

The Coastal Zone Management in Adapting to Climate Change: A case of Manterawu Island, North Sulawesi, Indonesia

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ABSTRACT

Manterawu Island is one of the outer most islands located in North Sulawesi Province. This island plays a very important role, especially related with the country borderline. Based on the census held in 2006, the number of people who lived in this small island is more than 1900 peoples. Like other small islands, Manterawu Island has various marine ecosystems, such as coral reefs, mangrove, and sea grass. Unfortunately, the utilization of those resources seems to be neglected. Those ecosystems are very essential in term of small islands management and need appropriate action to take into account.

Currently, climate change turns out to be one of the important environmental issues. Furthermore this phenomenon can cause adverse impacts for small islands related with those coastal zones and marine ecosystems, include the rising sea level, extreme weather events, fresh water scarcity, and coral bleaching. Small islands are among the most susceptible to climate change impacts; therefore it needs a comprehensive coastal zone management strategy that applicable to small islands in adapting to climate change as well.

This research try to estimate the area of Manterawu Island that will be inundated because of rising sea level, describe the main problem in coastal zone management related to climate change and propose some policy scenarios to overcome those problems, such as build the hard and soft structures, relocate the population to another safe areas, and integrated coastal zone spatial planning implementation. High resolution imagery (Quickbird) was used in this research to obtain the land use classification, while the contour data was used to build 3D inundation model. Later on, the result of this research and recommendations could be used by local government, relevant institutions, and all stakeholders, as an input in developing and implementing the small island coastal zone management in adapting to climate change.

Keywords: Climate change, Small Island, the outer most island, Manterawu Island, coastal zone management

I. Introduction

Climate change is any long-term significant change in the “average weather” of a region or the earth as a whole (Wikipedia, 2009). Climate change is calculated over a very long time between a matter of decades to millions of years. This change may be caused of the dynamic processes in the earth, external forces including variations in the climate outside the sunlight intensity and no less important result of human activity itself. Global climate change phenomenon is causing a significant change occurred in the physical and biological systems, among other things an increase in the intensity of tropical storms, changes of precipitation pattern, sea water salinity, wind patterns change, the influence of the reproductive period of animals and plants, species distribution and population size, the frequency of pest and disease outbreaks, as well as affect various ecosystems found in the area with a high latitude, place with high elevation, and ecosystems in coastal area (Depkominfo, 2007).

Based on the results of the study of some trusted institution, there is a trend of global temperatures increasing. One of the studies conducted by IPCC (Inter-Governmental Panel on Climate Change) (2007) shows that since 1850 there were eleven of the twelve hottest years have occurred within the last 12 years. Global temperature increase from the year 1850-1899 until the year 2001-2005 is 0.74 ± 0.18 °C. While the rate of sea water surface is increase and reach an average of 1.8 mm per year in the period between the years 1961-2003. Estimation of total sea water surface which was successfully recorded on the 20th century is 0.17 m. IPCC report also states that human activities have had a role in global warming since mid-20th century. Global warming will continue to increase with a higher acceleration in the 21st century, if there are no response efforts to overcome this issue.

Systematic and integrated efforts must begin now to increase resilience to climate change and improving the environment both in local level and global. If not, then the damage resulting from the impact of climate change will increase which in turn will impact on the difficulty in achieving sustainable development. Anticipating the impact of global climate change requires cross-sectoral approach at both the national level, regional and local, and not least, through international cooperation. Meanwhile, to reduce the risk of danger arising from climate change is done with the adaptation and mitigation efforts.

Adaptation is the action to be accustomed, in natural and social systems, to address the negative impacts of climate change. However, these efforts will be difficult to afford the benefits of an effective climate change when the rate exceeds the ability of adapting. Therefore, adaptation must be offset by mitigation, namely the efforts to reduce source and increase absorption of greenhouse gases, so that the development process is not hampered and the goal of sustainable development can be achieved. Thus, the next generation will not become a burdensome of the more serious climate change's impacts.

Related with the small islands, the effects of climate change-related should consider the sinking island, especially on the islands with a relative flat topography. Manterawu island or also known as Pulau Mantehage example is one of the small island; outer most area which have a relative flat topography, the location of this island is used as a starting outer point boundary. Manterawu Island has mangrove ecosystems, coral reefs, and yet a very high ecological value that need to be maintain to be everlasting.

II. Objectives

The objectives of this research are:

1. to describe the main problem of Manterawu Island management related to climate change
2. to estimate the inundate area of Manterawu Island due to the sea level rise
3. to adapt and mitigate facing the climate change and/or sea level rise problem in Manterawu Island

III. Study Area

The Manterawu island is one of 92 the outer most islands of Indonesia. This island is located in the Sulawesi Sea and bordered by the country the Philippines. Manterawu island is part of the government of North Minahasa, North Sulawesi province is located in the north of the island of Bunaken and Manado city with coordinates 1 ° 45 '47 "N, 124 ° 43' 51" E. Manterawu island or also known as the Island Mantehage have broad land 21.6 Km². The island has two seasons namely the west season (October – March) and the eastern season (May – August), the rainfall average 3000 – 3500 mm / year. Proximity to the Menado city can be within 1 hour 15 minutes by motor boat. This island has a 1,894 people (based on the census of 2006) which consists of 983 men and 911 women and consists of four ethnic groups, namely Sangihe Talaud, Bajo, Minahasa and Gorontalo.

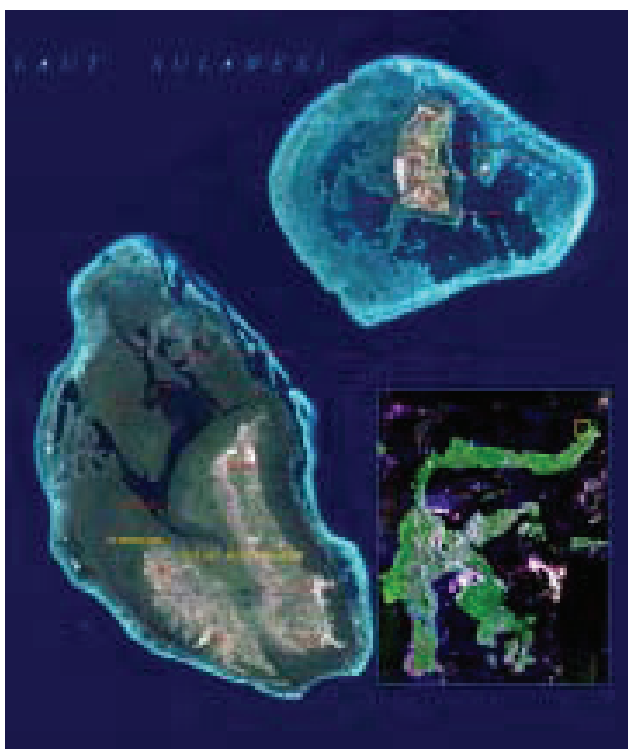


Fig. 1 The Study Area

IV. Methodology

Methods used in this research can be divided into three stages, which are:

1. Preliminary stage.

This stage is a preparation stage, which is included:

- Literature review
- Secondary data collecting
- Pra survey to get the early information of study area particularly the information about accesibility and accomodation.
- Image processing (geometric correction, atmospheric correction, enhancement, interpretation / classification. Satellite image used in this research is Quickbird acquired 2005.

2. Implementation stage, including:

- Field survey to achieve the information about land (soil, geology, and hydrology), demography, people behaviour as well as culture in those small islands, and also natural resources found in those islands, such as mangrove, coral reef and reef's fishes,

and seagrass. Field survey was conducted by the Centre of Marine Resources Surveys in June 2007.

3. Final stage, which is including
 - Re interpretation of remote sensing data
 - Data analysis (some alternative options for Manterawu Island due to climate change.)
 - Reporting

V. RESULT AND DISCUSSION

5.1. Small islands

The definition of small islands based on Bengen and Retraubun (2006), which described in the UNCLOS (1982, Chapter 121 Article VIII Paragraph 1) is: "The island is a land mass that naturally, surrounded by water, and always be/appear above the high tide." Furthermore, based on the Decree of Marine and Fisheries Minister No 41 Year 2000, a small island is the island that have a broad area of less than or equal to 10,000 km², with a population of less than or equal to 200,000 people "[4]. Regarding all definitions described above, small islands have unique characteristic related with geographical, physical, climatic, social, political, cultural and ethnic features and economic development. Furthermore, it will lead and create distinctive problems and vulnerability of small islands.

Based on UNFCCC (2005), small islands have some characteristics that underscore their overall vulnerability to climate change, climate variability and sea-level rise, which are:

1. Generally limited natural resources, with many already heavily stressed from unsustainable human activities
2. A concentration of population, socio-economic activities, and infrastructure along the coastal zone
3. High susceptibility to frequent and more intense tropical cyclones (hurricanes) and to associated storm surge, droughts, tsunamis and volcanic eruptions
4. Dependence on water resources for freshwater supply that are highly sensitive to sea-level changes
5. Relative isolation and great distance to major markets, affecting competitiveness in trade
6. Extreme openness of small economies and high sensitivity to external shocks
7. Generally high population densities and in some cases high population growth rates
8. Inadequate infrastructure in most sectors
9. Limited physical size, effectively eliminating some adaptation options to climate change and sea-level rise
10. Insufficient financial, technical and institutional capacities, seriously limiting the capacity of small islands to mitigate and adapt to any adverse impacts of climate change.

Based on all descriptions above, it is needed to take urgent steps for reducing the impact of climate change. One of the initial steps is vulnerability assessment, which will describe in the next section.

5.2. Problems faced Island Manterawu

Based on the results of field survey conducted by the Centre for Marine Resources Surveys - BAKOSURTANAL, this island has a mangrove ecosystem, coral reefs, and yet, and has become part of the Bunaken National Park since October 1991.

1. Mangrove ecosystem

Mangrove ecosystem in Manterawu Island is dominated by *Rhizophora stylosa* and *Rhizophora sp.*, *Avicennia sp.*, *Bruguiera sp.*, and *Sonneratia sp.* Based on the results of field observations, the mangrove ecosystem in this region is very vulnerable to damage and very difficult to do re-establishment, this is due to the occurrence of abrasion, very poor of mangrove growing media

(less of the mud), and strong sea waves during the west and east season which drift the young mangrove. In addition, there is a significant increasing of mangrove exploitation as the high demand of wood and land clearing for the pond.

The decreasing of mangrove ecosystems in this island accordingly effects the vulnerability of erosion, tsunami, fisheries degradation, and moreover is the possibility to be sinking. Because the mangrove forest plays an important role to protect the coastline from erosion, wind, tsunami, sea water intrusion and so on. Furthermore, it is work as nutrient source, nursery ground for fish, shrimp, and many animals that live in this ecosystem, and as a tourist attraction.

2. Coral reef ecosystem

Coral reef ecosystem spread around the island Manterawu. This island has a very beautiful and various coral reefs; therefore it is very suitable to be developed as one of tourist destinations in North Sulawesi. Coral reefs in this island and others in North Sulawesi are categorized as the Coral Reef Triangle of the world together with coral reefs in Maluku and Papua. A lot of biota associated in this ecosystem and make this ecosystem as a unique and valuable. Survey in 2007 shows that coral reef in Manterawu Island is associated with many biota, such as reef fish (most dominant), anemone, ascidian, and zoanthid sponge.

The condition of coral reefs in Manterawu Island is varying from excellent to poor condition. But in general, the water condition of Manterawu Island is still good; hence it is still support the growth of coral. Besides, the association of biota supports a balance of the existing coral reefs ecosystem. However, it is necessary for the community and local government to prevent this coral reef from destruction. The implementation of law and the awareness of law should be improved. For example, a lot of fishing bombing occurs during the absence of a patrol officer. This still reflects a lack of awareness of local communities in protecting the coral reefs. Besides the threat caused by people, the threat seriously affecting the growth of coral reef ecosystems is derived from the environment, such as temperature, salinity, light, sedimentation, currents and waves. With the increasing of temperature and sea surface as a result of global climate change, will increase vulnerability to the existence of coral reefs ecosystem.

3. Seagrass ecosystem

This ecosystem along with mangrove and coral reef ecosystem make a harmonized coastal process. This ecosystem is spread around the island Manterawu, but the most large distribution is the western island. In general, Manterawu Island has a mix species (mixed species Meadows). The profile of coastal ecosystem of Manterawu Island can be seen on the picture 2 below.

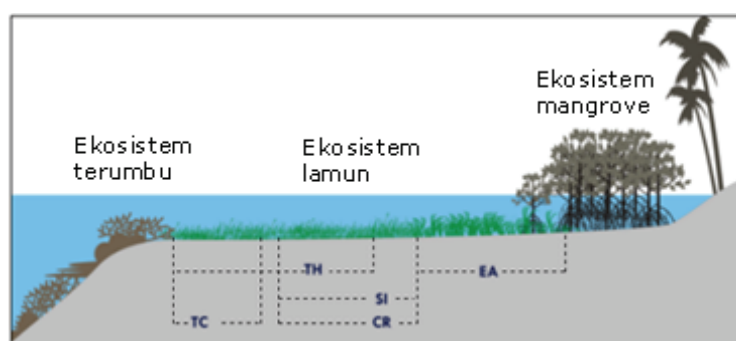


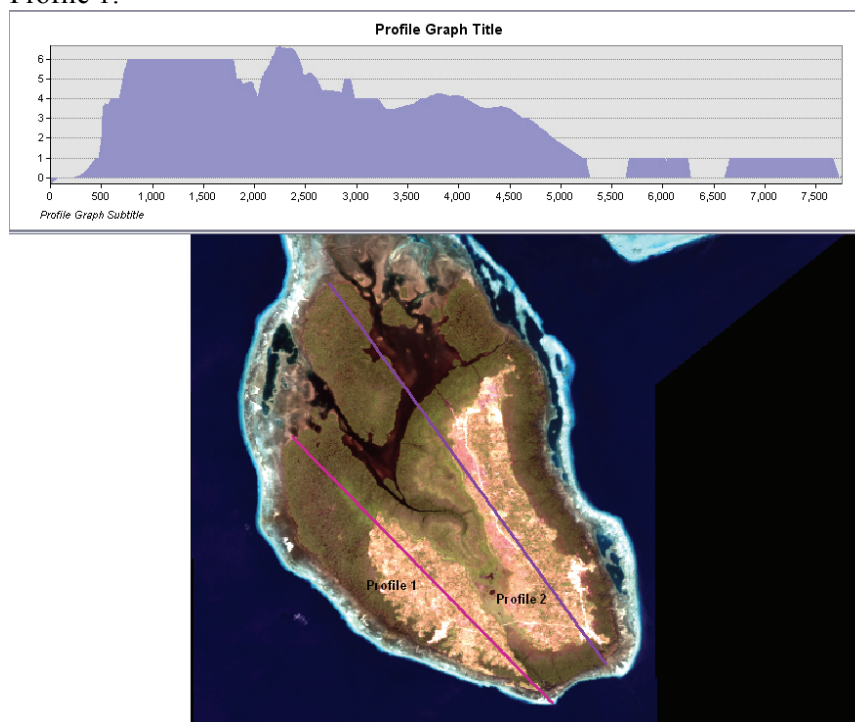
Figure 2. Coastal Ecosystems profile of Manterawu Island

Refers to the results of observations made between the years 1950 - 2000 from the related parties, there is a tendency of the increasing of average annual sea level (1 - 2.5 mm), with the projected scenario that the sea level rise until 2100 tended to have increased 20 - 60 cm . Thus the problems faced Island Manterawu, in the next years it is very important to take a appropriate actions to overcome it.

5.3. Result of 3-D analysis

Manterawu island consists of two separate islands. When viewed from the height of the northern part to the southern part, the northern part of this island is relatively flat (between 0 - 2.5 m above sea level) and in the southern part is relatively higher with range between 10 - 27 m above sea level (profile 1). The altitude of entire island is between 0 - 7 m above sea level (profile 2). The second island has more dense population compared with the first island; it can be seen from the road and settlement pattern.

Profile 1:



Based on the result above, we can make observe that the main island Manterawu will not be lost because of sea level rise, at least until 2100. Area with a height of up to 1 meter (mangrove area) will inundated by the sea water around year of 2050 with the assumption of an average sea level rise is 2 mm per year. However, local governments must remain aware of the occurrence of sea level rise face as the effects of climate change, especially related with the sustainability of coastal ecosystems (coral reefs, mangrove, and seagrass).

5.3. Proposed Adaptation and Mitigation due to Climate Change on the Manterawu Island

Nowadays, vulnerability has appeared as one of essential concept to understanding the impacts of climate change and natural hazards. From the vulnerability concept, we can also develop some possible risk management strategies. Regarding to small islands, the vulnerability describes the susceptibility of the small islands as a natural system including the societies (persons/groups/communities) towards hazards. Therefore, assessing vulnerability is an important step in disaster risk reduction due to natural hazards.

In addition, adaptation is very essential in the climate change issue. First, related to the impacts and vulnerabilities assessments and the other, related to the development and evaluation of response options. In order to assess the vulnerability and risk assessment, we should understand the expected adaptations and hence is fundamental to estimating the costs or risks of climate change

(Yohe et al., 1996; UNEP, 1998; Smith et al., 1999). Because vulnerability and its causes play essential roles in determining impacts, understanding the dynamics of vulnerability is as important as understanding climate itself (Liverman, 1990; Handmer et al., 1999).

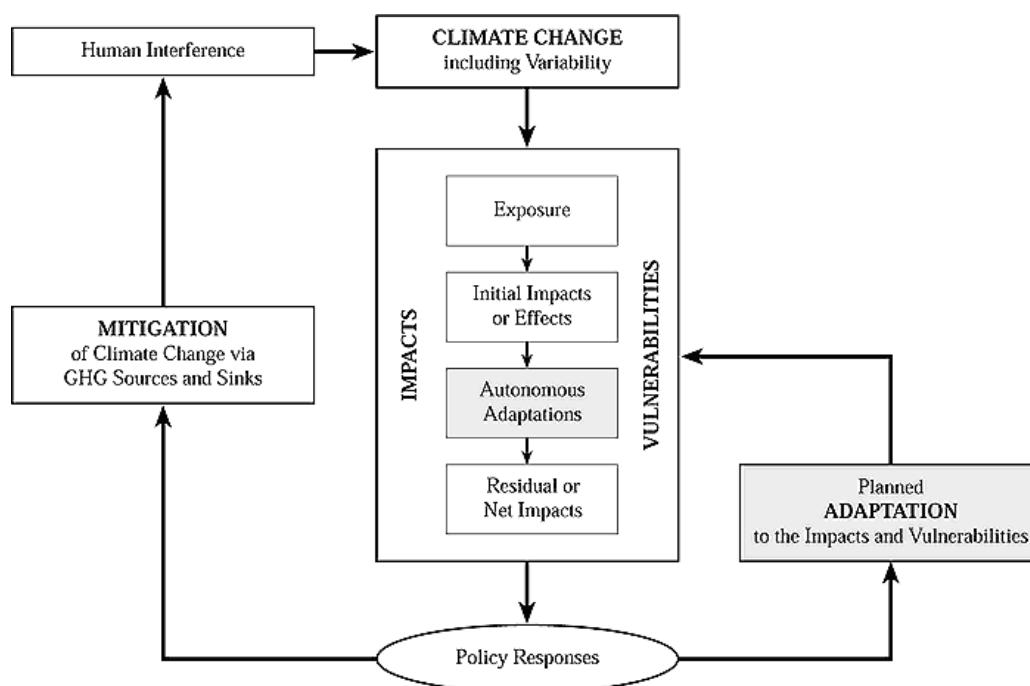


Figure 3. Places of adaptation in the climate change issue (Smith et al., 1999).

In order to viewing people’s vulnerabilities and capacities in four broad, interrelated areas: physical, social, economic, and environmental; the VCA (Vulnerability Capacity Assessment) matrix for Manterawu Island in relation with climate change was created (Table 1).

Table 1. VCA (Vulnerability Capacity Assessment) matrix

Aspects	Vulnerabilities	Capacities
Physical	<ol style="list-style-type: none"> 1. Infrastructure is quite adequate. 2. Some settlement concentrated in flat area, which very vulnerable due to sea-level rise and changes in the patterns of extreme events such as storms and coastal flooding. 	<ol style="list-style-type: none"> 1. Coral reef ecosystem, which located around this island, can protect the island from currents and waves.
Social	<ol style="list-style-type: none"> 1. Low perceptions of climate change risk 2. Lack of adequate skills and low education level. 3. Most of population is categorized as low income family. 4. Lack of knowledge in disaster management, and adaption of climate change. 	<ol style="list-style-type: none"> 1. Local leadership 2. Government starts to develop the small island and assist the island to adapt the climate change
Economic	<ol style="list-style-type: none"> 1. Mono-crop agriculture 	<ol style="list-style-type: none"> 1. Manterawu Island has the natural resources that are very

		potential to be developed, i.e. marine tourism (diving and snorkeling activities).
Environmental	<ol style="list-style-type: none"> 1. Coastal erosion 2. High susceptibility due to tsunamis, earthquakes, and storms as a result of climate change. 	<ol style="list-style-type: none"> 1. Bio-diversity of natural resources

Source: data analysis (2009)

Based on information above, information about people's vulnerabilities and capacities due to climate change clearly depicted. The next step is to make some of alternatives adaptations to minimize the vulnerabilities as well as maximize the capacities found, such as:

1. **Hard Structure / Hard engineering**
 This is including the development of construction in coastal area, such as seawalls, breakwaters, and bulkheads. The main objective of this structure is to prevent coastal from coastal erosion and flooding. Unfortunately, this approach has not always been efficiently implemented and has even helped to increase coastal vulnerability in some cases (Mimura, 1999a).
2. **Soft Structure**
 This structure perform some actions in order to build the natural protection, such as replanting of mangroves and protection of coral reefs, use of softer options such as artificial nourishment, and raising the height of the ground of coastal villages (Mimura and Kawaguchi, 1997).

Other option is using the "precautionary" approaches, such as enforcement of building set-backs, land-use regulations, building codes, and insurance coverage. In addition, application of traditional, appropriate responses (e.g., building on stilts and use of expendable, readily available indigenous building materials), which have proven to be effective responses in many islands in the past, ought to be more widely considered (Mimura, 1999a).

3. **Integrated Coastal Zone Management (ICZM) – integrated, sustainable coastal zone resource.**
 Based on several experiences in many small islands, this is the most appropriate adaptation strategy. This approach observes small islands as an environment and could not be separated from its physical and biological condition. It can be regarded as both an anticipatory and a predictive tool, with the capability to plan for and respond to medium- and long-term concerns such as sea-level rise as well as short-term, present-day needs. In addition, ICZM can provide an effective framework for resolving potential conflict among competing stakeholder interests. Government should form an essential part of their climate change national action plans (Huang, 1996).

In ICZM, re-enhancing the resilience of coastal systems has been suggested as an appropriate proactive adaptive response to reduce vulnerability. Klein and Nicholls (1998) stated that this could be a more cost-effective way to prepare for uncertain changes such as sea-level rise, rather than relying entirely on building traditional, more costly coastal defences.

In short, government should using resources in Manterawu Island to establish climate change institutions in local level that can guide and give efforts in this area, develop local climate change action plans and mitigation strategies, and initiate education, training, and

public awareness campaigns designed to engage the general populace on the problem of climate change.

RECOMMENDATION

Based on the results discussed above, we can conclude that the climate change and its effects cannot be prevented entirely. However, we need to do some adaptations due to climate change in order to minimize the impacts of this issue. Manterawu Island is among of 92 outer islands of Indonesia and it makes the existences of this island is very important, especially related with the country border and hazard vulnerability.

Vulnerability assessment which conducted within this research is using the VCA (Vulnerability and Capacity Assessment) Method. This has been used to assess the vulnerability with the emphasis on participatory and people oriented approaches. Natural resources in Manterawu Island seem to have the most affected impacts due to climate change.

Therefore, government, both in national and local level should cooperate to carry out some strategies to deal with this problem. The best strategy to overcome climate change is using the combination of top-bottom management and bottom-up management which included people's knowledge in risk management. In addition, government should implement and develop the legal aspect in order to reduce the illegal fishing; otherwise people will keep doing this and it could cause environmental degradation in Manterawu Island. Under these circumstances, progress in adaptation to climate change will almost certainly require the integration of appropriate risk reduction strategies with other sectoral policy initiatives such as sustainable development planning, disaster prevention and management, integrated coastal management, and health care planning.

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