed for learning inundation width as the result of SLR. In Indramayu case, the writer tried to find out the approach from estimation side of inundation. This can be done by seeing prediction for 20-50 years onward to how wide the inundation is as the result of SLR, and counting how wide the lost coast area on that account.

2. METHODOLOGY

This study was held in Kabupaten Indramayu, and covering 7 Kecamatan (subdistricts), i.e. Sukra, Patrol, Kandanghaur, Cantigi, Sindang, and Indramayu (Figure 1). Geographical border of chosen areas of this study are around 107° 52'00" – 108°17'00" E and 6°0'00' – 6°30'00 S. The chosen areas of this study are coast areas having land erosion making coast line back up along the year. It calls for joining two Figures from ASTER GDEM of the year 2002 with position of SO7E107 and SO7E108. Data of SLR is taken from SLR in Colorado University. Data processing uses software ArcGIS 9.3 and Global Mapper 11. Coast line are formed from ASTER GDEM Figure representing difference of earth surface height with lowest score is sea (</= 0). Prediction on SLR was made in two periods of 20 years and of 50 years.

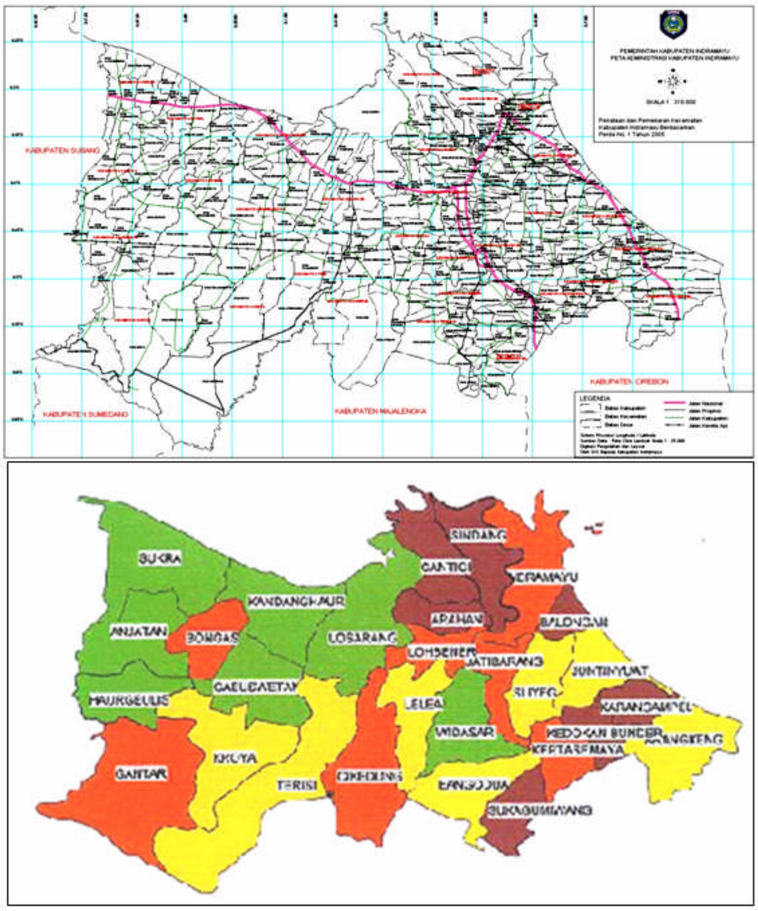


Figure 1. Map of administration border of Kabupaten Indramayu

Prediction was carried out by conversing value in meters/year, then to form contour line according the value of SLR of each year in 20 years and in 50 years. Contour line results of each year prediction and preciding coast line gave smoothing process as far as 1 km. So, the contour line and coast line can be overlaid to form new area which are the cutting result estimated as inundation area in 20 – 50 years to come.

Inundation width can be detected. Especially this can be on the sloping coast. As validation, a field survey has been carried out discovering how abrasion has impacted coast form and becomes main cause of decrease of land width (set coast line back up), disregarding effects of SLR. To make easy in comparing different inundation width in 2 period prdictions, the study areas are divided into 5 blocks (Figure 2)

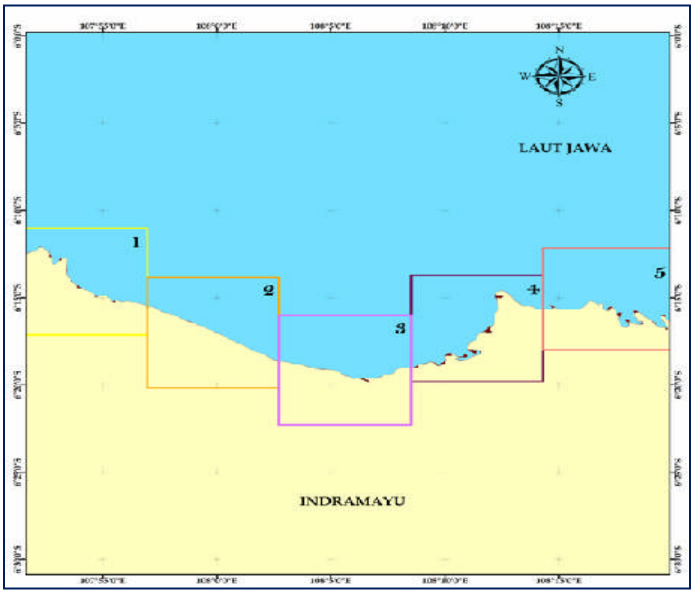


Figure 2. Division of study location

3. RESULTS AND DISCUSSION

SLR trend at Indramayu coast are around 3,8 mm/year (Figure 3). Based on processing results, it is known that on time ranging 20 – 50 years there will be inundation at Indramayu coast. On prediction of 50th year, inundation width will increase in some subdistricts. It can be predicted that Indramayu coasts are very vulnerable toward inundation by SLR. Figure 4 and 5 represent the inundation at indramayu coast in the time ranging 10 and 50 years. Small scale complicated for viewing detailed inundation in all coast line, threfore we devide area into 5 blocks for viewing detailed inundated area in every subdistricts.

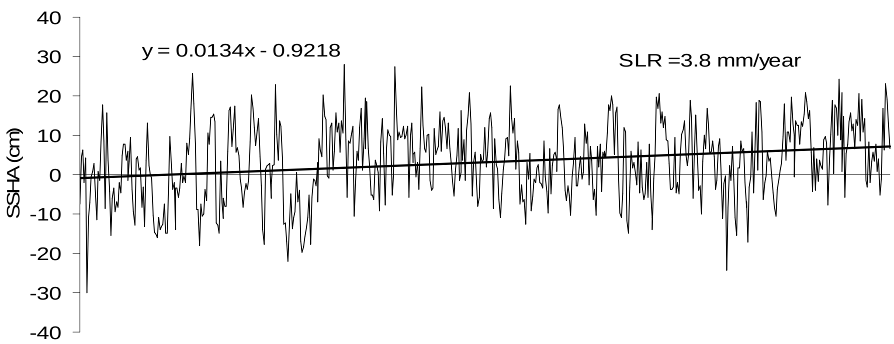


Figure 3. Sea Level Rise trend derived from satellite altimeter (1992-2009)

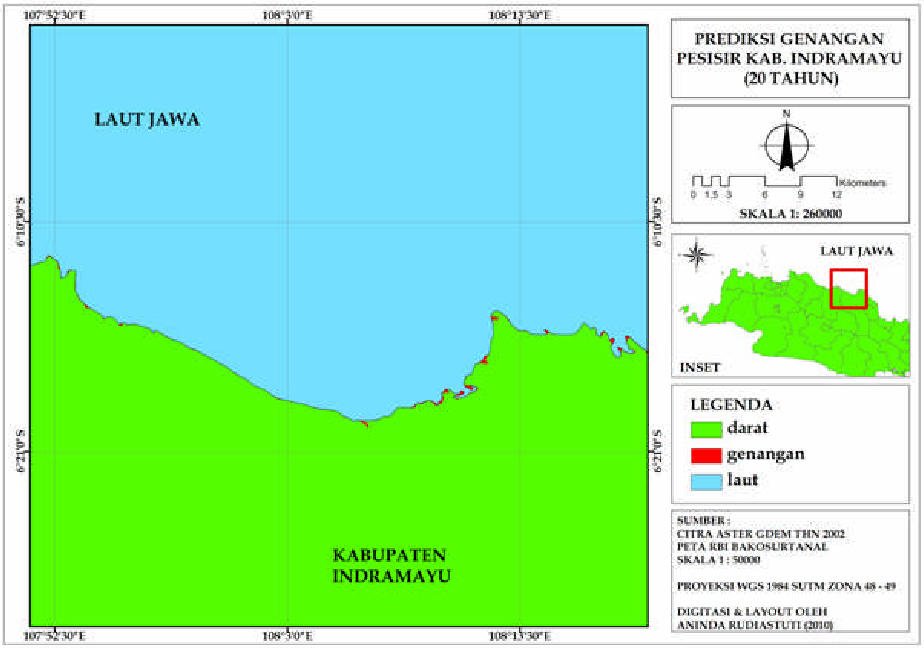


Figure 4. Prediction of coastal inundation at Indramayu in the next 20 years

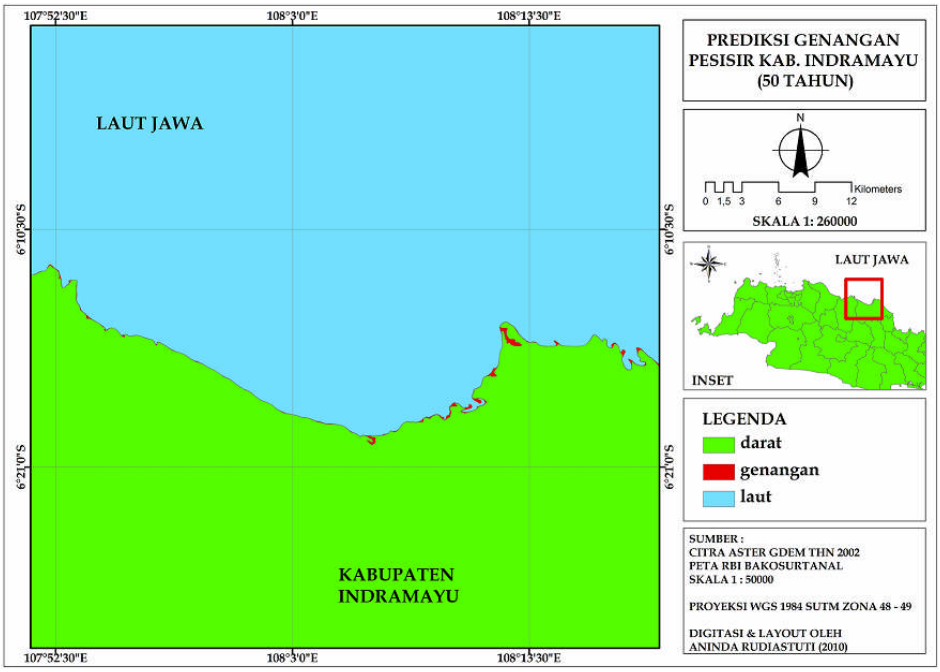


Figure 5. Prediction of coastal inundation at Indramayu in the next 50 Years

On both Figures above, red color marked on the map is coast area that will be inundated as results of SLR. Figure 4 presents inundation that happen for 20 years to come by taking average value on Indramayu coast line 0f 3.85 mm/year due to SLR. All Indramayu coasts will experience impact of SLR. However, coast area of some subdistricts, Sukra, Losarang, Cantigi, Sindang and Indramayu are dominant to be inundated. No too far difference with condition on 20 years prediction, the prediction of 50 years to come (Figure 6), Indramayu coast area will experience inundation by SLR.

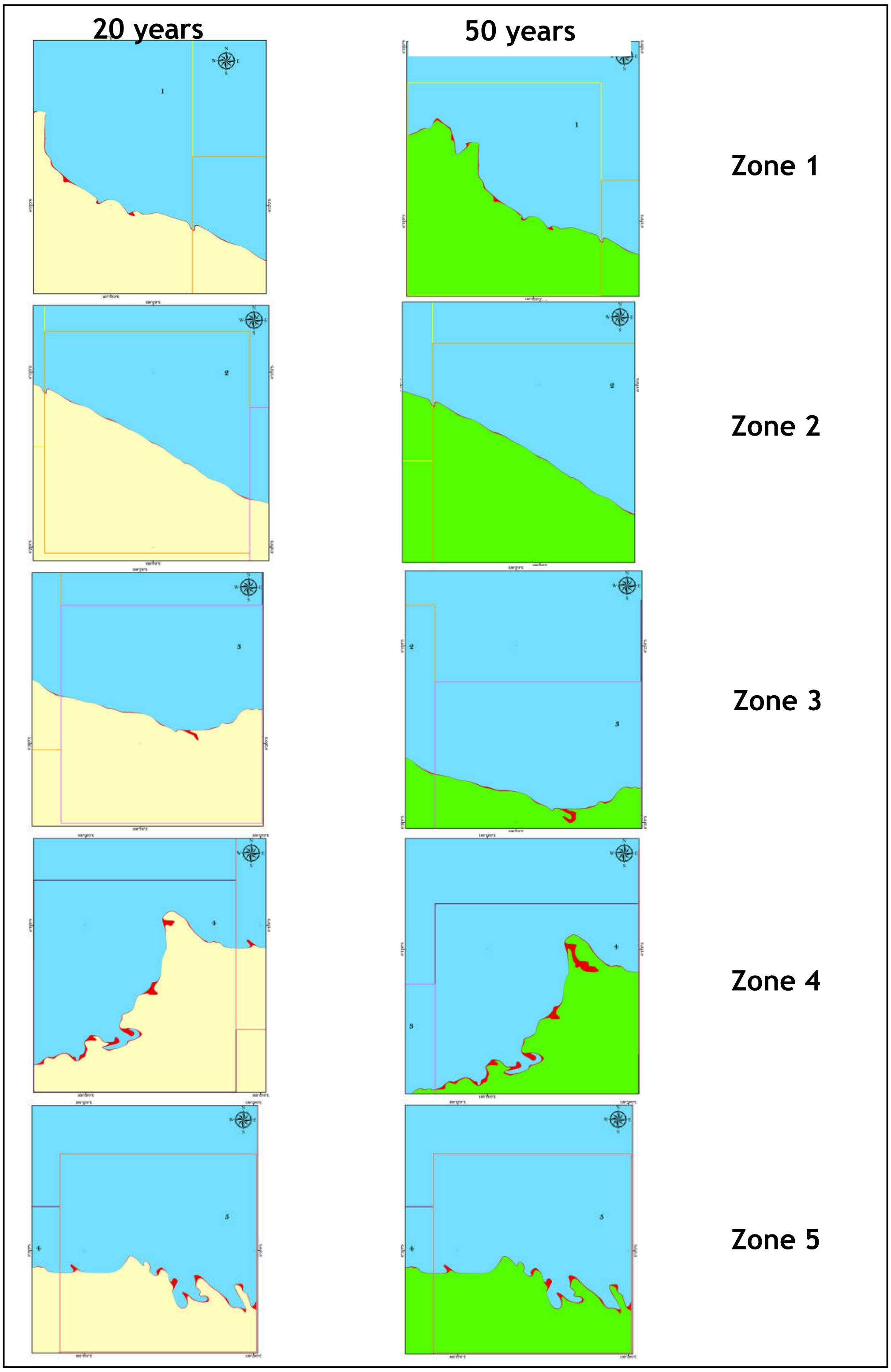


Figure 6. Comparison of coastal inundation for the coming 20 and 50 years

In Figure 5, Indramayu coast that has been divided into some zones to facilitate comparison of inundation width predicted on 20 and 50 years to come. From the

comparison on Figure 5 it is known that on zona 4th and 5th, change of inundation width will be significant in range time of 30 years.
Dominantly inundated area will still be same with on the time of 20 years to come, the inundation width will increase. Comparation inundation width of 20 years and 50 years prediction are presented on Tabel 1.

Table 1. Comparation of inundation width and land width in inundation width prediction caused SLR in 20 and 50 years later.

Years	Land (ha)	Inundation (ha)
20	14,156.40	33.2
50	14,144.90	44.7

Tabel 1 shows that inundation width on next 20 years prediction will reach 33.2 ha, and inundation width will increase together with increase time will reach 44,7 ha as 50 years prediction. Therefore, it will be decrease of width on land. For case of Indramayu coast, decrease width of land will also be aggravated by coastal erosion. Land erosion process and inundation by SLR will easily happen on Indramayu coast, because the sloping type of coast and coast geomorphology is sandy land that can easily eroded and will be fast inundated (Figure 6). Figure 6 depicted photographs of survey results on the field and photographs of Bapeda Indramayu (2006) showing that condition of Indramayu coasts has had land erosion and will be aggravated by increase of SLR. A number of low land on coast (which is used as fish pond or rice field) will easily inundated by SLR.

Figure 6. Photos of land erosion in coastal Indramayu

Data of land erosion in Indramayu in figure of 2007 tells that coast line of 114,1 km long, 42,055 km has been effected abrasion. These both processes, abrasion and inundation by SLR, will cause back up of coast line in land, and land lost.This will be great lost economically for resident making a living as fish cultivation on coast. It is, therefore, Indramayu coast is predicted to be vulnerable toward SLR, and for making sure stages of Indramayu coast vulnerability. This step can be done by further CVI Index.

4. CONCLUSION

Indramayu is vulverable toward SLR aggravated by land erosion condition that has happened in that area. Indramayu with sloping coast will make this area easily inundated. Prediction results are that by SLR, in 20 and 50 years to come, inundation will happen along the coast line. However, more dominant inundation will happen on east coast area of Indramayu. Determination of vulnerability actual stage and to overcome land erosion process can prevent more lost of land with that can be suffered by residents on coast area.

REFERENCES

AVISO. 2010. AVISO Data from Altimetry Sattelite. http:\\www.aviso.oceanobs.com [october 2010]

Bapeda Indramayu. 2006. Laporan Pemetaan dan Studi Abrasi-Deposisi Pesisir Kabupaten Indramayu. CV.Marga Bhuana. Indramayu.

Bapeda Indramayu. 2007. Data Abrasi Pantai Di Kabupaten Indramayu Tahun 2006. Dinas Perikanan dan Kelautan Kabupaten Indramayu.

Folland, C.K., N.A. Rayner, S.J. Brown, T.M. Smith, S.S.P. Shen, D.E. Parker, I. Macadam, P.D. Jones, R.N. Jones, N. Nicholls and D.M.H. Sexton. 2001. Global Temperature Change and its Uncertainties since 1861. Geophysical Research Letters 28: 2621-2624.

Ozyurt G. dan A. Ergin. 2009. Application of Sea Level Rise Vulnerability Assesment Model to Selected Coastal Areas of Turkey. Journal of Coastal Research, SI 56, 248-251. Lisbon, Portugal, ISSN 0749-0258.

Tim GIS Bapeda Indramayu. 2006. Peta Administrasi Kabupaten Indramayu. Pemerintah Kabupaten Indramayu.

COASTAL VULNERABILITY ASSESSMENT OF NORTH COAST BANTEN TO SEA-LEVEL RISE

Chigo Ovaria Sujarwadi[1], Vincent P. Siregar[1], Teguh Prayogo[3]

[1] Department Marine Science and Technology
Faculty of Fisheries and Marine Science, Bogor Agriculture University
[3]Researcher of the Deputy for Remote Sensing
Lembaga Penerbangan dan Antariksa Nasional

Abstract

In this study analyzed coastal vulnerability in north coast of Banten. The parameters used to analyze the vulnerability of coastal areas consist of two variables: the variable geology (geomorphology, elevation and shoreline change) and physical process variables (SLR, the average high tide and C). To obtain a zone of vulnerability then the parameters that have been processed and then given a score. After all parameters have a score, then to know the level of vulnerability of a region need to go through the calculation of Coastal Vulnerability Index (CVI). After the calculation results obtained, coastal vulnerability index which in turn are grouped into areas that are low vulnerability, moderate vulnerability, and high vulnerability. Distribution of this index by dividing by percent with range between the classes is 33 percent. It is known that many high vulnerability coastal areas are in coastal areas Tangerang sub district Kronjo, Mauk, Sukadiri, and Kosambi with a length of coast 28 km (± 16.09% of total length). Areas to the level of vulnerability is low widely available in the western region of the sub district of Banten is Ciwandan, Grogol, Pulomerak, Puloampel and Bojonegara n with a length of coast 64 km (36.78%).
Keyword: vulnerability, coastal, sea-level

1. INTRODUCTION

1.1. Background

The northern province of Banten is an area that is growing, at this coastal region of offerings have been widely used for various activities, like industry, fisheries, housing, and tourism. All of these activities can negatively affect the coastal environment of Banten, likely coastal erosion, pollution and household waste.

Sea-level rise is one of the phenomena caused by global warming, where global warming is caused by the increase in global temperature from year to year due to the greenhouse effect. Increasing air temperature causes the expansion of sea water and melting ice at the poles so that the sea level will rise and pose a threat, especially to the region that is located on the beach. According to the Intergovernmental Panel on Climate Change (IPCC) 2001 Sea-level rise has been occurring at 0.1 to 0.2 meters in 1901 to 2000 with increase in temperature by 0.6 ± 0.2 ° C. Meanwhile, according to the IPCC 2007 Sea-level increase is estimated at between 0.6 to 1.9 m occur in 2010 until 2030 with a temperature rise of 2.8 to 3.2 ° C and up to 1.0 to 3.7 m in the year 2060 until year 2090 with a temperature rise of 4.9 to 6.1°C.

1.2. Objective

The objectives of this study was to analyze the vulnerability of coastal areas north of Banten on SLR by using Geographic Information System.

2. METHODS

The location of study is Banten Province which includes Tangerang, Serang, and Cilegon. Geographically the study area is located at 5⁰50'16,91" LS - 6⁰12'44,59" LS and 105⁰54'33,45" BT - 106⁰43'39,62" BT (Figure 1). North Coast of Banten Province who will be research in this study is 1500 meters from the coastline to the boundary of each cell is a border sub district. Data processed in the Office of the Deputy for Remote Sensing LAPAN, Pekayon, Pasar Rebo, East Jakarta.

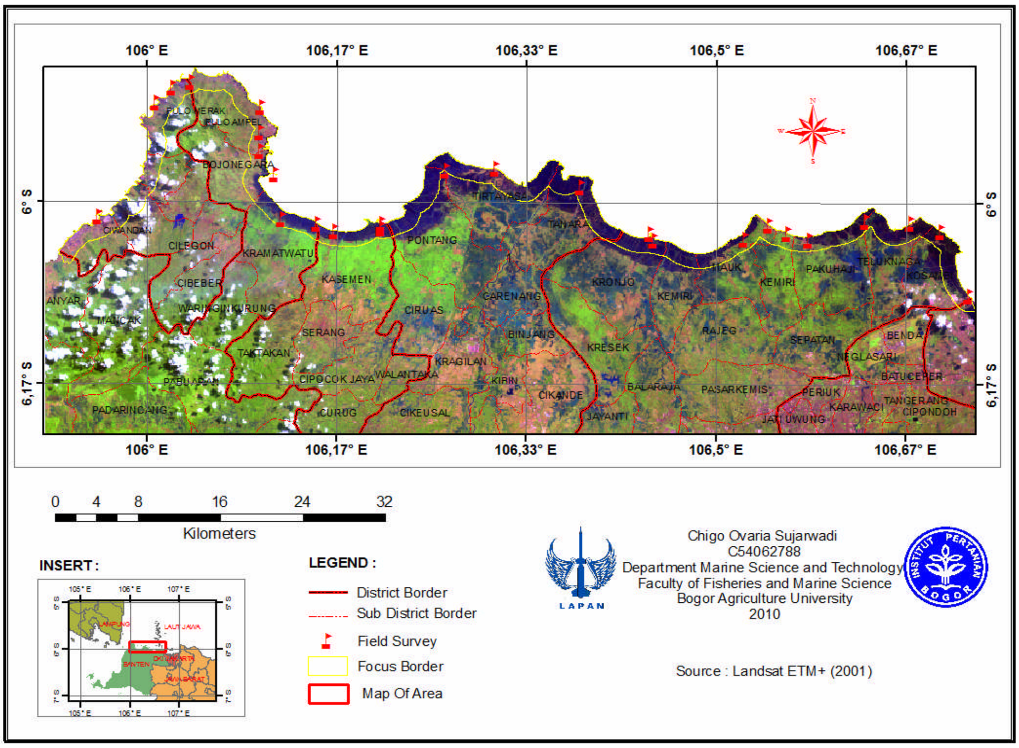


Figure 1. Study Site Map

The tools used are Global Positioning System (GPS) and Digital Camera as field survey equipment. Materials research is a Landsat satellite Figurery, Digital Elevation Model (DEM) - SRTM, Sea-level rise data from satellite,Tidal data, and wave height data.

Geomorphology data obtained from results of Figure processing ALOS Avnir path 123 row 64 which was recorded on April 28, 2007 and path 122 row 64 which was recorded on 15 november 2007. The method used for determining the geomorphological index value is by way of remote sensing methods and GIS. Geomorphological data obtained through the process of digitization on the basis of appearance of land use on ALOS Figurery, the results of this process is the file with a shapefile (*.shp).

The value of shoreline change (m/year) the northern area of Banten obtained from a comparison of Landsat satellite Figures of different year or multi-temporal. Each year a different Figure of coastline digitized using Figure processing software after geometric correction, both the results of digitizing the dioverlay to know the changes that occur. With the toolbar menu measure we measured the changes that occur, if recent years the shoreline towards the sea means an addition or accretion, but if the recent years the shoreline towards the land means a reduction or abrasion.
Value altitude northern coast of Banten Data obtained from Digital Elevation Model (DEM)- SRTM. Data in accordance with the study area at cropping and then exported for later height values can be classification into 5 classes using reclassify in accordance with the weighting determined by Gornitz et al . (1997).

Tidal data from downloaded in http://ilikai.soest.hawaii.edu/uhslc/datai.html then processed using Microsoft Excel, the data used in this study is the daily tidal data for 21 years (1984-2004) on station at 6.07° LS and 106.51° BT. Furthermore, tidal data per day looking for the difference between minimum and maximum every month, then averaged each year in order to obtain the results of the annual tidal for 21 years (1984-2004), who represents the North coast of Banten.

Data processing an average significant wave height begins with extracting data netcdf (*.nc) that are downloaded from http://data-portal.ecmwf.int/data/d/interim_daily/
using the ODV (Ocean Data View) into data formatted text (*. txt) at stations located in Banten North, the station at 6° LS and 106.5° BT. Furthermore, data at intervals of every 6 hours were averaged for each year in order to obtain an average output of significant wave height per year for 20 years (1990-2009), who represents the North coast of Banten.

Data of SLR from downloaded in http://rads.tudelft.nl/rads/data/ authentication.cgi consist of ASCII formatted files that have been formed into a "zip", consisting of satellite passes on earth and cycle or satellite spin on the same trajectory. Data of SLR that is used has a 10-day intervals for 16 years (1993-2008), Furthermore using Microsoft Excel to obtain the trendline or the average SLR each year representing the North coastal area of Banten.

To analysis coastal vulnerability using 6 parameters that have been processed and then given a score according to Table 1.

Table 1. Ranges for vulnerability Ranking of parameters on North coast of Banten.

No	Ranking / Variables	Very Low 1	Low 2	Moderate 3	High 4	Very High 5
a	GEOMORPHOLOGY	Rocky cliffed coasts, Fjords	Medium cliffs, Indented coasts	Low cliffs, Glacial drift, Alluvial plains	Cobble Beaches, Estuary, Lagoon	Barrier beaches, Sand beaches, Salt marsh, Mud flats, Deltas, Mangrove, Coral reefs
b	SHORELINE EROSION/ ACCRETION (m/yr)	> 2.0 Accretion	1.0 - 2.0 Accretion	+1 - -1	-1 - -2 Erosion	< -2.0 Erosion
c	Mean Elevation (m)*	> 30.0	20.1 - 30.0	10.1 - 20.0	5.1 - 10.0	0.0 – 5.0
d	RELATIVE SEA-LEVEL CHANGE (mm/yr)	< 1.8	1.8 - 2.5	2.5 - 3.0	3.0 - 3.4	> 3.4
e	SIGNIFICANT WAVE HEIGHT (m)	< 0.55	0.55 - 0.85	0.86 - 1.05	1.06 - 1.25	> 1.25
f	MEAN TIDE RANGE (m)	> 6.0	4.0 - 6.0	2.0 - 4.0	1.0 - 2.0	< 1.0

Source: - Pendleton et al. (2005) - Gornitz et al. (1997) (*)

After all parameters have a score, then to know the level of vulnerability of a region need to go through the calculation of Coastal Vulnerability Index (CVI) as follows (Pendleton et al. 2005):

$$CVI = \sqrt{\frac{(a*b*c*d*e*f)}{6}}$$

Where:: a = geomorphology d = sea level rise
b = shoreline changes e = wave height
c = elevation f = tidal

After the calculation results obtained, coastal vulnerability index which in turn are grouped into an area that is low vulnerability, moderate vulnerability, and high vulnerability.

3. RESULTS AND DISCUSSION

North coast of Banten dominated by geomorphological indicators Rocky cliffed coasts, industrial, and residential areas located on the west coast, while in the north central and north east coast of Banten beach area is dominated by alluvial plains, residential, delta, and groups of mangroves as shown in the Figure 3.

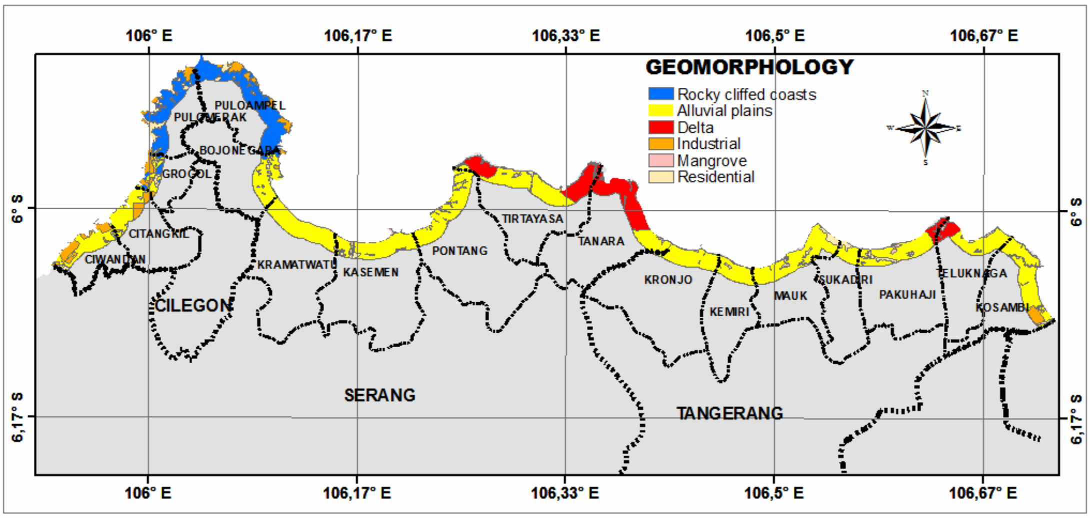


Figure 3. Geomorphology map

In general, the coastline on the north coast of the western experience additional because the location is a lot happening, so many of the industrial development until coastal reclamation and the eastern part is generally in the area of the river estuary. As for changes in the coastline that experienced the largest rate of reduction or abrasion occurs in the bay area, as shown in Figure 4.

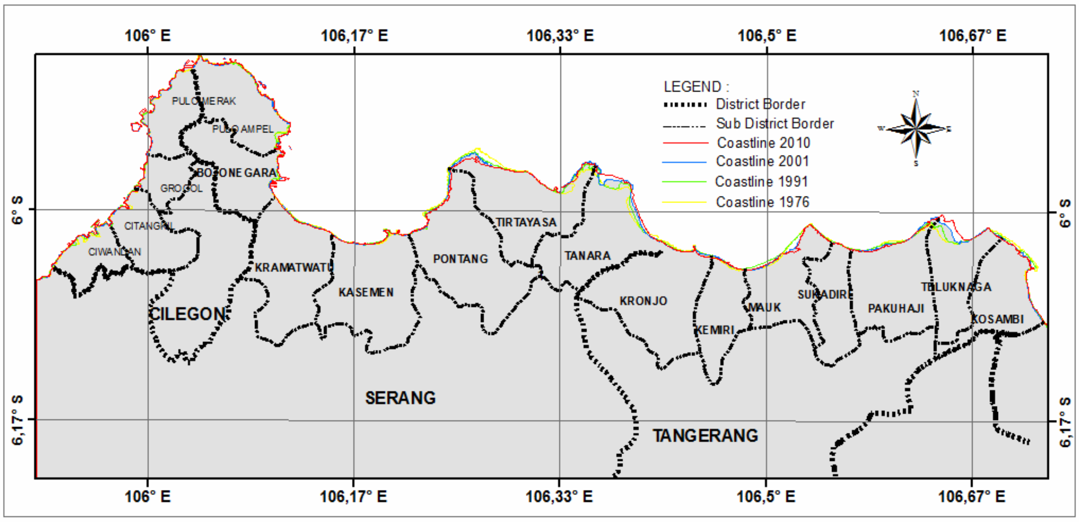


Figure 4. Shoreline changes (1976-2010)

Based on DEM-SRTM data in Figure 5, in general the northern coastal areas of Banten on the western part of the plateau area with an altitude varying from 0 to more than 30 meters, while the eastern part is a lowland area with a height of 0 to 5 meters.

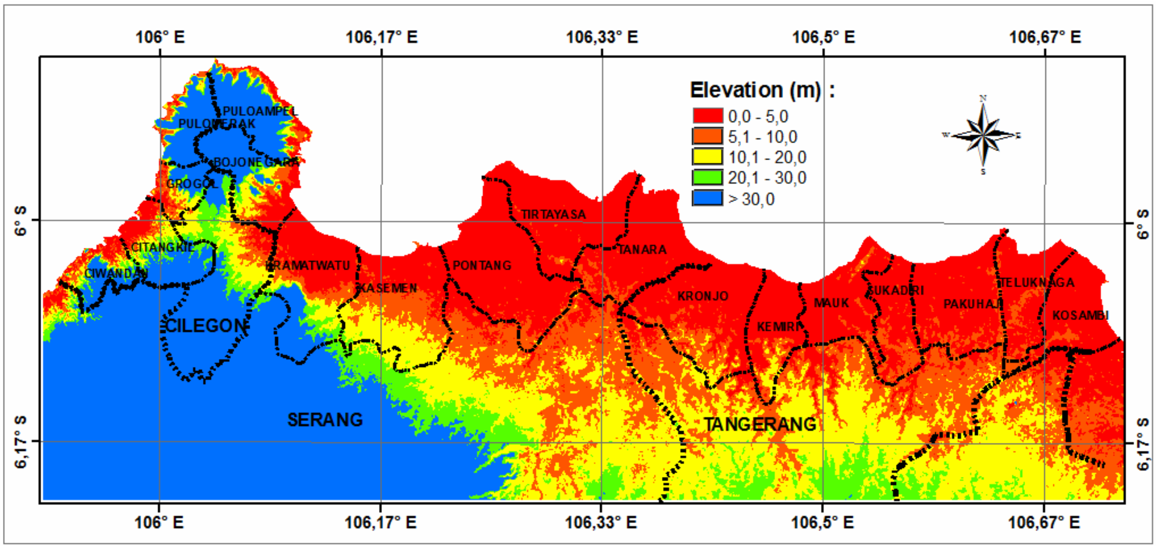


Figure 5. Coastal elevation

Figure 6 shows the faces of sea water along the northern coast of Banten for 16 years (1993-2008). Sea level along the northern coast of Banten ranged from -0.4474 to 0.3072 m with an average of about 0.0314 m. SLR along the northern coast of Banten, approximately 4.06 mm/year indicated from the average trend line.

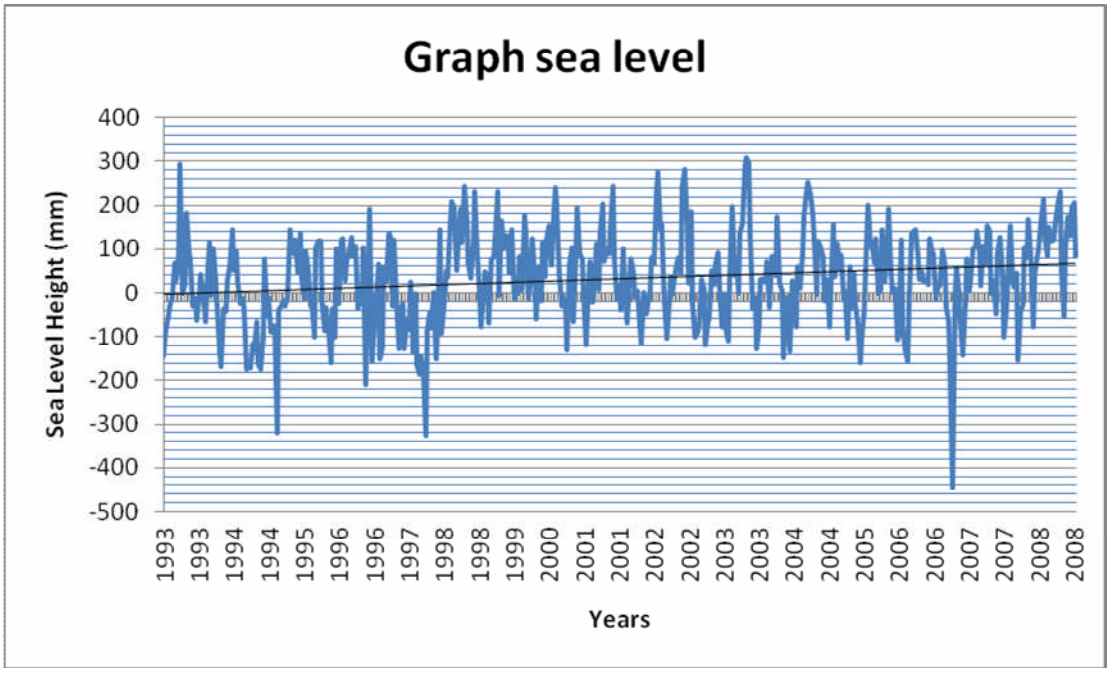


Figure 6. Graph sea level in 1993-2008.
Source: Data processing ECMWF

Significant wave height along the coast of Banten ranged from 0.381 to 0.499 m with an average of about 0.440 m. Based on the Figure 7 the value of significant wave height average occurred in the year 2008, while the smallest occurred in the year 1992. If observed from the significant wave height data in the next 20 years a tendency to increase in wave height of 3.05 mm / year indicated from the average trendline.

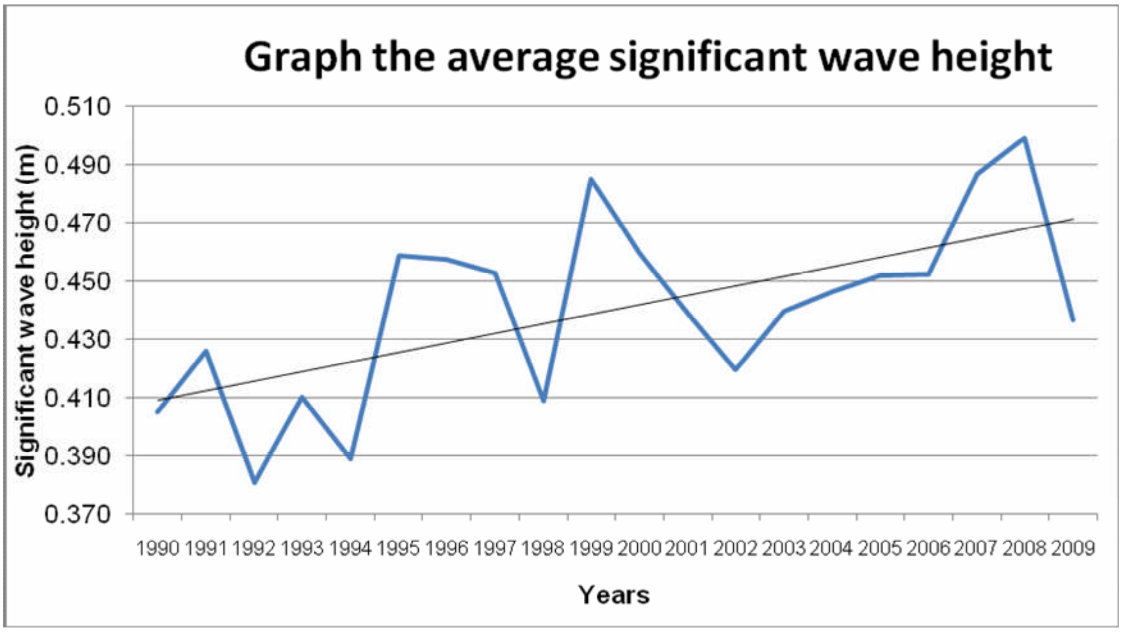


Figure 7. Graph the average significant wave height

Average different tidal along the coast of Banten ranged from 0.17 to 0.25 m with an average of about 0.20 m. Based on Figure 8 Average value different tidal largest tides occur in the year 1988, while the smallest occurred in the year 1991.

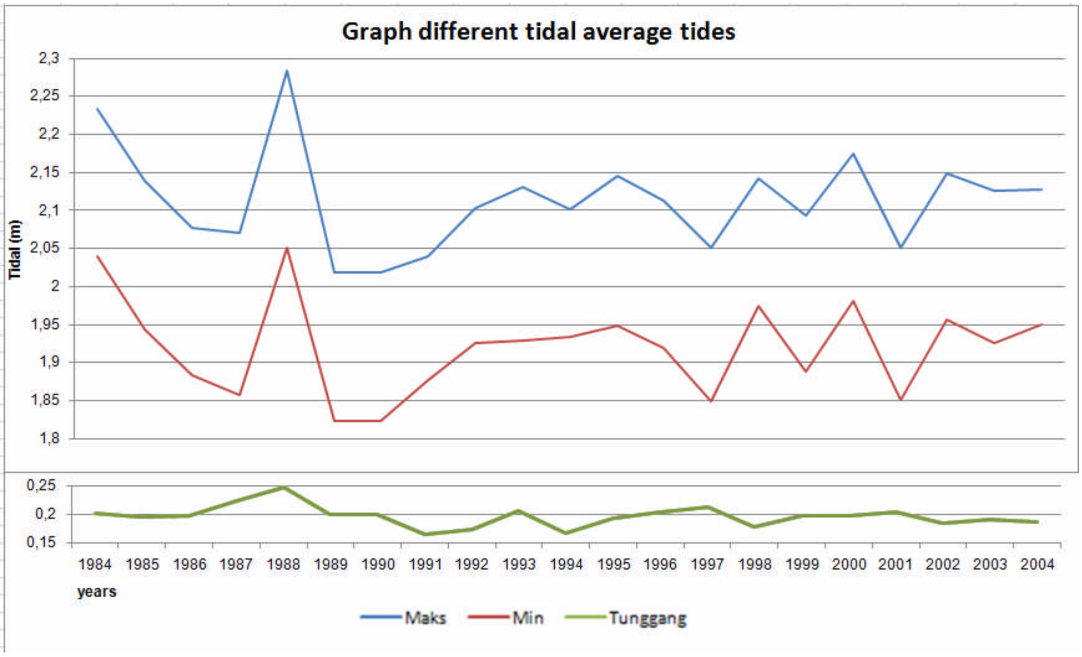


Figure 8. Graph different tidal average tides.

The map of coastal vulnerability Banten is shown in Figure 9. Based on the map of Northern Banten coastal vulnerability index It is known that coastal areas Cilegon based on the classification by Pendleton et al. (2005) and Gornitz et al. (1997), diveded into two classes sub district Citangkil come into the moderate vulnerability, sub district Ciwandan, Grogol and Pulomerak entered into the class are low vulnerability.

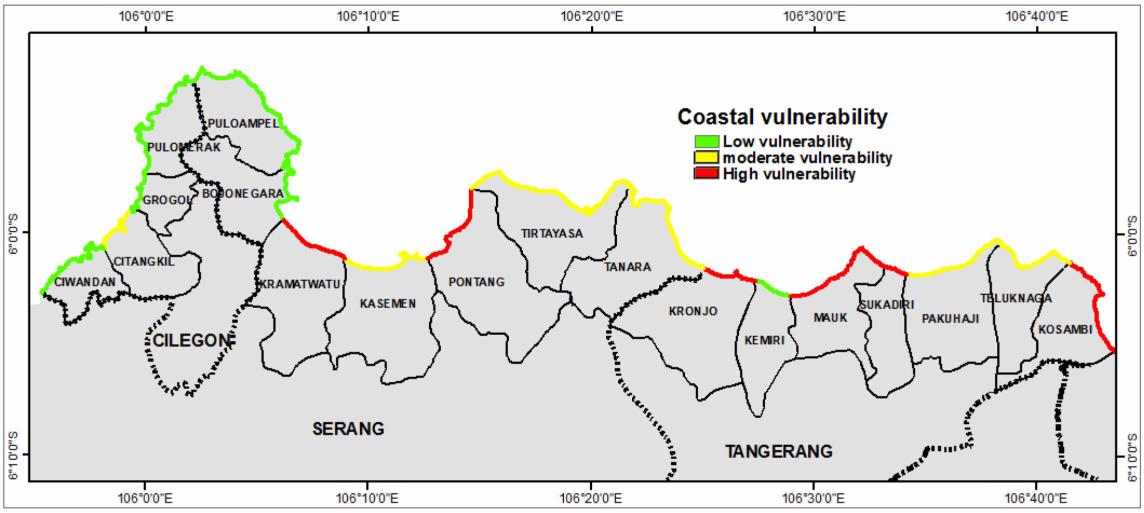


Figure 9. Map of Coastal vulnerability index

The coastal areas Serang into three classes namely sub district Kramatwatu and Pontang entered into the high vulnerability class, the class moderate vulnerability is the sub district Kasemen, Tirtayasa and Tanara, the sub district Puloampel and Bojonegara get into the class is low vulnerability. coastal areas Tangerang into three classes namely sub district Kronjo, Mauk, Sukadiri and Kosambi entered into the high vulnerability class; sub district Teluknaga Pakuhaji and entered into the class is moderate vulnerability, while the sub district kemiri included in the category are low vulnerability.

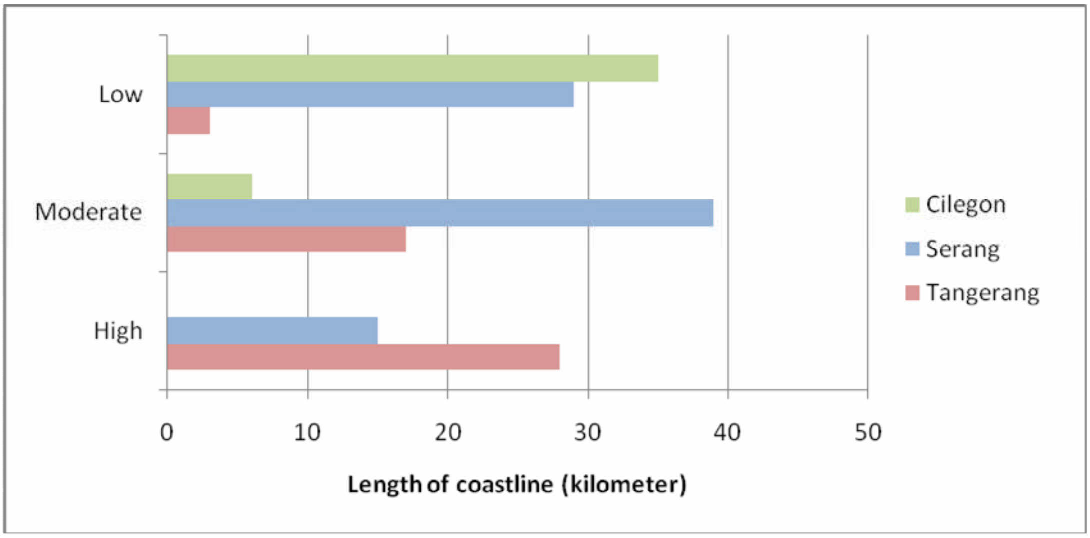


Figure 10. Distribution of coastal vulnerability

Distribution of levels of vulnerability to the north coast of Banten (Cilegon, Serang and Tangerang) are shown in Figure 10 where the total length of coastline included in the high vulnerability category range 44 km (approximately 25.29% of the total coast length), total length of coastline included in moderate vulnerability category along 63 km (36.21%), while the total length of coastline included in the category are low vulnerability along the 67 km (38.51%).

4. **CONCLUSIONS**

It is known that many high vulnerability coastal areas Tangerang sub district Kronjo, Mauk, Sukadiri, and Kosambi. While the coastal areas with low vulnerability categories in the coastal region north of the western sub district of Banten is Ciwandan, Grogol, Pulomerak, Puloampel and Bojonegara.
Further research is recommended to add the parameters associated with social economic as population more known for their impact on society, as well as research with a more narrow area of the region so that more accurate results.

REFERENCES

Gornitz, V., T. W. Beaty, and R. C. Daniels. 1997. A Coastal Hazards Data Base For The U.S. West Coast. Oak Ridge National Laboratory. Oak Ridge.Tennesse.

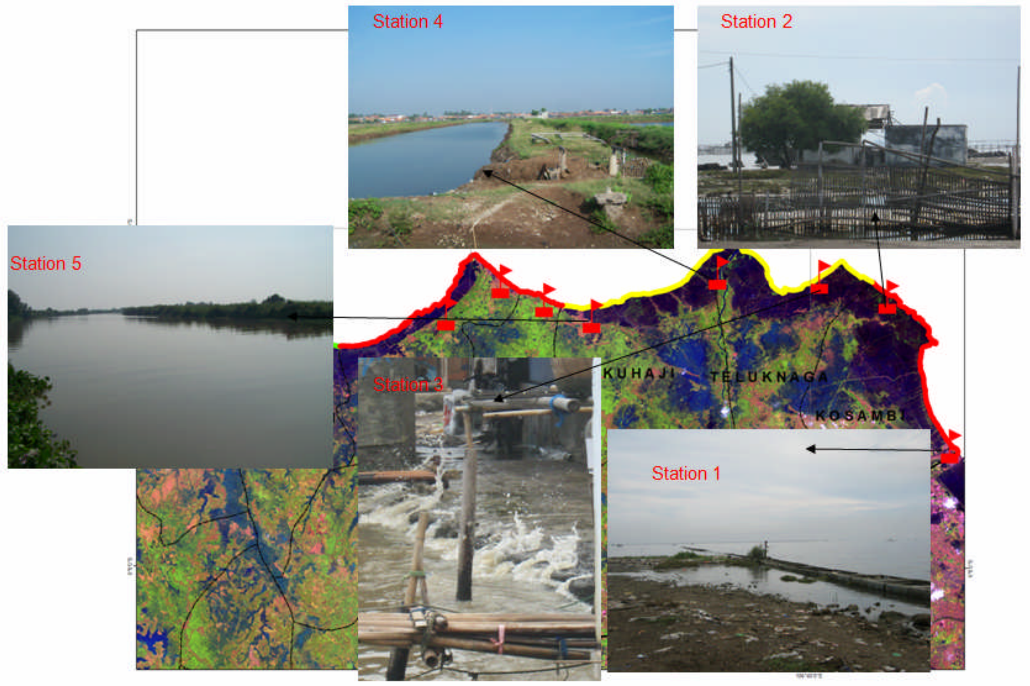
IPCC. 2001. Climate Change 2001: The Scientific Basis: Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change [Houghton, JT, Y. Ding, D.J. Griggs, M. Noguer, P.J. Van der Linden, X. Dai, K. Maskell and C.A. Johnson (eds)]. Cambridge University Press, Cambridge, United Kingdom. 881 pp.

IPCC, 2007: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, RK and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

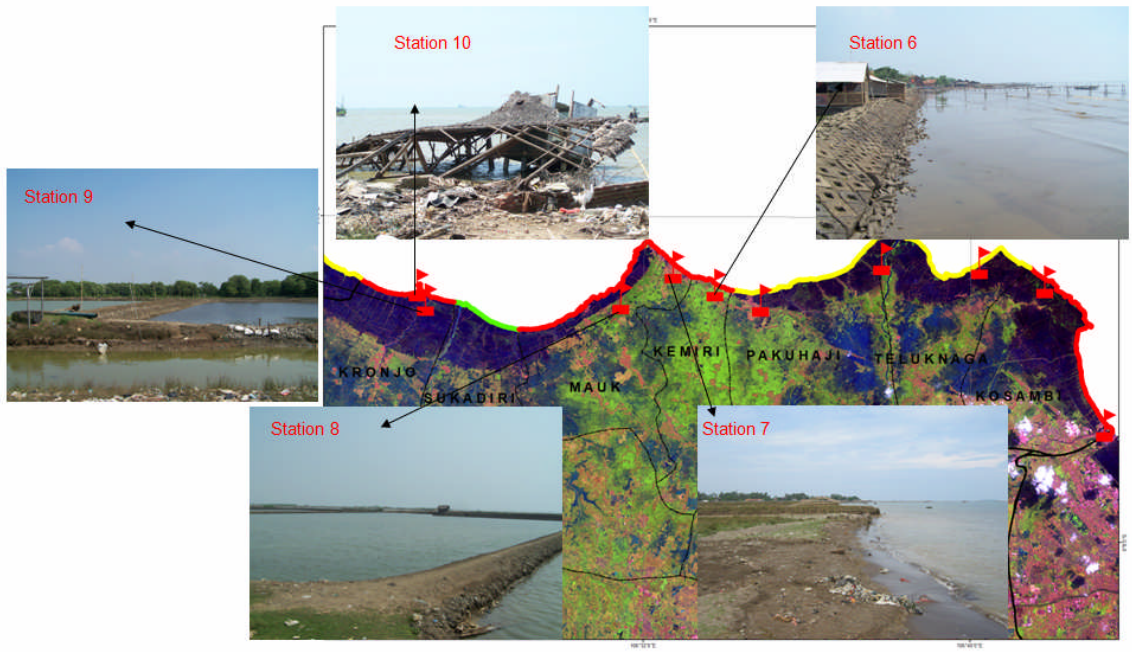
E. Pendleton A., E. Robert Thieler, and S. Jeffress Williams. 2005. Coastal Vulnerability Assessment of the Gateway National Recreation Area (GATE) to Sea-Level Rise. U.S. Geological Survey. Virginia, USA.

Photos of field survey

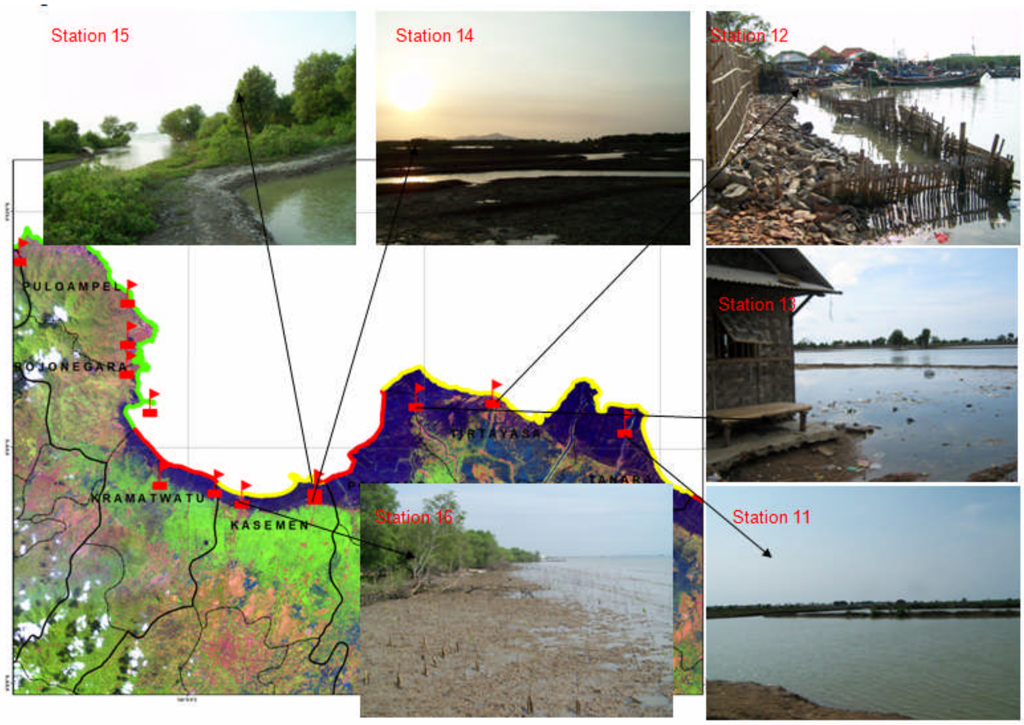
Tangerang



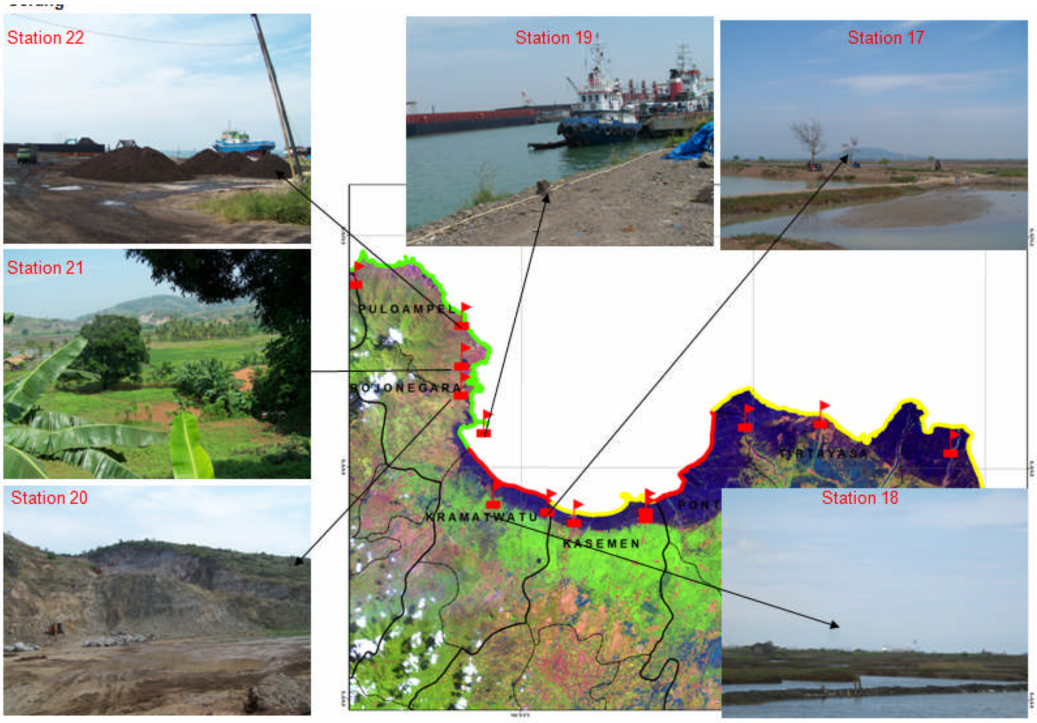
Tangerang



Serang



Serang



ASSESMENT OF INUNDATION COASTAL AREAS OF CIREBON DUE TO SEA LEVEL RISE

Fina Mariany, Jonson Lumban Gaol Risti Endriyani Arhatin
Department of Marine Science and Technology
Bogor Agricultural University

finamariany@gmail.com

Abstract

Coastal region is an area that's very vulnerable due to sea level rise. Cirebon regency is coastal region has a coastline about 54 km. Predicted inundation areas is done by applying a model based on the data GDEM Aster and sea level rise from satellite altimeter. In this study we predicted coastal inundation affect sea level rise for period of 20 and 50 years later.

Key words: sea level, altimeter, Cirebon, coastal

1. INTRODUCTION

Monitoring of changes in global sea front position is one of the actual issue in the current study. One effect of global warming is happening in our world today, resulting in wide impact such as sea level rise (sea-level rise). The phenomenon of sea level rise could provide a direct negative impact on coastal areas such as shoreline erosion, inundation of land areas near the coast, and increased risk of flooding.

Coastal region is one of many zones where the potential economic benefits owned coastal areas. Sea-level rise that caused permanent flooding and infrastructure damage in coastal areas, it is necessary to land management with the potential of existing natural resources.To support this policy, we need a model of the impact areas prone to inundation due to sea level rise on coastal areas.

Cirebon is located on the north coast of West Java province. Geographically, the municipality of Cirebon is located at position 108 ° 33" east longitude and 6 ° 41" south latitude. The landscape is *low-lying coastal areas,* with an area of ±3735.82 hectares administration with the dominant use of land for housing (32%) and agricultural land (38%). Cirebon is lowland with an altitude varying between 0-150 meters above sea level. Based on the percentage of slope, the area of Cirebon city can be classified as follows: slope of 0-3% spread in some parts of the city of Cirebon, except for some sub Harjamukti. The slope of 3-8% spread in most areas Kalijaga Village, a small village Harjamukti, District Harjamukti. The slope of 8-15% spread in some areas Argasurya Village, sub Harjamukti. The slope of 15-25% spread in the region Argasurya Village, sub Harjamukti

By looking at the projections of sea level rise for the next few years, then the impact will be generated can be estimated. Among these impacts are in the Cirebon region which resulted in damage to some land, facilities and infrastructure should be a media development in the economic sector in the region. In this paper views the approach of inundation that occurred 20 and 50 years in the future and how much area of inundation due to sea level rise.

2. METHODOLOGY

Based on geographical location, Cirebon regency located at position 1080 40 '- 108 0 48' east longitude and 6 °30' – 7 °00' (Figure 1).

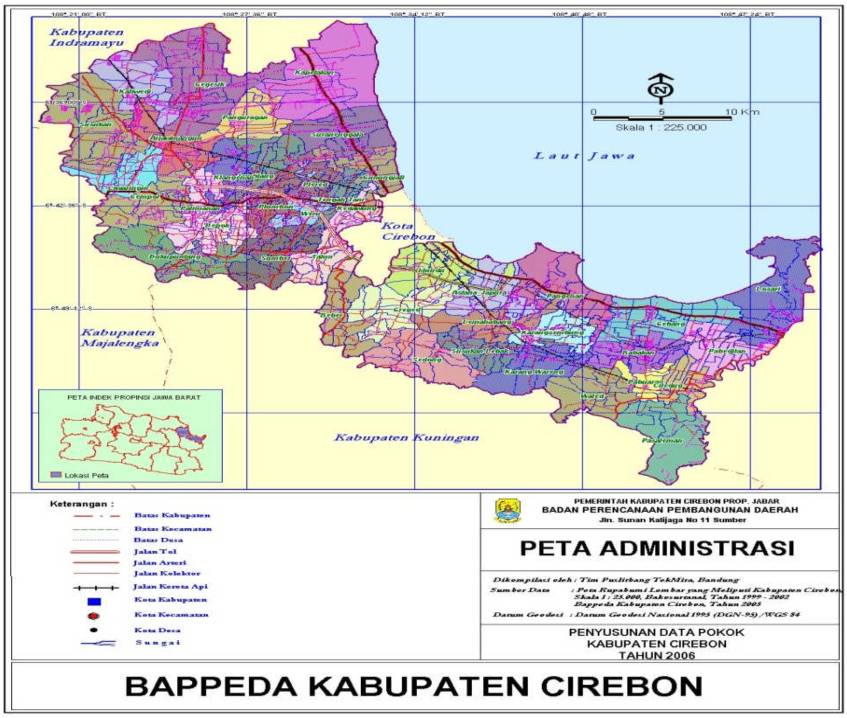


Figure1. Map of administration border of Distric Cirebon, West Java Propince

We used GDEM ASTER data acquisition in 2000 with the area code S07E108. The ASTER data downloaded through www.gdem.aster.ersdac.or.jp site. GDEM data was validated by NASA, METI, and the U.S. Geological Survey and with the support of the U.S. National Geospatial-Intelligence Agency. From ASTER data we process the Earth's surface topography (DEM) and geomorphology map (Figure 1). The data opened on the Global Mapper and ArcGIS software. The GDEM data using a grid system size 1 ° x 1 ° or 111.2 km x 111.2 km, with level of accuracy is 30 meters. Areas covered include the 83 ° latitude north to 83 ° latitude south, or means that nearly 99% of the earth's surface is covered in this GDEM data.

Sea level rise data anomaly derived from satellite altimeter obtained from Colorado University and the AVISO data base.

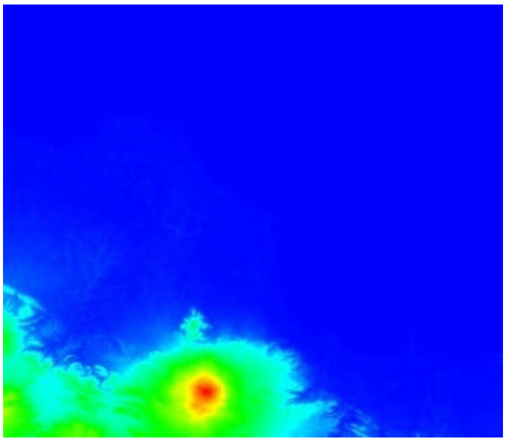


Figure 2. GDEMSATER data

Shoreline and contour lines derived form ASTER GDEM. The coastline from GDEM ASTER represents a height difference of earth with the lowest value is the sea (≤ 0). Contour lines are formed according to the value of sea level rise 3.8 mm/year. Prediction of sea level rise that takes place in two periods of 20 and 50 years, Predictions are made by converting the value of sea level rise in meters/year, made the establishment of contour lines based on the value of sea level rise in 20 and 50 years later. The contour lines and coastline can be overlay, and forming a new area which is the result of an alleged intersection inundation area in 20 and 50 years later.

3. RESULT

Sea level rise trend around Cirebon coast is 3.8 mm/year (Figure 3). Trend of SLR predicted inundation along of coast. Inundation areas derived from intersect DEM with the development of coastline due to sea level rise. Figure 4 and 5 is represent the coastal inundation in Cirebon coast in the time ranging 20 and 50 years later. Both the picture figured visible red color on the map is a coastal area that will be flooded due to sea level rise

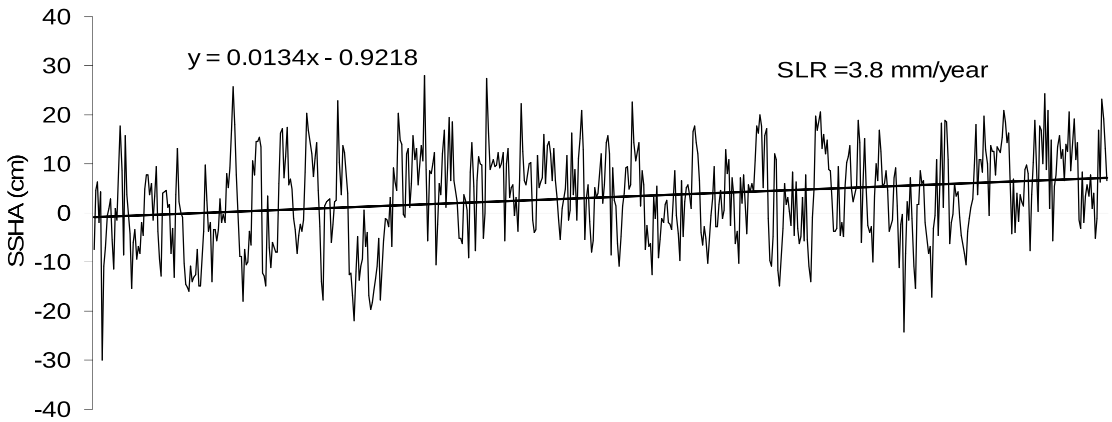


Figure 3. Sea level trend in Cirebon coast

.Figure 4 and Figure 5 shows that the areas which will have a pool of first time is Sub-district of Kapetakan, Suranenggala, Gunung Jati, Mundu, Astanajpura, Pangenan, Gebang, and Losari. It is very possible happen because the districts are in coastal areas that deal directly with sea. Inundation areas due to sea level rise during the period of next 20 years to 50 years does not differ much, it's just a growing area of inundation in the next 50 year period due to the length of time.

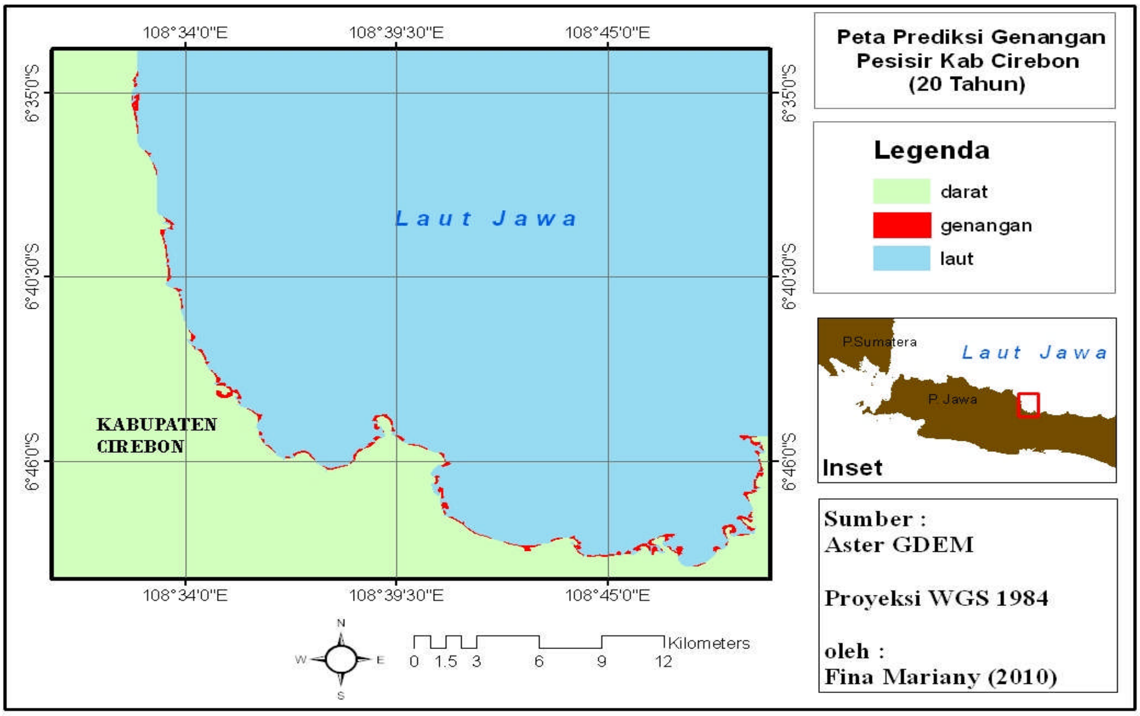


Figure 4. Prediction of coastal inundation due sea level rise in Cirebon coast 20 years later

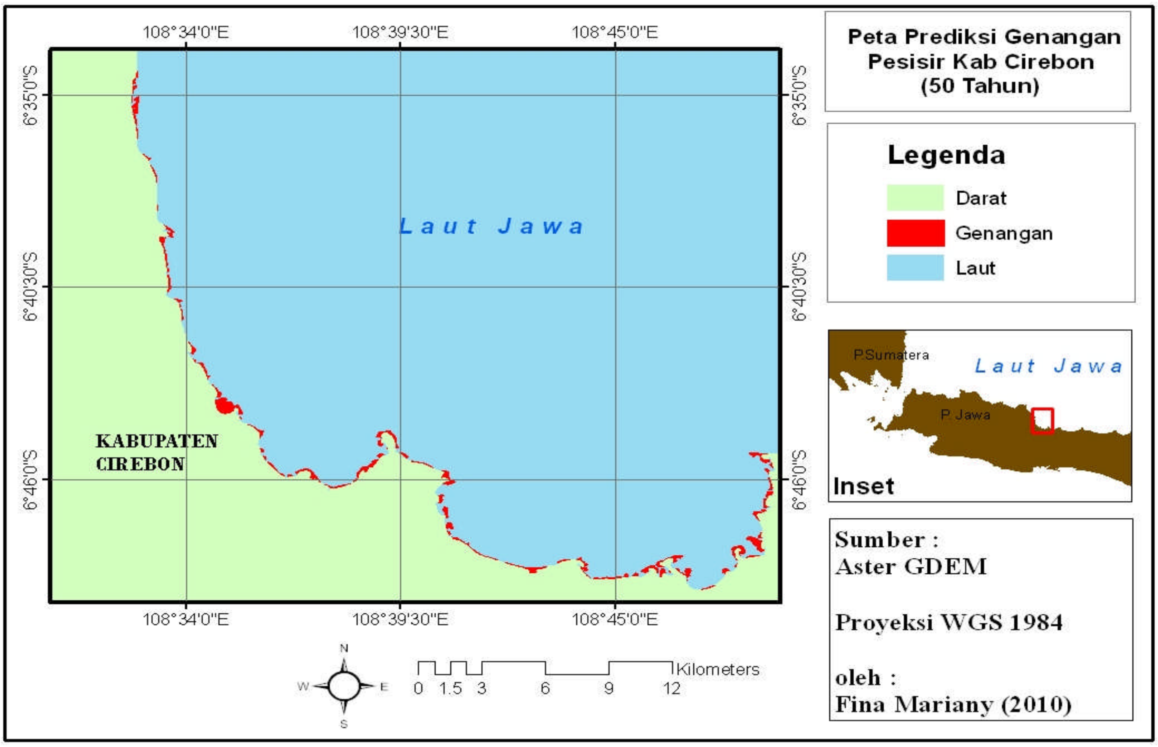


Figure 5. Prediction of coastal inundation due to sea level rise at Cirebon in the next 50 years

In Table 1, can be seen the comparison of coastal inundation for 20 and 50 year later. Generally, Cirebon coastal mainland reduction by erosion due to the morphology of Cirebon district is lowland.

Table 1. Prediction of inundation and land due to SLR 20 and 50 years later.

Land (ha)	Inundation (ha)	Years later
3,337.82	31.96	20
3,299,85	43.2	50

The field condition of Cirebon coast shown in Figure 6. Abrasion in Grogol Beach, north of Cirebon occur impact of development aquaculture activities. The process of inundation due to rising sea rise and abrasion can affect infrastructure damage and cause harm to people who have livelihoods in coastal areas. For adaptation to sea level rise is made coastal structures that directly resist the natural process and adjust the management of coastal and small islands with natural changes.

Figure 6. Coastline condition in District Cirebon, West Java Propince

4. CONCLUSION

Sea level rise trend (3.8 mm/year) can be negative impact on Cirebon coast . Coastal Inundation for 20 and 50 years later was predicted respectively 31.95 ha and m^2 43.17 ha. Abrasion affected the vulnerability of Cirebon coast due to sea level rise. To reduce the impact of sea level rise can be done by mangrove planting as along of the coast.

REFERENCES

AVISO. 2010. AVISO Data from Altimetry Sattelite. http://www.aviso.oceanobs.com/en/news/ocean-indicators/mean-sea-level/

http://www.gdem.aster.ersdac.or.jp/

Bapeda.2008 (http://bappeda.cirebonkab.go.id/)

Diposaptono,S. 2009. Menyiasati Perubahan iklim di Wilayah Pesisir dan Pulau-pulau kecil. Bogor

Fitria. 2007. Pengaruh abrasi di pantai grogol kecamatan cirebon utara kabupaten cirebon dan pantai bojongsalawe kecamatan parigi kabupaten ciamis terhadap komponen-komponen sistem pembangunan wilayah pesisir dan laut. [Thesis]. ITB. Bandung

INCREASING SEA LEVEL RISE AND ITS IMPACT ON THE COASTAL OF CENTRAL MALUKU DISTRICT

Jefry Bemba
Kjhairun University, Ternate, Ambon
E-mail: jefry_bemba@yahoo.co.id

1. INTRODUCTION

1.1 Background

Coastal areas and small islands have a unique ecosystems and specific natural resources. Economically, this areas including small islands have high potential of natural resources and other environmental services, that if not properly managed can impact on the welfare of future generations of life. However, the physical condition of these coastal areas on small islands are generally flat with a relatively low altitude of sea level makes this area vulnerable to all natural phenomena comes from the oceans, including sea level rise.

Indonesia, which is an archipelago country, it has an area of sea and beaches are very influenced by the characteristics and sea conditions, including tides, sea waves, sea currents. In line with global warming which has triggered the global sea level rise (*eustatic sea level rise*), according to ADB (2001), Indonesia is predicted to experience the air temperature warming of 0.4 - 3.0 ^{o} C and sea level rise of 15 - 90 cm by 2010, it would require the management of coastal areas including small islands and harmonized with the existing potential natural resources (Sutrisno, 2005).

Lately, the coastal region is very disturbed by the frequency of significant sea level rise. This gives a fairly serious impact on coastal areas, such as flooding, erosion and intrusion of sea water. If the sea surface ocean conditions continue to increase and decrease the mainland regularly, it will cause flooded region, this will be a new problem for coastal cities, of the coastal districts is the Central Maluku District.

Flood tide is an event caused by global sea level rise. The existence of high tide and tidal inundation would affect the conditions that occur. Many opinions emerged about the cause of flooding rob. One of it is increasing average sea level or mean sea level as a result of global warming. The phenomenon of global warming caused by excessive greenhouse contribution, it is a fairly serious impact for the world climate. If this condition persists (sea level rise) is feared inundation rob will widen. The impact continued to be generated according to some experts is the increasing rate of erosion, changes in coastal ecosystems, shoreline retreat, increased damage to buildings near the beach and the disruption of people activities in residential areas, aquaculture and industries.

With the reasons mentioned above it is considered very important in this simulation where it can be seen how broad the area to be flooded as a result of sea level rise that can be prepared a plan to overcome or reduce its impact. To support this policy, we need a simulation based on spatial model which predicts the impact of sea level rise on coastal areas in the future.

1.2. Objective

The purpose of this simulation is to visualize the spatial impact of sea level rise in the future to set a sensible policy for managing the island in a sustainable manner.

2. METHODOLOGI

This study using a Digital Elevation Model (DEM) to describe the condition of some parts of Maluku this time. DEM is the height model which presented in digital form in raster data compiled by the thousands or more pixels (picture elements), where each pixel has a height value. The reason of using DEM because it has a raster format to facilitate the mathematical analysis, in this case to predict sea level rise and land subsidence conditions that created mathematical formula. The high anomaly data of sea sea level rise were obtained from altimeter satellite from 1993-2009 taken from the University of Colorado, USA database.

Furthermore, this DEM model was later given the formula for areas prone to inundation rob scenario that is affected by sea level rise alone. DEM data created from the high point which interpolated. In this research it will be made a simulation predicting rob up to 100 years from now as a result of sea level rise.

3. RESULTS

3.1 Overview of Study Area

Central Maluku District is one of the districts in Maluku Province, the capital city is Masohi. Administratively, the district has an area of 11595.57 km² overall consisting of 11 sub-districts, the borders are:

North : Seram Sea
South : Banda Sea
West : Buru District
East : Province of Papua

Table 1. List of sub-districts in Central Maluku

No	Sub-District	District	Province
1	Amahai	Maluku Tengah	Maluku
2	Banda	Maluku Tengah	Maluku
3	Kota Masohi	Maluku Tengah	Maluku
4	Leihitu	Maluku Tengah	Maluku
5	Nusa Laut	Maluku Tengah	Maluku
6	Pulau Haruku	Maluku Tengah	Maluku
7	Salahutu	Maluku Tengah	Maluku
8	Saparua	Maluku Tengah	Maluku
9	Seram Utara	Maluku Tengah	Maluku
10	Tehoru	Maluku Tengah	Maluku
11	Teon Nila serua	Maluku Tengah	Maluku

Source: Moluccas in Figures 2007

Potential fishery in Central Maluku District from time to time enough to dominate the contribution of the agricultural sector in general. One of them is because of the many natural riches contained within. Regional District of Central Maluku have the potential of marine and fisheries are very reliable. The potential of capture fisheries include 136.116.1 km² sea area with a long coastline of the area of 1,256,230 km² from 147.480.6 km² areas.

The potential of fish resources which are owned by 484,532 tons/year with a total allowable catch amounted to 387,324 tons/year. The potential is only used for 41.307.1 tons/year. In addition to the potential of marine fish in Central Maluku also have a potential coral reef with an area of 1667.4 ha (good condition 1202 ha and damaged 469.8 ha) The seaweed potential breadth of 977, 9 ha. Support facilities in Central Maluku region are 6 units of cold storage, ice scaller 2 units, 1 unit of fish landing base, and 3 units fish auction places.

In general, the climate in the Maluku Islands including Central Maluku District is tropic and temperate monsoon climate, where the climate is strongly influenced by the existence of a vast ocean waters and take place in rhythm with climatic seasons there. The average temperature based on Mateorologi station in Ambon, Tual and Saumlaki amounted to 26.8 °C, 27.7 °C and 27.4 °C. Minimum temperature respectively 24.0 °C, 24.7 °C and 23.8 °C, while the maximum temperature of 30.84 °C, 31.1 °C and 31.1 °C. Air humidity based on Ambon Meteorology Station is 83.4%, the lowest in January by 76% and the highest in September by 91%. In accordance recording Meteorological Station Tual, humidity averaged 85.4%, while recording Saumlaki Station Meteorology showed an average humidity of 80.2%.

Annual rainfall prevailing in the area of Maluku Province is varied enough so that grouped into several zones. identified division agroclimate zones based on the classification of annual rainfall on their respective territories:

- West Southeast Maluku District with a group of annual rainfall 900-1200 mm, 1200-1500 mm, 1500-1800 mm, 1800-2100 mm, 2000-2500 mm, 3000-4000 mm.
- District of Southeast Maluku and Aru Islands District with rainfall group tahunan2500-4000 mm, 3000-4000 mm.
- Central Maluku, West Seram, and East Seram with group annual rainfall 2000-2500 mm, 2500-4000 mm, 3000-4000 mm and 3000-4500 mm.
- District Buru with group annual rainfall 1000-1400 mm, 1400-1800 mm, 1800-1200 mm.
- The city of Ambon in the 2500-3000 mm annual rainfall.

Figure 1. Documentation in the coastal areas of Maluku

Topography of Central Maluku, West Seram and sinister eastern section is generally hilly, caused by the junction of the two plates called the Pacific and Mediterranean sircum. This causes the formation of its territory is a plateau topography with slopes above 40%. Areas with this slope category are included in the category of very steep. Distribution of slope degree according RTRW slope Maluku shows 4 classes, respectively: 0-2% slope flat, gently sloping/undulating 3-15%, 15-40% moderately steep and very steep 40%.

3.2 Condition of Central Maluku Coastal Related to Sea Level Rise

Global trends that cause sea level rise, the average predicted by observing the melting ice from land to the condition of a warming world, together with the purposes of thermal energy at the top layer of sea water. The uncertainty of global trends is problematic in itself, but the best estimates can be used in planning for the future, provided information about local and regional trends are well documented.

To find out more about the development of inundation areas in the future then the height anomaly data for seawater surface from year 1994 to 2010. Height anomaly data in the coastal marine sandstone of Central Maluku district from 1993 to 2009 is shown in Figure 2. Height anomalies of Sea Surface showed an increase for 4.5 mm/year.

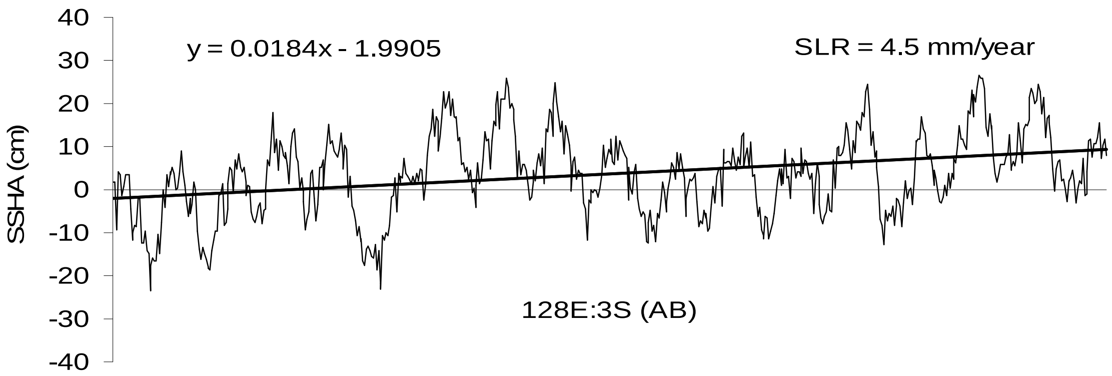


Figure 2. SLR trend on the coast of Central Maluku (1994-2010)

Based on data anomalies sea level rise can be seen that the coastal areas in several districts located in Central Maluku district has an average annual rate of increase in sea level is high enough each year. Furthermore, if these data are simulated to see the level of inundation in coastal areas Barru at 100 years of simulation results are obtained as shown in Figure 3.

Based on simulation in Figure 3 shows that regions that experienced inundation in the next 100 years spread almost evenly along the coastal areas. The simulation results obtained that the local area who will have a pool in the next 100 years that is equal to 15.45 ha. Areas that will experience the largest pool is situated on the Sub-District Amahai and Masohi City, where both the region is a dense residential area.

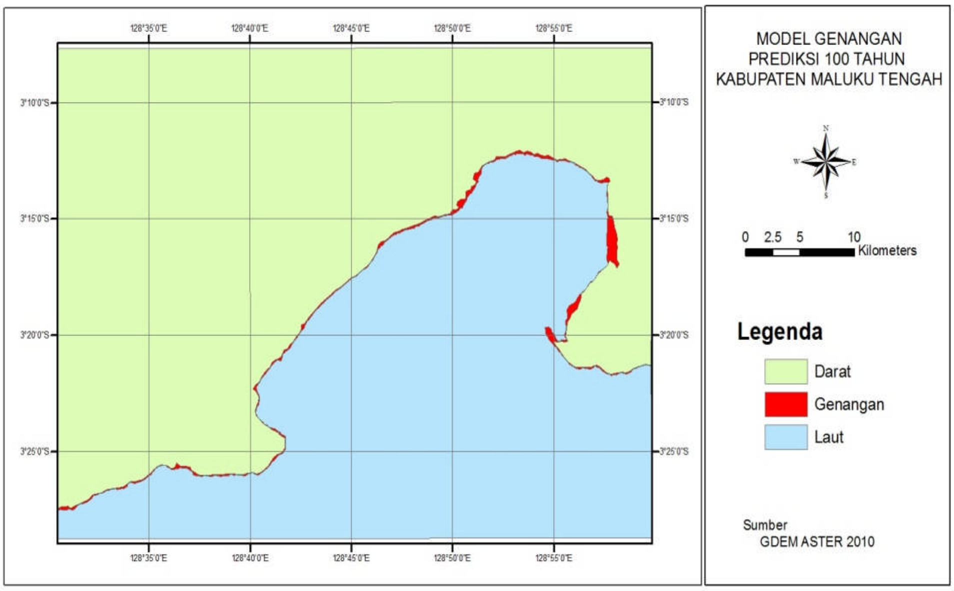


Figure 3. Simulation of the inundation in Central Maluku District for 100 years later

his condition shows that the coastal areas in Central Maluku District most of it has a high slope of the beach, but in some of sub-districts, including areas that are vulnerable to inundation of sea water. This situation may indicate the need for structuring policy utilization of coastal areas including small islands in a sustainable manner tailored to the potential of existing resources, as part of an effort to mitigate the damage caused by the phenomenon of sea level rise. This of course should be anticipated in order to avoid more extensive flooding due to the widespread inundation area means that more land area would be lost.

4. Conclusion

The conclusions that can be drawn from this research are:
In coastal areas of Maluku is shown that the trend of sea level rise is 4.5 mm/year.
Sea level rise have a negative impact on residential areas located in several sub-districts (Amahai, Masohi) in Central Maluku District.

References

Fauziah, Asmaul. 2008. Dampak kenaikan Muka Air Laut Terhadap Wilayah Pesisir. Universitas Negeri Surabaya. Surabaya.

http:/www.Universitas Colorado, USA. Anomali tinggi paras laut dari satelit altimeter dari tahun 1993-2009

Situs Resmi Kabupaten Maluku Tengah. www.malukutengah.go.id. [Accessed on tanggal 10 Desember 2010]

Sutrisno, D. 2005. Dampak Kenaikan Muka Laut Pada Pengelolaan Delta: Studi Kasus Penggunaan Lahan Tambak di Pulau Muara ulu Delta Mahakam (Disertasi, 2005)

STUDY OF COASTAL VULNERABILITY DUE TO SEA LEVEL RISE OF EAST BORNEO PROVINCE

Kaharuddin
Email : iklkahar@gmail.com

1. INTRODUCTION

1.1. Background

Coastal region is a region highly vulnerable to environmental pressures both from land and from sea. One of the pressures that recently threatened the sustainability of coastal areas in all parts of the world is the existence of sea level rise. In general, sea level rise is the impact of global warming is sweeping across this hemisphere. Based on the IPCC report (International Panel On Climate Change) that the average global surface temperatures increased from 0.3 to 0.6 0C. Since the late 19th century and until the year 2100 the earth's temperature is expected to rise about 1.4 to 5.80 C (Dahuri, 2002 and Bratasida, 2002). Rising global surface temperature causes melting of ice in the north and south poles of the earth and become involved in sea level rise. It is estimated that from 1999-2100 the next year sea level rise of about 1.4 to 5.8 m (Dahuri, 2002).

According to the Intergovernmental Panel on Climte Changes (IPCC, 2007) that global warming occurs intensively since 1970, until now continues to the present. The effect of global warming is directly reflected by changes in global temperature. Implications of climate change as global warming, as indicated by the increase in greenhouse gases, especially carbon dioxide (CO2) and methane (CH4), this condition results in some natural phenomena, namely fluctuations in rainfall and sea level rise. As an archipelago, Indonesia is most vulnerable to sea level rise. Has done projections of sea level rise for parts of Indonesia, until the year 2100, predicted the existence of sea level rise up to 1.1 m which is impacted on the loss of coastal regions and small islands covering an area of 90,260 km^2.

Vulnerability is defined as a condition determined by physical factors, social, economic and environmental or process that may increase vulnerability (susceptibility) of a society to the impact of hazards (hazard), ISDR (2004). Furthermore, based on (UNDP / UNDRO, 1995), explains that the susceptibility (vulnerability) is the rate the probability of an object consisting of community disaster, structure, service or geographical area were damaged or interruption due to the impact of the disaster or the tendency of a thing or being damaged by the disaster.

Frazier (2010) Despite the potential for storms in the current climate conditions continue to threaten coastal communities, there is concern that climate change, particularly the potential for rising sea levels, could affect the impact of future storms. To examine the potential effects of sea level rise on the vulnerability of communities to future storms, we examine the variation in exposure puddle in the East Kalimantan coast. To see the influence of contemporary sea level rise and inundation area to scenario variations in the rate of inundation due to rising sea levels.

Analysis of inundation estimates indicate that most of the population, economic activity, and critical facilities in the zone and activities of contemporary sea level rise in the future. In addition, sea level rise of contemporary inundation zone exposures effectively causing exposure to the population and assets (infrastructure, natural resources, etc.).

1.2. The objectives

The purpose of this study is how to estimate the inundation of the causes of the increase in sea level looks as global climate change impacts. Simulations on a small scale in the eastern coastal area of East Kalimantan with a different time estimates provide additional information in terms of the extent of exposure to a pool of raising sea surface. Also how they affect the dynamics of coastal ecosystem, vulnerability of coastal communities, and face rising sea level linkages with development variables and development services as well as infrastructure in coastal areas.

2. METHODS

Projections of the estimated inundation and impact scenarios used in this study, as well as socio-economic attributes assessed to examine the changes in exposure community using SRTM DEM data and software Global Mapper, ArcGIS. Sea Level Rise trend estimated from satellite altimeter data.

Data used in this study is the high anomaly data from satellite altimeter sea level from the year 1993-2009 derived from the database University of Hawaii Sea Level Center (UHSLC), USA. Beach slope data derived from SRTM DEM data obtained from http:/www. Gden.aster.ersdac.or.jp. To visualize Aster DEM data used in the Global Mapper software to analysIS whereas for coastal inundation areas due to rising sea level used ArcGIS software.

3. RESULTS

Geographical Location of the Province of East Kalimantan (East Borneo) that is 02 ° S -04 ° North Latitude and 113 ° - 119 ° East Longitude, with an area of 9.8 million ha of sea waters on 02 ° S - 04 ° North Latitude and 117 ° - 119 ° East Longitude and 1185 km long coastline , which extends from south to north in Pasir District in Nunukan district. East Kalimantan Province consists of 13 regencies / cities and some 10 of them have territorial waters of the sea with geographical location (land into the sea). In this inundation estimates only cover areas District Samarida to Bontang, which were located at a latitude / longitude, Samarinda (117 ° - 117 ° East Longitude and 00 ° - 00 ° South Latitude). Bontang City (00 ° S 00 ° N and 117 ° - 118 ° E). East Kalimantan soil structure generally consists of red-yellow podzolic soil, alluvial soil and quartz sand. Alluvial, consisting of sand, clay and mud that formed in fluvial and coastal.

There are two effects that became a major issue with regard to climate change, namely fluctuations in rainfall and sea level rise which causes the logged water on the mainland near the coast. Other effects caused by sea level rise are coastal erosion, reduced salinity of sea water, decreasing surface water quality, and increased risk of flooding.

Sea surface height anomaly data for 16 years (1993-2009) is shown in Figure 1. These data are known is a strong seasonal cycle of water mass movement patterns and sea surface height differences are influenced by the wind, the movement pattern of currents, tides.

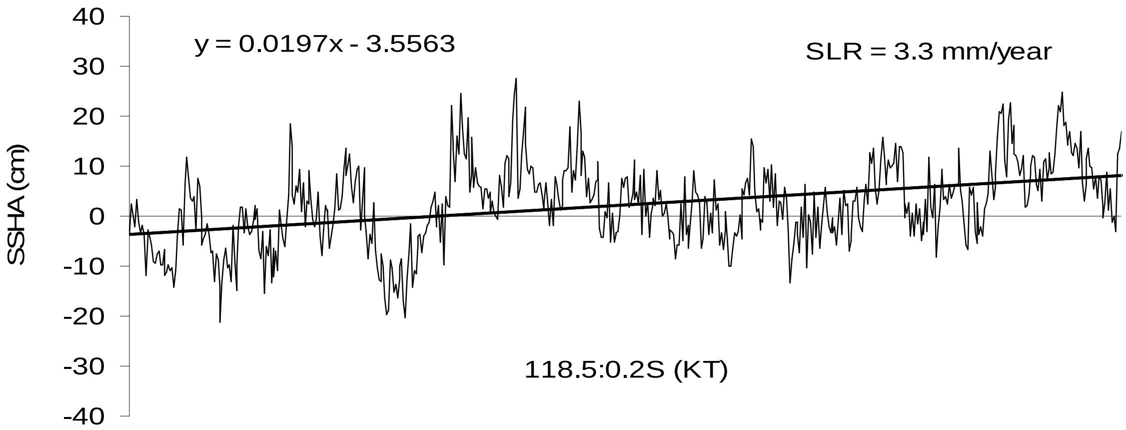


Figure 1. Trend TPL anomaly in the waters of East Kalimantan (1993-2009)

We analysis SRTM DEM data by using ArcGIS softwere to estimate the extended of coast inundation due to trend of rise sea levels 3.3 mm/year. Map of the estimated pool of the scenario time interval of 20 years and 50 years in the coastal region of East Kalimantan (Samarinda coastal, aquatic mammal, and Bontang) is shown in Figure 2, and 3. The second map shows the inundation area is different based on the estimated time. In the estimation of inundation by a 20-year scenario pool area does not seem obvious, but if the coordinates / scale in larger scale will be obvious area of inundation along the coast. Unlike the case with estimates at 50 years, which illustrates a significant area along the coast. Inundation area that looks real clear that extensive exposure to the estimated inundation in 50 years in the future. In the scenario 20 years there are some who seem inundated coastal side has a different area of inundation and contrast after a time interval of 30 years later.

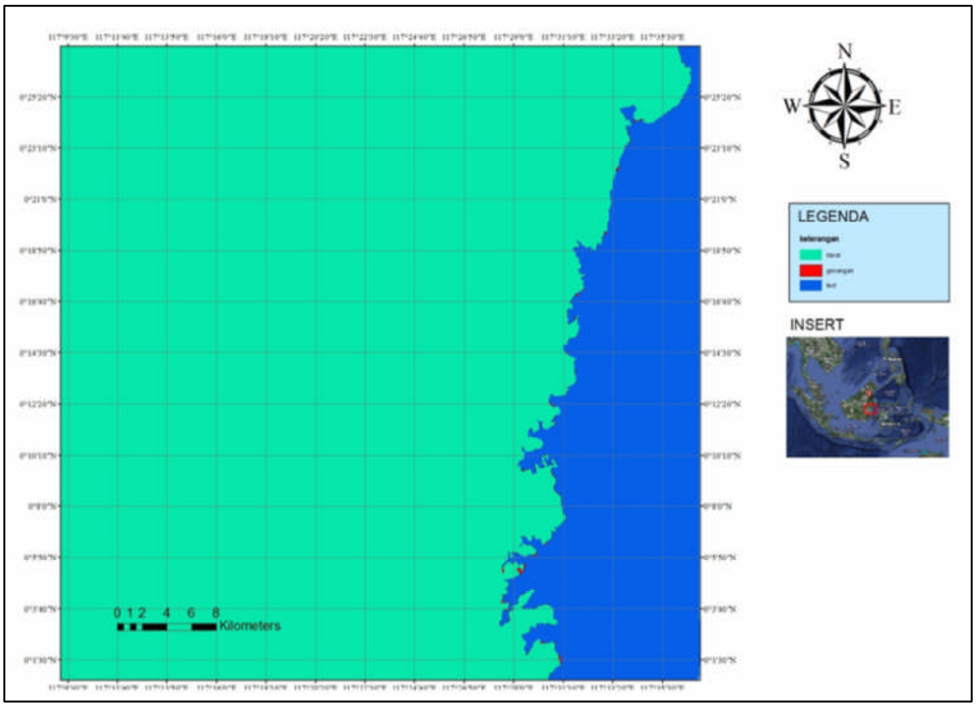


Figure 2. Simulation of coastal inundation of East Kalimantan the 20 years later

Estimates of potential inundation by the time interval the next 20 years on sea level rise for 1.5 cm (7.8 x 20 years) with a radius of 3 KM, with a view does not show a significant pool of wide exposure, but if the study further exposure despite a pool of very large impact not be felt directly. The total area of the flooded area estimation of the overall length of the coast about 3235888.073 m^2.

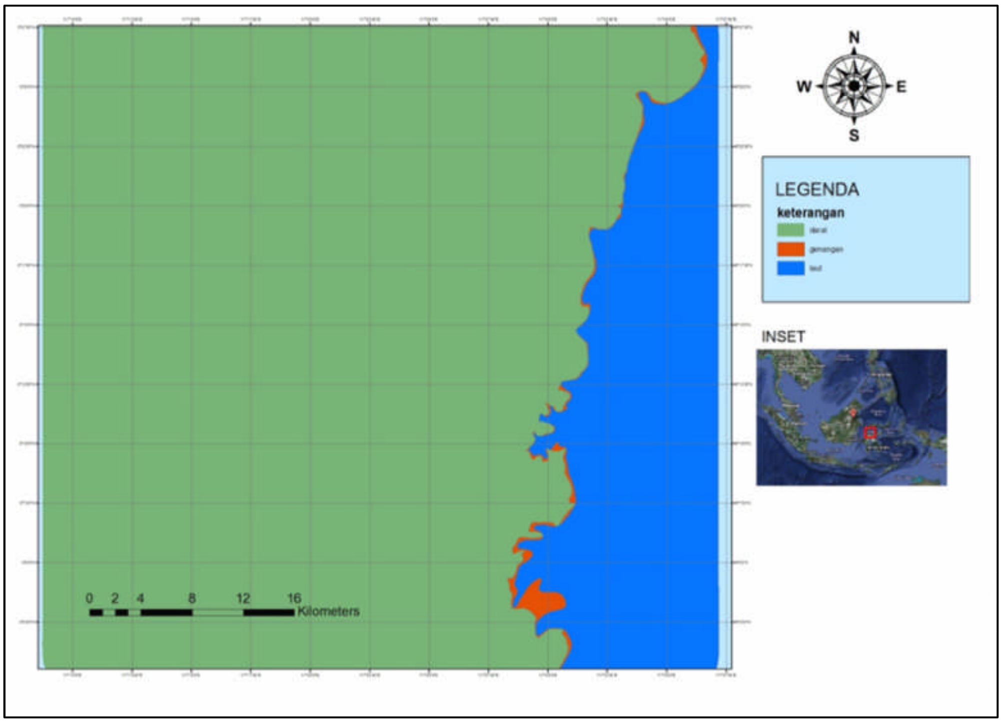


Figure 3. Simulation of coastal inundation of East Kalimantan the 50 years later

Based on estimates of potential inundation zones with 50 years give a real picture of coastal areas along the coastline until Bontang Samarinda. The red color in the estimation of sea level rise for 3.90 cm (7.8 x 50 years) with a radius of 3 KM, indicate that significant exposure in most of the coastline. Broad exposure found on the territory of Samarinda, Kutai Kartanegara or rather in Mahakam Delta to coastal of Muara Badak. The total area of the flooded area estimation of the overall length of the coast is about 32.36 ha.

Population and asset exposure in the inundation zone Estimates

Estimates indicate that sea level rise could increase the vulnerability of coastal areas of Samarinda and Bontang, the broader impact on communities, residential areas, business areas, and facilities necessary and essential as it has been felt today. Furthermore, sea level rise in coastal areas will have the same impact on the estimated inundation area with increasing intensity of tides. Increased extent of inundation and exposure risks from sea-level rise is very clearly shown in the estimated pool of 50 years. The main cause of the extent of exposure of the pool in 50 years, in addition based on topography and soil structure is also the increasing activities of the community. In general, people mostly inhabit the coastal region as an area of potential exposures that can be said to be a major inundation zone of exposure to sea level rise. Socioeconomic factor and others (non-climate) analysis extent of that is given to the rate of sea level rise and inundation in the area of exposure. Both of factors are also a major control on the size of the impact with and without sea level rise.
Level rise projections (Pfeffer et al, 2008) explains that other socioeconomic aspects of development (eg, economic assets, land cover / land use attributes, and future patterns of land use) and attempts to characterize the spatial variability in exposure between people in a region logged because of sea level rise. Focus on coastal communities and their variations in population and asset exposure to danger which is enhanced by a pool of more recent projections of sea level rise. The purpose of this study was to determine whether and how the sea level rise and estimated that the improved socio-economic impact of changing the potential of raising a pool in the future and how these impacts can vary between communities.

Community Variation in Risk Exposure Puddle

Losses incurred by the estimated pool of impact on the activities of traditional fisheries and shrimp aquaculture. Traditional fishing may experience significant deterioration in the condition of changing weather and ocean waves. Raising the wave as a result of rising sea level gives a positive value and negative for shrimp aquaculture along the coast of East Kalimantan. The condition of sea level rise was also having a positive impact on shrimp aquaculture in the form of tide, but not have significant impact on traditional fishing.

The largest resident population living in coastal areas where they are exposed to various hazards such as coastal areas Mahakam and other exposed areas within a radius of sufficient puddle into the stricken area through the new. In developing countries, flood defense exposed populations of less developed and more frequently subject to disruption due to the floodwaters, economic losses, and many cases of lost property. In the 21st century (Nicholls.2004) explains that the incidence of flooding and the number of people affected in coastal areas will change due to various causes, related to changes in: (1) flood level, (2) exposure to flooding, and (3) standard flood management infrastructure.

Coastal areas are very productive on a global scale (Holligan and de Boois, 1993). As an example of one component of ecology, coastal wetlands (collectively comprised saltwater marshes, mangrove associated extensive intertidal areas without plants) can undergo substantial changes and losses due to sea level rise. This area provides a number of important functions such as waste assimilation, local nurseries, to fisheries, flood protection and nature conservation. Therefore, loss of wetlands can be significant impact to humans, though not always immediately felt by those affected. In combination with human activity, it is estimated that 1-m rise in sea level could threaten up to half of the world's coastal wetlands disappear internationally (> 168,000 km^2). However, the wetland area has been under much pressure and declining rapidly: about 1% of global coastal wetlands are lost each year in the late 20th century, primarily by direct human reclamation, although a clear loss mechanisms (Hoozemans et al, 1993) . Therefore, significant losses are possible without climate change, but they will be exacerbated by sea level rise caused by humans.

4. CONCLUTIONS

Significant sea level rise will provide an idea of how the contributions and their impacts on the mainland of East Kalimantan. Extent of inundation that will soak the land in coastal areas, either temporarily or permanently in a local scale will have an impact on the order of human life today and the next future.

Based on the estimated time prediction results found that in 2020 and 2050 in the East Kalimantan coast which is the concentration of population growth and development and is an exposure area due to inundation of sea water paras aggrandizement. A variety of natural phenomena as trigger sea level rise, both temporal and continuously, will eventually have an impact on the extent of exposure to inundation. This becomes a very important information and real time nature must be supported by both observation and control as well as the implementation of policy. As the research results and some important solutions to reduce risk by various justified adaptation strategies in local land use planning and mitigation of the East Kalimantan region.

REFERENCES

IPCC (Intergovenrmental Panel on Climate Change), Climate Change 2007 : *The Physical Science Basis. Summary for Policy Makers, Contribution of Working Group I to the Fourth Assessment Report of the Intergovenrmental Panel on Climate Change.* Paris, February 2007. http://www.ipcc.ch/, 2007.

Dahuri R 2002. *Pengaruh Global Warming terhadap Pesisir dan Pulau-Pulau Kecil. Seminar Nasional Pengaruh Global Warming terhadap Pesisir dan Pulau-Pulau Kecil Ditinjau dari Kenaikan Permukaan Air Laut dan Banjir*. Jakarta.

Frazier T, G Wood, N Yarnal, B Denies, HB. 2010. *Influence of potential sea level rise on societal vulnerability to hurricanestorm-surge hazards, Sarasota County, Florida*. Jurnal of the Aplied Geography. Elsevier

Nicholls RJ. 2004. *Coastal flooding and wetland loss in the 21st century: changes under the SRES climate and socio-economic scenarios.* Flood Hazard Research Centre, Middlesex University, Enfield EN3 4SF, UK. Global Environmental Change 14 (69–86)

Hoozemans F, MJ Marchand, M Pennekamp, HA, 1993. *A global vulnerability analysis: vulnerability assessment for population, coastal wetlands and rice production on a global scale*, 2nd edition. Delft Hydraulics, the Netherlands.

Pfeffer WT, JT Harper, S & O'Neel, (2008). *Kinematic constraints on glacier contributions to 21st-century sea-level rise*. Science, 321(5894), 1340–1343

SEA LEVEL RISE AND ITS IMPACT ON THE COASTAL OF SOUTH BARRU DISTRICT, SOUTH CELEBES

Dwi Fajriyati Inaku* and Muhammad Banda Selamat**
*Graduate Student of Marine Technology Program, Bogor Agri. Univ
*E-mail: wiwikinaku@gmail.com
**Hasanuddin University, Makassar

1. INTRODUCTION

Within the last 10 years, there has been climate change are felt on earth. This is very influential on the nature and all human activity. Because of human nature and there is a reciprocal relationship of mutual influence.

Indonesia, which is an archipelago, has a large area of sea and. Part coast of Indonesia is strongly influenced by the properties and state of the sea. These include tides, waves, ocean currents. Areas affected by the properties and state of the sea called the coastal areas.

Lately, the coastal region is very disturbed by the frequency of significant sea level rise. This gives a fairly serious impact on coastal areas, such as flooding, erosion and intrusion of sea water. If the sea surface continue to increase and decrease the mainland regularly, it will cause logged a region, this will be a new problem for coastal cities, including one of it is Makassar in South Sulawesi.

Flood tide is an event caused by sea level rise. The existence of high tide and tidal inundation would affect the conditions that occur. Many opinions emerged about the cause of flooding rob. One of it is the increasing average sea level or mean sea level due to global warming. The phenomenon of global warming caused by excessive greenhouse contribution is a fairly serious impact for the world climate.

If this condition persists (sea level rise) is feared inundation rob will widen. The impact continued to be generated according to some experts is the increasing rate of erosion, changes in coastal ecosystems, shoreline retreat, increased damage to buildings near the beach and the disruption of people activities in residential areas, aquaculture and industry.

With the reasons mentioned above it is considered very important in this simulation where it can be seen how broad the area to be flooded by rob until 2030 due to sea level rise that can be prepared a plan to overcome or reduce the effects of that rob.

2. METHODOLOGY

This study using Digital Elevation Model (DEM) to describe the condition of some parts of South Sulawesi nowadays. DEM is the height of the model presented in digital form in the form of raster data compiled by the thousands or more pixels (picture elements), where each pixel has a height value. The reason this election is because DEM has a raster format to facilitate the mathematical analysis, in this case to predict sea level rise and land subsidence conditions that created the mathematical formula. The high anomaly data separately sea level used were obtained from satellite altimeter from years 1993-2009 taken from University of Colorado, USA database.

Furthermore, DEM model was later given the formula for areas prone to inundation rob scenario that is affected by sea level rise. DEM data created from the high point which interpolated. In this research the rob prediction simulation are up to 50 years in the future as a result of sea level rise.

3. RESULTS AND DISCUSSION

Barru is one of districts in South Sulawesi, which has a territory lies on the coast of Makassar Strait, stretching from south to north along approximately 78 km. Barru geographically located at coordinates 4°0,5'49" to 4°47'35" south latitude and 119°35'0" to 119°49'16" east longitude, which has approximately an area of 1174.72 km^2 (117,427 ha), with the southern border with Pangkep District, west bordering the Makassar Strait, the northern borders with Pare-Pare City, and the east by District Soppeng.

Area of Barru District

No.	Sub-District	km^2	Ha
1	Tanete Riaja	174,29	17.429
2	Tanete Rilau	79,17	7.917
3	Barru	199,32	19.932
4	Soppeng Riaja	78,90	7.890
5	Mallusetasi	216,58	21.658
6	Pujananting	314,26	31.426
7	Balusu	112,20	11.220
Total Area		1.174,72	117.472

The topographical Barru have a pretty varied region, comprising marine areas, lowland and mountain areas with altitude ranging from 100 to 500 m above sea level. The region is located along the eastern districts, while the western region with topographic elevation 00-20 m facing the Makassar Strait.

The climate in the region including tropical Barru district, within one year occurred twice change of seasons, the rainy season occurs in October through March with the wind blowing from the west, and the dry season occurs in April through September with the wind blowing from the direction of east.

The type of soil in Barru dominated by regosol area of 41,254 ha (38.20), mediterranean area of 32,516 ha (27.68%), lisotol covering 29,043 ha (24.72%), alluvial area of 4659 ha (12.48%).

Based on the characteristics of existing natural resources, Barru has 4 regions, namely:

- Mountainous area located to the east, are generally located in the district and subdistrict Tanete Pujananting Riaja. This area is the area of agriculture, mining and farming region area.

- South area is Tanete Rilau Sub-District which is the gateway from the District Fisheries Pangkep with ample potential as ponds and marine fisheries.
- Middle region as the Capital City of Barru District which is the center of agropolitan located in Barru Sub-District.
- Northern Region consists of Balusu Sub-District, Soppeng Riaja and Mallusetasi Sub-District which is the exit to the Pare-pare City, in addition to the region as an area of agriculture and fisheries, also is an area of marine tourism, particularly tourism, located in Mallusetasi Sub-District. Barru topography is quite varied consists of marine, lowland and mountain areas.

Barru have 0-1700 meters altitude above sea level with a large surface area is slope, hilly – half are mountain and the other is a flat area.This slope region can be seen in the Table 1 and 2:

Table 1. Circumstances based on the slope Barru Region Year 2009

SLOPE (°)	CRITERIA	AREA (Ha)	PERCENTAGE (%)
0 – 2	Flat	23.453	19.96
2 – 15	Ramps	7.652	6.51
15 – 40	Tilt	52.951	45.08
> 40	Steep	33.416	28.45

Source : Badan Pertanahan Kabupaten Barru

Table 2. State region Barru based on height above sea level in 2009

NO	Sub-District	Area (Ha) with attitude					
		0-25	25-100	100-500	500-1000	1000-1500	>1500
1	TANETE RIAJA	1.475	5.565	27.040	13.225	1.475	75
2	TANETE RILAU	4.914	1.155	1.848	-	-	-
3	BARRU	11.736	2.735	2.865	4.185	416	-
4	SOPPENG RIAJA	6.262	1.723	6.995	2.075	50	-
5	MALLUSETASI	1.932	1.365	14.034	3.327	-	-
6	PUJANANTING	-	-	-	-	-	-
7	BALUSU	-	-	-	-	-	-
TOTAL		26.319	12.543	52.782	23.812	1.941	75
PERCENTAGE (%)		22,40	10,68	44,93	20,27	1,65	0,06

Source : Badan Pertanahan Kabupaten Barru

The location of Barru District are approximately 100 km, north of the city of Makassar (South Sulawesi Provincial Capital). Based on inter-regional traffic lane, the area is a cross-regional Barru who skipped lane country road as the economic path that connects several regencies (districts) in South Sulawesi Province, such as lines in the District Soppeng, Bone and Sengkang through the Sub-District Tanete Rilau and Tanete Riaja. Meanwhile, the Provincial Capital to the northern tip of South Sulawesi through Rilau Tanete Sub-District, Sub-District Barru, Sub-District Balusu, Soppeng Riaja and Mallusetasi Sub-District which borders with the City of Pare-Pare. Generally, in Makassar coastal the elevation less than 4 meters as shown in Figure 1 (Kobayashi, 2002)

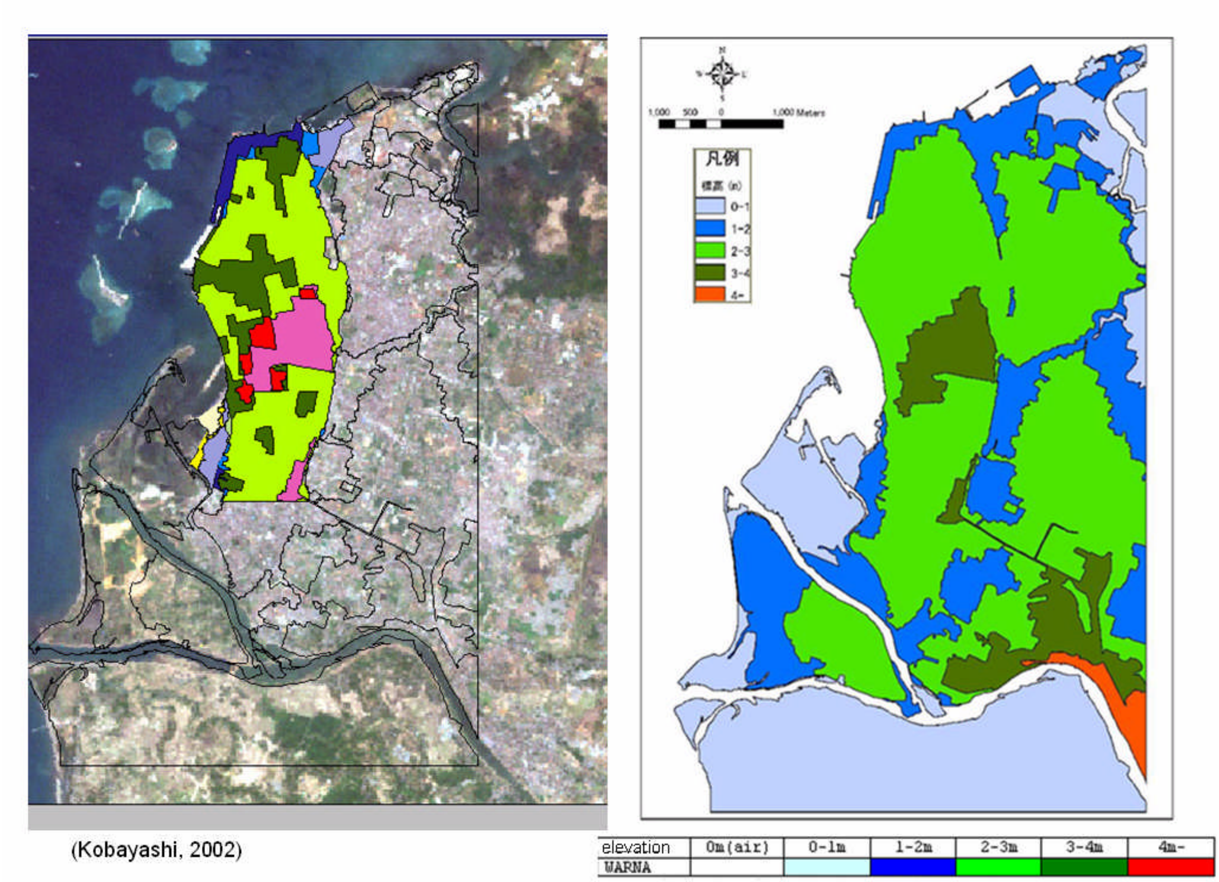


Figure 1. Coastal elevation in Makassar (Kobayasi, 2002)

Barru Coastal Condition relation to sea level rise

Global trends that cause sea level rise, the average predicted by observing the melting ice from land to the condition of a warming world, together with the purposes of thermal energy at the top layer of sea water. The uncertainty of global trends is problematic in itself, but the best estimates can be used in planning for the future, provided information about local and regional trends are well documented.

The conversion of mangrove ecosystems extensively for the purpose of marine cultivation or production in the field, seriously reducing the ability of coastal protection against storms and wave energy and reduce the rate of sediment accretion in the coastal areas. Barru Coast is one of regencies in South Sulawesi, which has a fairly high fishery potential. Coastline stretches in the western district, overlooking the Strait of Makassar. Various marine aquaculture has the potential to be developed. Most of the development of marine aquaculture is using land as a place of cultivation of mangroves. This causes the area of mangroves in coastal areas Barru subtracted, this results in reduced levels of resistance to the threat of coastal storms and erosion. In the long term conversion of mangrove land even this function could affect the vulnerability of this coastal area to sea level rise.

To find out more about the development of inundation areas in the future then the height anomaly data are used paras seawater from year 1994 to 2010. Height anomaly data in the coastal marine sandstone Barru from 1993 to 2009 is shown in Figure 2. Height anomalies of Sea Surface showed an increase TPL 3.0 mm / year.

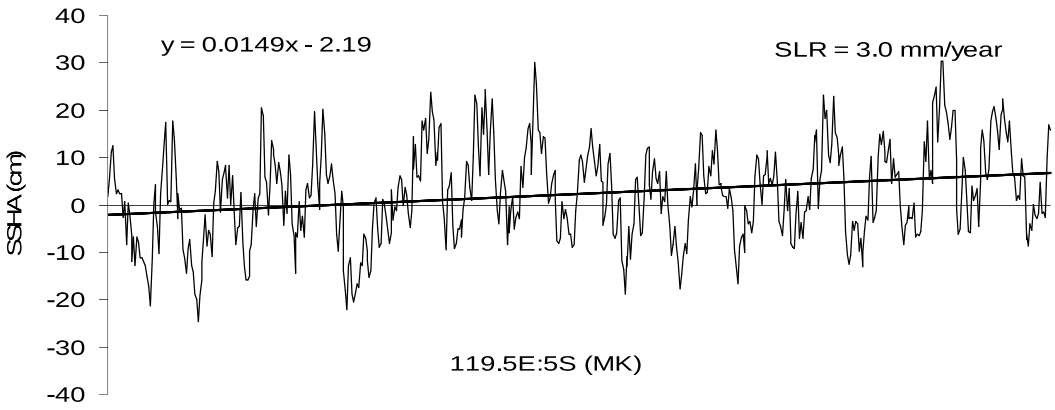


Figure 2. Trend of sea level in Makasar (1993-2009)

Based on data anomalies sea level rise can be seen that the coastal region has an average Barru sea level rise is high enough each year. Furthermore, if these data are simulated to see the level of inundation in coastal areas Barru at 50 years of simulation results are obtained is shown in Figure 3

.

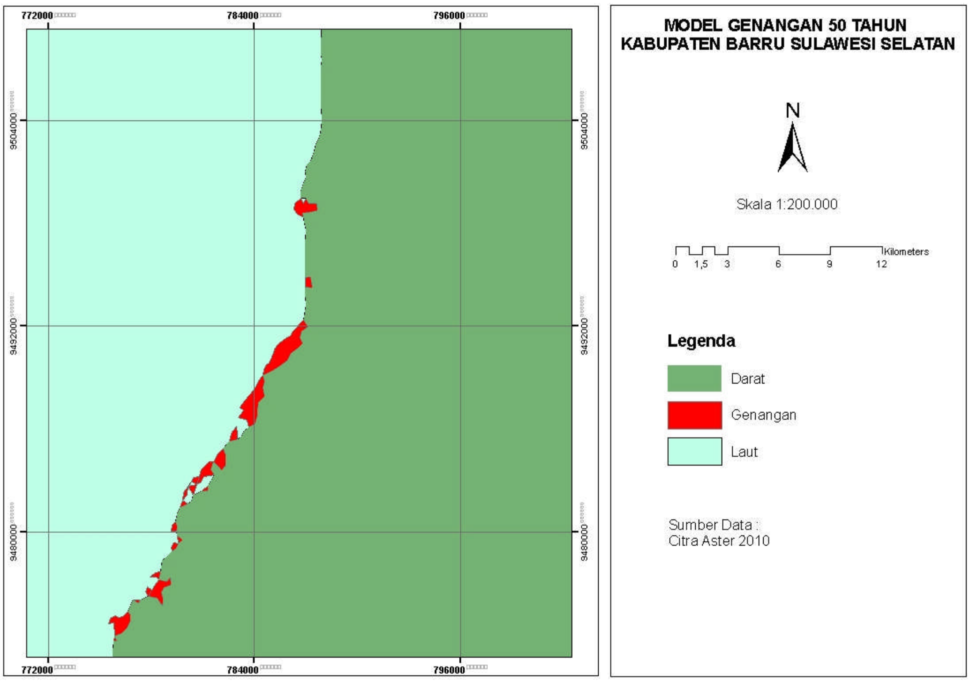


Figure 3. Simulation of the Coastal Region Puddle Barru next 50 years

Based on simulation results contained in Figure 2 shows that regions that experienced inundation in 50 years almost evenly spread along the coastal areas

Barru. In addition, the results show also a large number of areas of inundation area in the next 50 years that is equal to 0.000818 Ha same as 10.051097 km^2. This indicates that the coastal areas in Barru are vulnerable. This course should be anticipated in order to avoid more extensive flooding due to the widespread inundation area means that more land area would be lost.

4. CONCLUSION

Generally coastal areas located on the beach with a fairly flat terrain and is traversed by rivers. When the tides, some areas are below sea level. This resulted in the area extremely vulnerable to the impacts caused by the rising sea levels for example the frequency of flooding, erosion and intrusion of sea water. Areas with a certain critical impact due to these changes can be simulated. Based on the simulation results for coastal inundation in Barru seen that for the prediction of the next 50 years most of the inundation of coastal areas experiencing Barru. This is certainly to be seen early for the impact caused by the inundation can be anticipated as early as possible.

Reference

Fauziah, Asmaul. 2008. Dampak kenaikan Muka Air Laut Terhadap Wilayah Pesisir. Universitas Negeri Surabaya. Surabaya.

Kobayashi H. 2002. Assessment of Sea Level Rise Impact in Makassar, and Semarang. Research Center for Advanced Information Technology, Nationhal Institute for Land and Infrastructure Management(NILIM), Ministry of Land and infrastructure and Transport, JAPAN

Wensite of Barru Distict: www.barru.go.id. [Accessed on December 4, 2010]

SEA LEVEL RISE AND ITS IMPACT ON THE COASTAL AREAS IN JAKARTA METROPOLITAN CITY

Andi Rahman
Mininstry of Marine Affair and Fisheries, Jakarta

Abstract

The rising of sea level is a result in today's global warming phenomenon. As had been confirmed by Prijatna *et al*, 2006, initial studies that showed the position of the seawater interface in Indonesia had been conducted. This indicated a rise in all regions in a range of approximately 10 mm per year to 20 mm per year. This phenomenon is a major threat to the existence and the environment of small islands and coastal areas in Indonesia. This report seeks in conveying the images projected on inundation coastal areas due to sea level rise in Jakarta because of global warming with a 100-year model generated through the Digital Elevation Model (DEM). The trend in sea level rise, which is use to project inundation areas, is 4.5 cm per year in 100 years. The analysis from the software showed that in the year 2110, it is estimated that the coastal areas of Jakarta will be inundated with seawater.

Keywords: the increase in sea interface, global warming, coastal areas

1. Background

Some of the impacts from this phenomenon were towards a variety of complex and multiple factors (multiple complex factors). As was expressed by Kurnio, 2009, the impacts were the increase in coastal erosions, increase in floods caused by storm, the production of the main material will be blocked, the increase in widespread of inundation areas, the change in the characteristics qualities of surface waters and ground waters, the increase in loss of properties and coastal habitats, the risk of floods and potential loss of lives, loss of resources and cultural values, impacts on agricultures and fisheries through the declining qualities of land and water, and loss of tourism functions, recreations and transportations.

Meanwhile, the increase in the sea interface will affect the coastal areas, small islands and outer islands in Indonesia where the presence of these environmental changes affect the existence and sovereignty as an integral part of the Unitary Republic of Indonesia (NKRI). In this study, one of which analyzes the inundation in the densely populated capital city of Jakarta, which is the center of government and business. According to Seibold, 1994, from the view of the Earth experts, the increase in the sea interface is not something new because in the history of geology, especially in the Holocene periods, which began since the peak of ice age about 18,000 years ago, sea level is located at approximately 130 meters below sea level now. After that, the sea level continues to rise until the current position around 6000 years ago. This is important given that this phenomenon is globalized. About 60 percent or 80 percent from the radius of 50 kilometers from the coast, people stay permanently and do activities. The issues on the increase in sea level were confronted, especially after the global climate change conference in Bali late 2007. A few millimeters on the sea level rise could be accelerated by global warming phenomenon, which threatened the coastal lowlands and islands around the world, especially Indonesia, which is an archipelago.

2. Objective

To know the projected inundation areas from the increase in the sea interface in the coastal areas in Jakarta as a result of global warming using satellite imagery and to assess the impacts and vulnerabilities of coastal areas against the increase of sea interface.

3. Data

The data used in this study is the sea surface high anomaly data from satellite altimeter from the year 1993-2009. It is gained from the database of the University of Colorado, USA. Global Mapper software is use to visualize the Aster DEM data whereas ArcGIS software is use to analyze coastal inundation areas due to sea level rise.

4. Results and Discussions

Based on some literatures on the coastal areas in Jakarta, the annual incidence of flood showed that the phenomenon were more likely to be every year in certain months with the intensity that kept increasing. Meanwhile, meteorologists concluded that this phenomenon occurred was the cause of accumulation of water mass at the side of the beach due to the tangential pressure on the sea surface caused by strong gusts of winds or storms that had happened for a long time and for a great distance (Remote Forcing), which then led to the increase of sea interface along the coasts.

The beaches in Jakarta have potential in causing tidal surge capacities, in which lies the coastal geography that is bay-shaped, which is an area that is susceptible to flood. The total area of North Jakarta is 139.56 km^2 that stretches from west to east along approximately 35 km that juts into the land between 4 to 10 km. Altitudes between 0 to 2 m in certain places are below the sea level, which is largely made of marshes or brackish water ponds. The region consist of beach area and an estuary containing of 13 rivers and 2 flood canals, causing this region susceptible to flood, because of either flood or high tides.

DKI Jakarta is an area with a topography that tends to slope that is 0 to 2 degrees in the northern and center part, 0 to 5 degrees in the southern part. Naturally, the causes of flood is the morphology in the form of lowlands, high rainfalls in the hinterland areas, surface flow (run off), a large river or a drainage gradient, tidal influence and river sedimentation around the estuaries.

The phenomenon of sea level rise that occur will slowly enlarge the areas of flood in Jakarta, especially from the rapid physical development. As a result, open land for infiltration of rainwater will become limited and narrow. This situation causes an enlargement in the surface flow and as a result, the surface becomes limited and causes flood in some places.

Meanwhile, according to Hadi *et al*., 2009, the results from the simulation model on inundation areas caused by sea level rise of 0.57 cm per year for 2010 are shown in Table 2 and for 2050 are shown in Table 3. Susceptible inundation areas in North Jakarta cover areas such as Cilincing, Koja, Kelapa Gading, Tanjung Priok, Pademangan and Penjaringan. Inundation areas will expand in 2050. District that will experience the largest inundation is the district of Panjaringan, dominated by a volume of 198,551 ha. In 2050, the industrial area with the largest inundation area will be the district of Tanjung Priok with a total area of 62,787 ha and the residence district with the largest inundation area will be in Cilincing with a total area of 17. 929 ha.

On the other hand, results that were reviewed by the Oceanographic Janhidros Laboratory on the leveling measurements point of elevation (Bench Mark) at Pondok Dayung with High Point Geodesy at Pasar Rebo during 1996-2006 showed that the soil had been declining at an average of about 9 mm every year. This showed that the lands in Jakarta keep declining but showed an increase in the sea interface.

Table 1. Area of Inundation per Type of Land Area in North Jakarta Year 2050 (Ha)

Districts	Industries/ Offices	Residential Areas	Roads	Railway Tracks	Garden	Salt Fields	Rice Fields	Empty Land	Park	Body Water
Cilincing	8.327	17.929	0.573	-	0.324	0.152	2.805	25.312	1.564	77.942
Koja	7.921	1.817	0.768	-	0.055	-	0.085	2.993	0.319	26.457
Kelapa Gading	0.117	0.496	0.090	-	0.102	-	0.054	0.658	0.389	9.685
Tanjung Priok	62.787	7.458	0.921	0.041	-	-	-	12.213	0.842	159.383
Pademangan	57.457	1.458	3.396	0.057	-	-	-	12.608	7.438	59.026
Penjaringan	7.923	9.828	5.390	0.015	0.211	-	0.046	141.986	30.354	198.551

The inundation of coastal areas in Jakarta in Table 2 shows the depth of inundation areas in 2050, in Kelapa Gading is 0.53 m, followed by Pademangan 0.39 m.

Table 2. Depth Inundation (meters)

Districts	Depth
Cilincing	- 0,066
Koja	- 0,122
Kelapa Gading	0.528
Tanjung Priok	0.353
Pademangan	0.387
Penjaringan	0.374

The consequences on the rise in sea level referring from the socio-economic views, 2050 Coastal Vulnerability Maps of Jakarta City (Radjawane *et al*., 2009) showed that almost all districts from Pademangan, Penjaringan, Cilincing, Tanjung Priok and Koja were stated as high susceptible area. Affected population in Cilincing and Koja increased along with the population density in Pademangan, Tanjung Priok and Koja. As a result, all districts were stated as a high susceptible area.

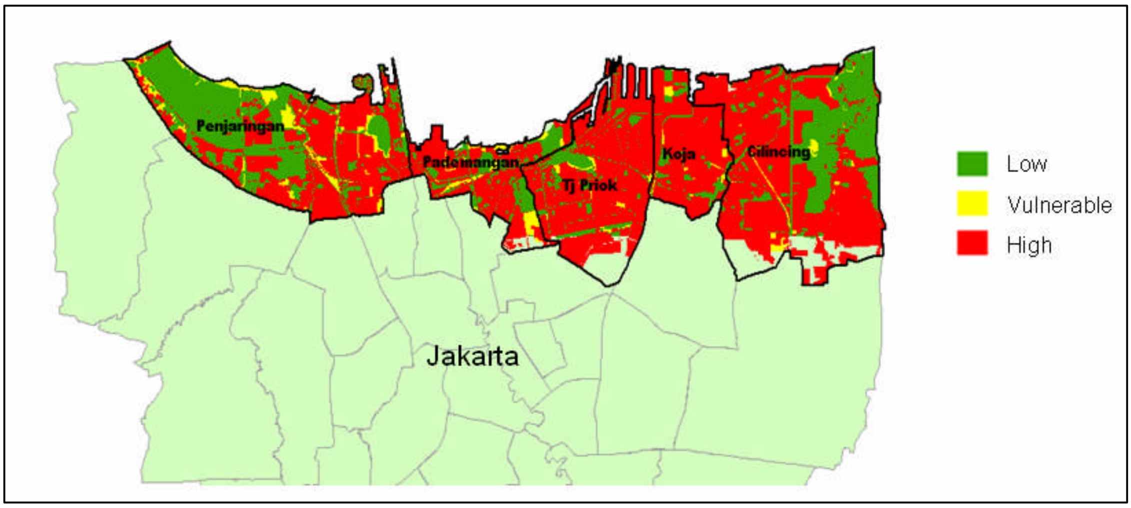


Figure 1. Coastal vulnerability of Jakarta (Radjawane et al, 2009)

In the projected inundation area development in the future, high anomaly data were used in the coastal areas in Jakarta from 1993 to 2009 as shown in Figure 2. The data showed an increase in sea level of 4.5 mm per year.

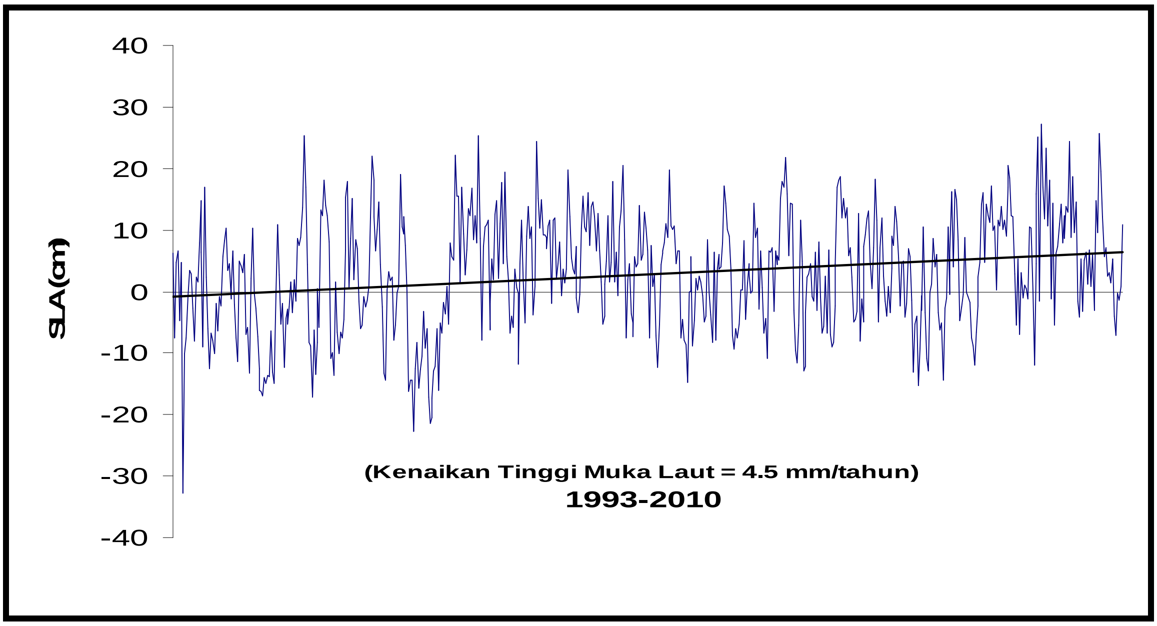


Figure 2. The Trend n Sea Level Rise around the Jakarta waters (1993-2009)

Based on the trend anomaly in the sea level rise shown above, simulation results on inundation in coastal areas due to the rise in the sea interface in the next 100 years can be obtained. It is shown in Figure 3. The results showed that in the next 100 years, there will be an additional inundation in coastal areas.

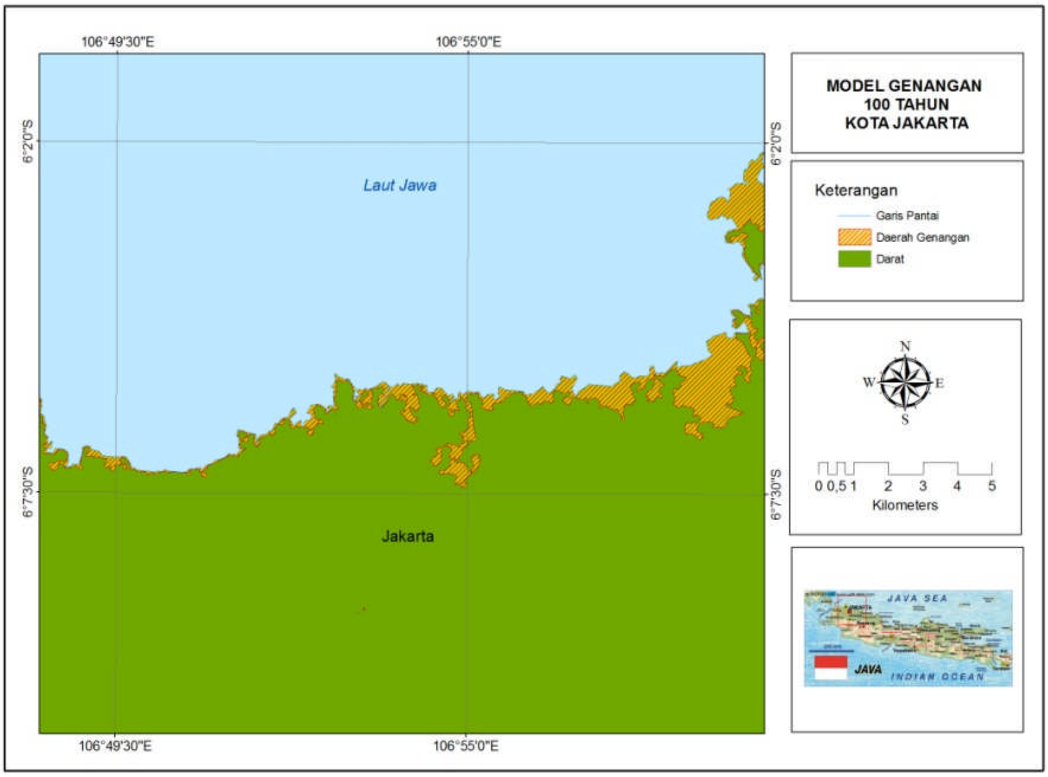


Figure 3. The Simulation on Inundation in Coastal Areas in Jakarta in the next 100 years

Figure 3 shows that most of the inundations in coastal areas in Jakarta are bordered with the coastline and the most dominant inundation area is located on the east coast region. These results indicate a very influential effect in the rise of the sea interface towards the coastal regions in Jakarta. One of the reasons is that the coastal areas have a gentle slope and the regions are located at the highest tide point. Prediction coastal areas in Jakarta that are susceptible to inundation are Cilingcing, Koja, Kelapa Gading, Tanjung Priok, Pademangan and Penjaringan.

In addition, the impacts of inundation caused by sea level rise were estimated to be because of the increase of greenhouse that causes the increase in the earth's temperature (global warming). This results in the swelling of seawater as a result from human activities such as transportations, industrial activities, constructions of buildings, which are all coated with glass (green house effect) and so on.

Analyses on susceptible areas towards the rise in sea interface were objected in order to identify the areas of inundation, so that the government and societies could respond to the disaster on the rise in sea interface by reducing the impact. The efforts that could be done could be structural (technical) or non-structural (non-technical).

Some pictures showing a result in the rise of the sea interface in Jakarta caused by rain and as a result, it could not be accommodated, can be seen below (Figure 4).

Figure 4. Coastal indundation in Jakarta City

REFERENCES

Coastal and Marine Directorate, Ministry of Maritime Affairs and Fisheries, 2009. Mitigation Guidelines for the Coastal Zone and Small Islands. Jakart

Regional Research Center for Marine and non-biological Resources, 2009. Relative sea level rise and Vulnerability of Coastal Areas and the small islands in Indonesia

Public Relations Directorate General of Marine, Coastal and Small Islands Ministry of Marine Affairs and Fisheries, 2007. Outermost small islands: Threats and challenges

Kurnio, 2009. Sea Level Change Issues In Perspective Through the Study of Marine Geology "Coastal Vurnerability Index (CVI)" Some Selected Coastal Java. Regional Research Center for Marine and non-biological resources. Jakarta

Hadi et al, 2009. Impact of Increase in Front of the Sea In the North Coast of Jakarta and the Thousand Kepuluan. Regional Research Center for Marine and non-biological resources. Jakarta.

Radjawane et al, 2009. Identification Vulnerability of Coastal Sea Front Against Increase In North Jakarta. Regional Research Center for Marine and non-biological resources. Jakarta