Vulnerability assessment of Olango Island to predicted climate change and sea level rise

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Executive summary

The Asia-Pacific Network for Global Change Research (APN) funded a study assessing the vulnerability of Olango Island, in the Central Philippines, to predicted climate change and sea level rise. The study was coordinated by the Environmental Research Institute of the Supervising Scientist (***eriss***), in Australia, and Wetlands International–Oceania, with the major local collaborator being the Philippines Department of Environment and Natural Resources (DENR).

The study's major objectives were to raise awareness of the issue of climate change and sea level rise in the Asia-Pacific region, to provide advice and training to national and local agencies on procedures for Vulnerability Assessment, and specifically, to obtain a preliminary understanding of the potential impacts of climate change and sea level rise on the biological, physical and socio-economic attributes of Olango Island.

Olango Island was chosen as a study site for several reasons: It is a small, coral reef island (~6 × 3 km) with low topographical relief and a maximum elevation above sea level of only 9 m; it sustains a population of over 20 000 and is already under pressure from anthropogenic activities including fishing, groundwater extraction and mangrove harvesting; it is a major wetland site for shorebirds, being nominated for the East Asian–Australasian Shorebird Reserve Network and listed as a wetland of international importance by the Ramsar Wetland Convention. Due to its importance as a flyway stopover site, a 920 ha wildlife sanctuary was established in the south of the island.

The vulnerability assessment included the following steps:

- describing the physical, biological and socio-economic attributes of Olango Island;
- establishing a predicted climate change scenario based on existing literature;
- identifying existing natural and anthropogenic 'forcing factors' and their impacts;
- assessing vulnerability to existing forcing factors;
- assessing vulnerability to climate change and sea level rise;
- documenting current responses to coastal hazards;
- recommending future monitoring requirements and management strategies;
- identifying information gaps and research priorities.

Information was obtained from existing literature. In addition, the outcomes of a workshop with participants from local, regional, national and international government and non-government agencies were used in the assessment.

The major physical attributes of Olango Island include the low topographical relief, sandy shorelines and limestone outcroppings, the groundwater lens and the monsoonal climate. The major biological attributes include mangrove forests, seagrass beds, coral reefs, birdlife and other wetland fauna. The major socio-economic attributes include the large population in general, livelihood activities such as fishing and shell and seaweed collection, infrastructure and freshwater supply.

The predicted climate change scenario for Olango Island was based on predicted regional scenarios by the Intergovernmental Panel on Climate Change (IPCC) and the Philippine Atmospherical, Geophysical and Astronomical Services Administration (PAGASA) where possible. Where such information did not exist, estimates from IPCC global scenarios were used.

The predicted scenario for Olango Island is:

- A rise in mean sea level of 30 cm by 2030, and 95 cm by 2100;
- An increase in mean global sea surface temperature of 0.5°C by 2010 and 3°C by 2030;
- A 20% increase in typhoon intensity;
- A tendency for increased rainfall, intensity and frequency.

The major existing natural forcing factors on Olango Island are the south-west and north-east monsoons, typhoons, storm surge and El Niño. Some of these have positive impacts on the island, by way of recharging the underground water supply, while the major negative impacts include flooding, erosion and infrastructure damage. The major anthropogenic forcing factors involve the exploitation of natural resources, such as over-fishing and illegal fishing, over-extraction of groundwater, mangrove harvesting and coral extraction. These factors could result in erosion, saltwater intrusion, shortages of freshwater, habitat destruction and the loss of biodiversity.

Assessment of the vulnerability of Olango Island to existing forcing factors indicated that the island is already under enormous pressure, mostly from natural resource exploitation, although typhoons and associated storm surges also exert negative impacts. Many of the natural resources are already severely degraded, particularly the fisheries and the under ground supply of freshwater. The sustainability of these resources is in doubt, although recent management recommendations have provided the first step towards long-term sustainability.

Climate change and sea level rise will undoubtedly place additional stress on Olango Island and its attributes. Given its low elevation and topographical relief, more than 10% of the current land mass would be lost in the event of a 95 cm rise in sea level. In addition, more severe typhoons and storms surges would result in an even greater portion of the island being subjected to inundation and flooding. Given that the majority of human settlement on the island occurs in close proximity to the shoreline, this represents a major problem. An increase in sea level would also facilitate saltwater intrusion into the underground freshwater lens, although this could be offset by an increase in rainfall. Potential effects on the biological attributes include loss of mangrove stands due to an inability to recolonise inland, bleaching and death of corals due to increased sea surface temperature, and loss of feeding grounds and roosting habitat for resident and migratory shorebirds. Potential effects on socio-economic attributes include the displacement of people, loss of infrastructure and loss of livelihood options.

While the current issues facing Olango Island are immediate and serious, the vulnerability of the island to climate change and sea level rise is sufficiently great to require consideration in future management plans.

Current responses to the current and future hazards facing Olango Island include a number of resolutions and ordinances at the local (Barangay) level, such as the declaration of local fish sanctuaries and marine reserves, and prohibition of sand extraction and illegal fishing. Regional responses, such as the Mactan Integrated Master Plan address land use issues for Olango Island, while DENR has drafted management recommendations for the wildlife sanctuary, in which the issue of climate change and sea level rise is recognised. DENR also conducts a bird monitoring program in the wildlife sanctuary. The USAID-funded Coastal Resource Management Project (CRMP) has completed a Coastal Environmental Profile of Olango Island, which will assist in developing a coastal zone management plan. On a national scale there also exist a number of plans and policies relating to coastal zone management and mitigation/protection plans against coastal hazards.

Major parameters recommended for future monitoring are outlined. They include: geophysical parameters such as storm surge, shoreline erosion, mean sea level, groundwater salinity and water and air temperature; biological parameters such as bird populations, mangrove growth and distribution, seagrass cover, coral cover and reef fish biomass; socio-economic parameters such as tourism growth, population structure and infrastructure development. A number of future management strategies are also proposed, including the creation and maintenance of buffer zones, the provision of livelihood opportunities for the local people and developing awareness of techniques for natural resource management. Management measures to address potential impacts of climate change and sea level rise include reviewing the feasibility of physical barriers to protect against storm surge, prohibition of shoreline vegetation harvesting, regulation of groundwater extraction, protection of the groundwater catchment area, establishing fish sanctuaries, seeking alternative livelihoods, developing a formal education program and reassessing future coastal development plans.

A number of information and research gaps were also identified. There were major deficiencies in storm surge data, the quantification of coral and sand extraction, natural disaster damage estimates for lives, property, and natural resources, groundwater salinity and transmissibility data, the biology and ecology of endangered species, and the impacts of mangrove forestation on the seagrass beds. In addition, the lack of a detailed topographic map made it difficult to make precise estimates of the potential impacts of sea level rise on the island.

The vulnerability assessment highlighted the magnitude of the immediate threats facing the local comunities and natural resources of Olango Island. First and foremost among these threats are the increasing population and the associated depletion of the fisheries and underground freshwater supply. Even in the absence of climate change and sea level rise, sustainability of these resources will not be achievable if management plans do not address the problems. Olango Island possesses many characteristics that make it highly vulnerable to climate change and sea level rise; it is a small, low-lying coral reef island with a large, technologically poor population. Thus, climate change and sea level rise will only serve to place further stress on those natural resources that are already under threat. Subsequently, recently drafted local, regional and national management plans need to recognise and address the possible consequences of climate change and sea level rise.

1 General introduction

1.1 Background

The archipelagic nature of the Philippines with more than 32 400 km of coastline makes the country susceptible to climate change, be it global or localised in magnitude. Its coastal zone can change drastically, but often times gradually and imperceptibly. About three decades ago, very few people discussed the issues of global warming, El Niño phenomenon, seawater intrusion nor the idea of ozone depletion. In recent years, particularly in the 1990s, these issues have become bywords among Filipinos, children and adult alike, and more often than not are associated with terrifying events. Such events include the Mt Pinatubo eruption in 1991, the destructive fires in Indonesia in 1997 and Hurricane George in 1998 that devastated some parts of the United States. In addition, China had its worst flood in many years, coinciding with the onset of the La Niña phenomenon.

A key to effective sustainable management of the country's coastal zone is the understanding of the changes occurring within and around it. This is made even more urgent and imperative because millions of lives and economic investments depend on its stability and sustainability. Changes to the coastal resources, be they biological or otherwise, can be attributed to both human and natural causes, and climate change can exert a profound impact on them. These issues are well illustrated in the Philippines, such as the example of Olango Island, a small, coral reef island located in the Central Visayas, between Mactan Island and Bohol (figure 1).

The concept of climate change has prevaded the thinking of many people in the Philippines. This has been expressed by comments about temperature and rainfall extremes and variability. In such terms the general populace is aware of apparent changes in the climate, if not the actual extent and consequences of such change. This has been most noticeable with a general increase in awareness of the El Niño phenomenon and its influence on the weather.

1.2 Rationale for the selection of Olango Island

The benefits conferred by wetlands to humans, plants, and animals and to the environment are increasingly being recognized (Dugan 1990, Maltby et al 1994, Finlayson 1996). They not only provide food, wood, water and protection but also serve as habitat to many aquatic and terrestrial creatures including migratory birds.

In 1998, the Asia Pacific Network for Global Change Research funded a project entitled 'Vulnerability assessment of major wetlands in the Asia Pacific Region'. Sites were selected based on the importance derived by the community from the wetland and its conservation value. The selection of sites was also linked to areas of international importance for migratory shorebirds. Olango Island in the Philippines was selected for the vulnerability assessment for the following reasons:

- At the southern end of Olango is a wildlife sanctuary, the first Ramsar site in the Philippines, which serves as a habitat for thousands of birds, both migratory and resident. From the east coast southward and westward, stand natural and man-made mangrove forests, seagrass beds and fringes of coral reefs (CRMP 1998). Together with the birds, these features constitute a vital coastal resource that are likely to be vulnerable to climate change and sea level rise.
- The island has a low slope and maximum elevation of only 9 m. Thus, it is deemed vulnerable to sea level rise resulting from climate change, and impacts on its coastal

resources, livelihood, tourism and transportation should be a major concern. The island is considered susceptible to inundation, erosion and storm surges.

- The island is overpopulated and this puts extreme pressure on the limited coastal and terrestrial resources of the island (area of 1029 ha and a combined population of more than 22 000).

1.3 Objectives of the assessment

The aim of the vulnerability assessment for Olango Island is to consolidate and collate basic information on the resources and existing developmental structures, policies and other responses that might be affected by climate and other anthropogenic changes, and to formulate strategies to minimise the impact of such changes. To accomplish this, a number of specific objectives were set:

1. To assess the vulnerability to current forcing factors, climate change and sea level rise.
2. To determine the likely impacts of current forcing factors and climate change and sea level rise.
3. To recommend management strategies and responses to current forcing factors, climate change and sea level rise.
4. To recommend schemes to monitor climate change and sea level rise.
5. To increase the awareness of local and national decision planners and makers to the potential impact of climate change and sea level rise.
6. To encourage planners and leaders to incorporate the vulnerability assessment framework into local and national management processes for managing natural resources.

2 Introduction to vulnerability assessment

2.1 Definition

The Intergovernmental Panel on Climate Change defined and explains vulnerability as follows (Watson et al 1996):

> Vulnerability defines the extent to which climate change may damage or harm a system. It depends not only on a system's sensitivity but also its ability to adapt to new climatic conditions.
>
> Sensitivity is the degree to which a system will respond to a change in climatic conditions (eg the extent of change in ecosytem composition, structure, and functioning, including primary productivity, resulting from a given change in temperature or precipitation).
>
> Adaptability refers to the degree to which adjustments are possible in practices, processes, or structures of systems to projected or actual changes of climate. Adaptation can be spontaneous or planned, and can be carried out in response to or anticipation of changes in conditions.

In recent years, scientists, researchers, environmentalists, managers and leaders have formulated guidelines for sustainable utilisation and conservation of wetlands in the Philippines (eg Calumpong et al 1997, Magsalay et al 1989a,b, Davies et al 1990). This reflects the committment of the Philippine government to conserving the country's remaining coastal resources.

2.2 Historical background

In the early 1970s, there was growing concern in the global scientific community about the greenhouse effect and the resultant increase in atmospheric temperature. Thus, global warming was suspected to induce the melting of polar ice caps, thereby increasing sea level (Watson et al 1996). These changes coupled with the occurrence of El Niño phenomenon and other climatic disturbances encouraged the international community to convene the First World Climate Conference in 1979. It was during this conference that the World Meteorological Organization and the United Nations Environment Program conceived the World Climate Program. This research program ushered in the creation and the eventual ratification of the Montreal Protocol in 1988, which is aimed at reducing the levels of ozone and carbon dioxide in the earth's atmosphere. In the same year the Intergovernmental Panel on Climate Change (IPCC) was convened (Houghton et al 1990). At about the same time the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) sponsored the Greenhouse 1988 Conference, Planning for Climate Change (Pearman 1988).

The IPCC was given the task of assessing the scientific data related to climate change and its impacts on the environment, society and economy, and formulating strategies to manage the greenhouse effect. In 1990, a group of experts from the IPCC was created to develop and assess a common methodology or approach for coastal vulnerability assessment, which would be acceptable and applicable worldwide. The initial methodology was conceived at the first meeting (IPCC & Coastal Zone Management Subgroup 1991). Two years later a meeting was convened in Venezuela where case studies from participating countries were reported applying the vulnerability assessment framework (Houghton et al 1992). The report from this meeting was presented during the Earth Summit in 1992 in Rio de Janeiro, and was accepted as the basis for Agenda 21, Chapter 17 of the United Nations Conference on Environment and Development (UNCED) on matters concerning the oceans and coasts.

Agenda 21 requires countries to 'cope with and adapt to potential climate change and sea level rise including development of a globally accepted methodology for coastal vulnerability assessment, modelling and response strategies, particularly for priority areas such as small islands and low lying coastal areas' (Houghton et al 1990). The common methodology has been applied in many countries. Australia was one of those that first used and assessed the applicability of the methodology (Kay & Waterman 1993, Waterman 1996) in the Alligator Rivers Region, which incorporates Kakadu National Park, in the Northern Territory (Bayliss et al 1997).

In January 1991, Manila hosted a regional workshop on Climate Change and Vulnerability and Adaptation in Asia and the Pacific which was attended by experts from 20 countries and territories. Other workshops were also conducted in Africa, Europe and Latin America. In 1992, the Philippines Inter-Agency Committee on Climate Change (IACC) was created and was co-headed by the Department of Science and Technology and Department of Environment and Natural Resources. Its function was to address the various issues of climate change and to implement the Philippine Strategy for Sustainable Development. A national symposium on Climate Change was held in Manila in October 1998. The outcomes of the symposium included the identification of three major sectors as sensitive to climate change; water resources, agriculture and coastal resources (Perez 1998).

3 Approach of the assessment

3.1 Overview

The approach used in this report followed the common methodology of vulnerability assessment based upon that devloped by the IPCC-Coastal Zone Management Subgroup (1992) and modified by Waterman (1995) and Bayliss et al (1997). The approach focused on the existing environmental changes resulting from both human activity and prevailing climatic conditions. These were evaluated based on published scientific data on coastal attributes, climate model predictions, perceived forcing factors, relevant policies and regulations, management plans and mitigating measures applicable to Olango Island. The generalised assessment framework is outlined in figure 1.

The framework included several activities:

1. Identification of the study site.
2. Search of secondary information on climate change and sea level rise predictions on global, regional and localised scales.
3. Literature inventory and profiling of the biogeophysical and socio-economic and political attributes of the island.
4. Identification of perceived forcing factors and their impacts.
5. Assessment of the vulnerability of the various attributes to both current forcing factors and climate change and sea level rise.
6. Identification and formulation of response strategies and monitoring requirements.
7. Identification of information and research gaps.

3.2 Data sources

Published scientific papers, reports, unpublished manuscripts, workshop and symposium papers, management plans, master plans, maps, aerial photographs, and tide tables that were solicited from the following agencies, offices and universities were the main sources of information in this report:

- Department of Environment & Natural Resources, Region 7 and Cebu City (DENR-Region 7)
- Department of Agriculture (DA)
- Department of Public Works and Highways (DPWH)
- Philippine Tourism Authority (PTA)
- Philippine Coast Guard (PCG)
- Philippine Atmospherical, Geophysical and Astronomical Services Administration (PAGASA), Mactan and Manila
- Lapulapu City Government
- Local Government Units, Olango Island
- Cebu Provincial Government
- Mines and Geo-Sciences Bureau (MGB).

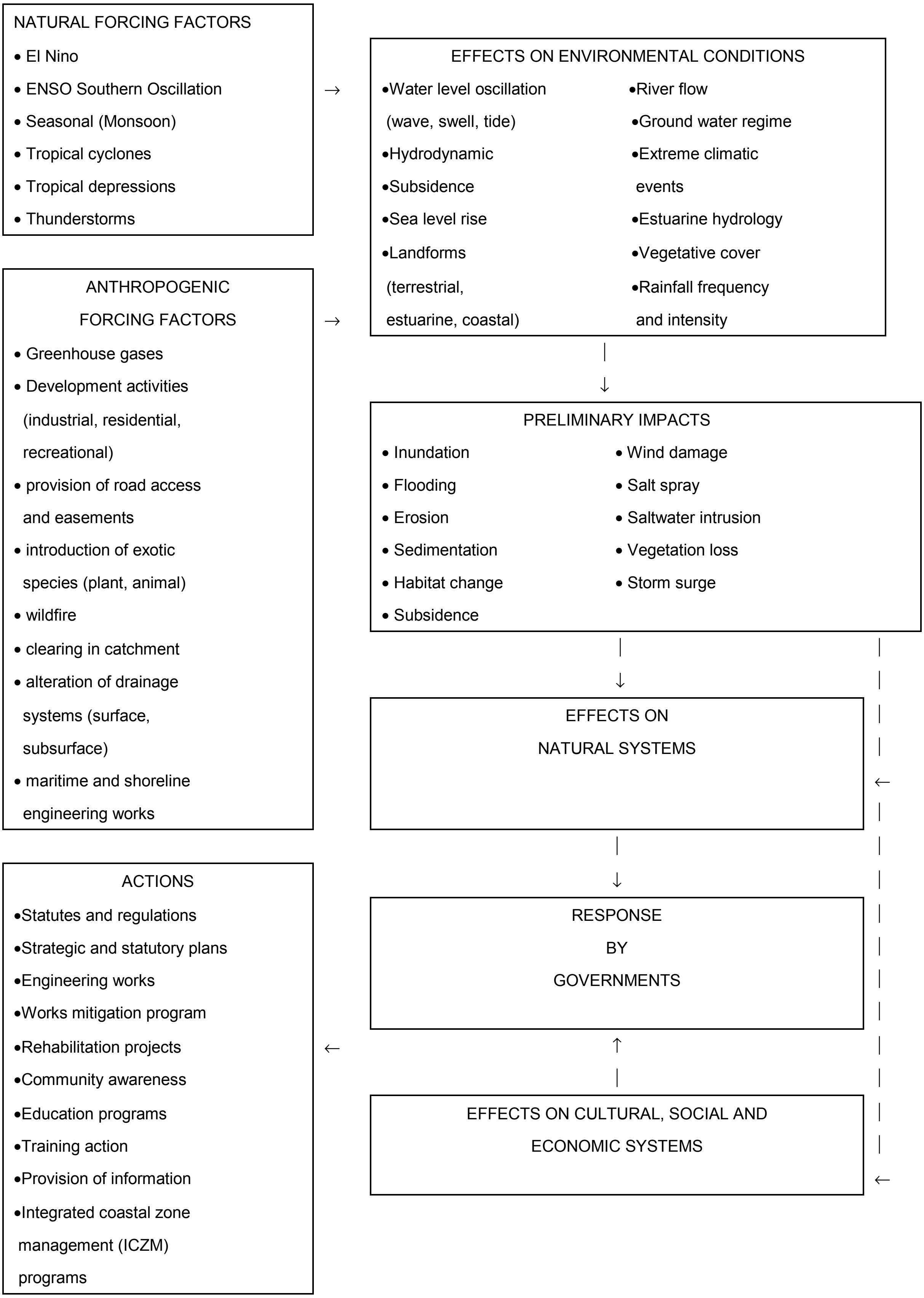

Figure 1 The framework used in the vulnerability assessment (after Bayliss et al 1997)

- Silliman University (SU)
- University of San Carlos – Marine Biology Section (USC-MBS)
- University of San Carlos – Water Resources Center (USC-WRC)
- Coastal Resource Management Project (CRMP)
- National Mapping and Resource Information Administration (NAMRIA)
- Save Nature Society (SNS)
- Ninoy Aquino International Airport (NAIA)
- Environmental Research Institute of the Supervising Scientist (***eriss***), Jabiru, Australia
- Wetlands International–Oceania (WI-Oceania), Canberra, Australia.

3.3 Activities

A workshop on the vulnerability of Olango Island to climate change and sea level rise was conducted on 8–9 December 1998 at Mactan Island to identify issues that were specific to the island, provide further, specific information towards the vulnerability assesment, and formulate management strategies to address the issues (Vulnerability assessment of major wetlands in the Asia-Pacific region 1999). The output of the workshop forms an integral component of this report.

A number of support activities relevant to the vulnerability assessment of Olango were undertaken, including:

- Monthly monitoring of birds of Olango Island.
- Validation of identified threats, disturbances and perceived anthropogenic forcing factors.
- Presentation of the vulnerability assessment to the Association of Barangay Councils, Lapulapu City.
- Identification and validation of additional islands/sites deemed vulnerable to climate change and sea level rise.
- Consultation with the Barangay (local council) communities on vulnerability and proposed measures and responses.
- Conference with the Marine Biology Section of the University of San Carlos on the vulnerability of the flora and fauna of Olango Island.

4 Climate change and sea level rise

4.1 Definition

Climate is an environmental condition where all physical and chemical attributes interact with each other producing a local environmental temperature, humidity and rainfall peculiar to a particular region or place. The IPCC (1994) defined climate as:

> the summation of all interacting atmospheric processes and weather conditions affecting a locality. The atmosphere is subject to natural variations on all time scales, ranging from minutes to millions of years. However vulnerability assessment is currently considered in the context of variation in climate that is expected to result, or has resulted from human interference with atmospheric processes.

Any decrease or increase in the magnitude of the climatic factors is deemed within the bounds of climatic change.

4.2 Concepts of climate change

A number of ideas and concepts have been proposed to explain the causes of climate change. One such concept is the greenhouse effect resulting from the accumulation of carbon dioxide, methane and other gases. Human activities for the past one hundred years or so have resulted in increased levels of many gases, primarily carbon dioxide, methane, chlorofluorocarbons and nitrous oxide. These are better known as 'greenhouse gases' and tend to warm the atmosphere in a process known as 'greenhouse effect'. In the Philippines, the most important effects of climate change are expected to be on sea-level rise, intensification of typhoons and the El Niño Southern Oscillation.

IPCC (1992) summarised the 'greenhouse gases' process as follows:

> The earth absorbs radiation from the sun. This is then redistributed by the atmosphere and ocean, and re-radiated to space. Some of the thermal radiation is absorbed by the greenhouse gases including water vapor and re-radiated in all directions. The result is the surface loses less heat and stays warmer. This phenomenon is known as the greenhouse effect. Any factor which alters the radiation received from the sun or lost to space and the redistribution of energy within the atmosphere and between the atmosphere, land and ocean will affect climate. Increased greenhouse gases will reduce the efficiency of the earth to cool and will tend to warm the lower atmosphere and surface. Any changes in the radiative balance of the earth, including those due to increase in greenhouse gases or aerosols will tend to alter atmospheric and oceanic temperature and the associated circulation and weather patterns.

Changes in the levels of greenhouse gases and aerosols are projected to cause regional and global changes in climate and its parameters, such as temperature, precipitation and sea level (IPCC 1992).

4.3 Predicted climate change scenario

4.3.1 Global and regional

To predict climate change is not as 'simple' as predicting the weather in a television news report, but rather its methodology utilises quantitative and qualitative data that are analysed to produce a scenario. Pittock (1993) describes a climate change scenario as 'a description of a possible future climate based on a number of assumptions including emission rates, model sensitivity and regional patterns of climate. Scenarios are used as reference to determine what will be the outcome if such events will take place. It is a picture of the future climate based on quantitative information.'

Modelling and predictions of potential climate change are being carried out in many developed countries based on an increasing number of scientific studies, which a group of experts from the IPCC have assessed in several reports since 1990. Some major predictions and conclusions of the IPCC (Houghton et al 1990, 1992; Watson et al 1996) related to global climate change are summarised below:

1. Greenhouse gas emissions will continue to increase during the next century and due to burning of fossil fuels, land use change and agriculture will lead to concentrations that are projected to result in changes to the climate.
2. Increases in greenhouse gases have resulted in warming of the surface of the earth.

3. Increase in global mean surface air temperature relative to 1990 of about 2°C by the year 2100.
4. Average sea level is expected to rise as a result of thermal expansion of the oceans and melting of the glaciers and ice-sheets.
5. Global prediction of sea level rise is between 8–30 cm by 2030 and 15–95 cm by 2100. Beyond 2100 the sea level will still rise.
6. Small island nations maybe forced to impose controls on the internal and international migration of human populations.
7. About 46 million people per year are at risk of flooding due to storm surge. A 50 cm sea level rise would increase it to 92 million; a 1.0 m sea level rise will raise it to about 118 million people.
8. Land losses prediction due to sea level rise are 6% for the Netherlands, 17% for Bangladesh and 80% for Majuro Atoll in the Marshall Islands.
9. The coastal area of Japan will be threatened with 50% industrial production being lost if sea level rises by 1.0 m. Ninety percent (90%) of the beaches in Japan will disappear.
10. Changes in precipitation and its frequency and intensity will affect the magnitude of runoffs, floods and droughts.
11. It is predicted that extreme events will change in magnitude and frequency more rapidly than the average (more hot days, more floods and dry spell).
12. El Niño and La Niña will continue to occur, resulting in droughts and floods.

Further predictions and conclusions related to regional, or local climate change in the Philippines (Perez 1998) include:

1. The temperature in Lake Lanao watershed in Mindanao will increase by 2–4°C (table 1).
2. A 3.1°C increase in temperature in Angat Dam in Northern Luzon (table 1).
3. A 1.0 m sea level rise by 2100 will inundate coastal areas in Manila Bay.
4. A 0.3 and 1.0 m rise in sea level will inundate about 2000 and 5000 ha of land in Manila, respectively.
5. Highly populated areas in Manila will experience severe storm surges.

Table 1 Changes in annual rainfall and temperature of Angat Dam and Lake Lanao in the Philippines, based on three global circulation models (Perez 1998)

Site	GCM*	Rainfall Ratio	Change in Temperature (°C)
Angat Dam	CCM	0.94	2.0
	UKMO	1.03	3.1
	GFDL	1.15	2.4
Lake Danao	CCM	0.95	2.0
	UKMO	1.15	2.6
	GFDL	1.25	2.3

* Global circulation models – UKMO: United Kingdom Meteorological Office; GFDL: Geophysical Fluid Diagnosis Laboratory; CCM: Canadian Climate Center Model.

4.3.2 Predicted climate change for Olango Island

The predicted climate change scenario for the Cebu region of the Philippines in the next century is based on the following predictions:

- A rise in sea level of 8–30 cm by 2030, and 15–95 cm by 2100 (Houghton et al 1990).
- An increase in mean global surface temperature of 0.1–0.5°C by 2010 and 0.4–3.0°C by 2030 (Whetton et al 1994; table 2)
- An increase in typhoon intensity by up to 20% that is linked to sea surface temperature, and increase in storm surges (Henderson-Sellars & Zhang 1997).
- A tendency for increased rainfall, intensity and frequency (Whetton et al 1994; table 3).

Table 2 Temperature (°C) change scenario for 2010 and 2070 (Whetton et al 1994)

	Year	
Region	**2010**	**2070**
Indonesia, Philippines, Coastal South and Southeast Asia	0.1–0.5	0.4–3.0
Inland South and Southeast Asia (not South Asia in June/July/August)	0.3–0.7	1.1–4.5
Inland South Asia in June – July – August	0.1–0.3	0.4–2.0

It is predicted that in areas that are affected by the south-west monsoon, particularly in the western part of the Philippines, the intensity of rainfall will not increase significantly up to 2010, but by 2070, there will be a tendency towards an increase in rainfall (table 3). In the eastern parts, however, which are greatly affected by the north-east monsoon, there will be no significant increase in rainfall up to 2010 but there will be an increase in rainfall intensity during both the dry and wet seasons by 2070 (Watson et al 1996; table 3).

Table 3 Rainfall scenario for 2010 and 2070, expressed as % change (Whetton et al 1994)

	Year			
	2010		**2070**	
Region	Wet season	Dry season	Wet season	Dry season
South-west Monsoon Region :	0	0	0 to 10	-10 to +10
India, Pakistan, Bangladesh, Philippines (western part) and Vietnam (except east coast)				
North-east Monsoon Region: Indonesia, Philippines, Vietnam, Sri Lanka, Malaysia	0 to -5	0	-5 to +15	0 to +10

The Philippines Atmospheric and Geographical and Astronomical Services Administration (PAGASA) has reported that the surface temperature in the Philippines has increased, while sea level has also risen by 2 cm from 1963 to 1993 based on tidal gauge readings in Manila Bay (PAGASA 1998).

Bengtsson et al (1995) suggested that there will be a decrease in the number of typhoons in the southern hemisphere but the distribution in the region will remain the same. Holland (1997) suggested there is a possibility that the intensity of typhoons may increase, particularly in areas where the sea-surface temperature can reach between 20–29°C. Henderson-Sellers and Zhang (1997) suggested that the maximum potential intensities of cyclones will remain the same or undergo an increase of up to 10–20%. Warwick et al (1993) claimed that even if intensity and frequency did not change, damage caused by such storms would be likely to increase simply due to the effects of sea level rise.

The Environmental Center of the Philippines Foundation (1998) reported that:

> temperature in East Asian seas are expected to increase by 1°C. The resulting enhanced evaporation and increased precipitation or rain will affect water salinity. The rain will wash more nutrients out to sea, which can be either good or bad for seagrasses and coral communities depending on the actual load. Increased erosion will alter nearshore areas and adversely affect the breeding and nursery function of the ecosystem. A rise in the sea level within the predicted range of 20 cm by the year 2025 is likely to be insignificant compared with human-induced influences on the coastal environment. Nevertheless, it will most likely harm the seagrasses and coral communities, which will be battered by more frequent and severe storms and wave surge. They will also suffer due to greater shoreline erosion, changes in dynamic coastal physical properties, and damage to shoreline protective structures and facilities.

4.4 Predicted impacts of climate change

Watson et al (1996) report that:

> sea level rise is the most obvious climate related impact in coastal areas. Densely settled and intensely used low lying coastal plains, islands and deltas are especially vulnerable to coastal erosion and land loss, inundation and sea flooding, upstream movement of the saline/freshwater front, and seawater intrusion into freshwater lens. Especially at risk are the large deltaic regions of Bangladesh, Myanmar, Vietnam and Thailand, and the low-lying areas of Indonesia, the Philippines and Malaysia. Socio-economic impacts could be felt in major cities, ports and tourist resorts; artificial and commercial fisheries; coastal agriculture and infrastructure development. International studies have projected the displacement of several million people from the regions' coastal zone in the event of 1 m rise in sea level.

Following are some conclusions drawn from the assessment made by the IPCC (Houghton et al 1992) on the information available for the Asian region, including the Philippines and Olango Island:

> Projected increase in evapotranspiration and rainfall variability will have a negative impact on the viability of freshwater wetlands resulting in shrinkage and desiccation. Sea level rise and increases in sea surface temperature are the most probable major climate change related stress on coastal ecosystem. Coral reefs maybe able to keep up with the rate of sea level rise but will suffer bleaching from higher temperatures. Landward migration of mangroves and tidal wetlands is expected to be constrained by human infrastructure and activities. Increased population and increased demand will put additional stress on water resource. Agricultural areas are vulnerable to episodic extreme events, floods, droughts, cyclones and El Niño phenomenon. Low-income rural populations that depend on traditional agricultural systems or marginal lands are vulnerable. Coastal lands are vulnerable. Sea level rise is the most obvious climate related impact. Densely settled and intensely low lying coastal plains, islands and deltas are vulnerable to coastal erosion and land loss, inundation, sea flooding and salt water intrusion. Socio-economic impacts could be felt in tourism resorts, commercial fishing, artisanal fishing, coastal agriculture and infrastructure. It is projected that several millions of people will be displaced assuming a 1.0 metre rise in sea level and the cost of response could be immense.

The various impacts of climate change and sea level rise on coastal areas and small islands including Olango may take the form of ecological changes, socio-economic damage and physical disturbances. Watson et al (1996) listed five impacts on various coastal resources that can be attributed to climate change and sea level rise (table 4).

Table 4 Climate related events that impact upon attributes of coastal zones and small islands (Watson et al 1996)

Attributes	Climate Related Events				
	Coastal Erosion	Flooding Inundation	Siltation Intrusion	Sedimentation Changes	Storminess
Human settlement	Yes	Yes			Yes
Agriculture		Yes	Yes		Yes
Freshwater Supply		Yes	Yes		
Fisheries	Yes	Yes	Yes	Yes	Yes
Financial Services	Yes	Yes			Yes
Human Health					Yes

In a report entitled *Local Action Plan on Climate Change for the Coastal Resource Sector*, Perez (1998) detailed ten impacts predicted to occur as a result of climate change (table 5).

Table 5 Predicted impacts of climate change on the various attributes of coastal zone (Perez 1998)

Attribute	Predicted impacts
Ecological	Redistribution of wetlands.
	Damage to coral reefs.
	Reductions in biological diversity.
	Wildlife extinction.
Socio-Economic	Loss of natural and man-made structures.
	Dislocation of population.
	Change of livelihood.
Physical and Chemical	Shoreline erosion.
	Saltwater intrusion.
	Change in salinity.

Some of the major points are outlined below:

- There would be an increase in erosion of beaches and cliffs due to the direct removal of materials by wave action.
- Direct inundation of low-lying islands can occur as they are submerged beneath the rising waters. This includes coastal wetlands that are vulnerable to rapid rates of sea level rise.
- High sea levels can cause saltwater intrusion into surface and groundwater affecting the amount and quality of potable water supply.
- Mangrove growth and other habitats of benthic organisms will be affected by changes in salinity.
- Sea level rise will increase the risk of flooding and storm damage. Vulnerability becomes higher with increase in storm surges and typhoon frequency and intensity.
- Wetlands and tidal flats may disappear where supply of sediments become inadequate, or where there is limited space for them to move inland changes in erosion and sedimentation characteristics will affect geographic features. The roles of wetlands and tidal flats as habitats will be diminished. Coral growth will be significantly affected by increased sedimentation, turbidity and water temperature.

5 Description of Olango Island

5.1 Geophysical attributes

5.1.1 Topography

Olango Island lies between latitudes 10°13’ and 10°16’ North, and between longitudes 124°02’ and 124°04’ East. It is located in the centre of the political jurisdiction of Region 7, Central Philippines. Around it are the bigger islands of Leyte in the east, Bohol in the south, and Mactan and Cebu in the west (figure 2). Associated with Olango are the islets of Caubian in the north-east; Camungi, Pangan-an, Caohagan and Nalusuan in the southeast; and Sulpa and Hilutungan in the south-west. The island is bordered by four bodies of water: the Camotes Sea in the north; Cebu Strait in the south; Olango Channel in the east; and Hilutungan Channel in the west (figs 3 & 6).

Olango is a low lying limestone island with an area of about 1030 ha. It is approximately 4 km east of Mactan Island and 15 km east of Cebu City. It is 3 km across at its widest part and about 6 km long. It has a tidal range of about 1.0 m and a low topographic relief with a maximum elevation of not more than 9.0 metres at its highest point, close to the centre of the island. The northern part of Olango is slightly elevated and has a rocky shoreline (plate 1). Other parts have a very gentle slope with a sandy coastline and small areas of flat and outcropping limestone. This slope allows a quick flow of tidal seawater exposing vast tidal flats during low tide and submerging the same during high tide (plate 2).

In the mid-western section of the island, adjacent to Santa Rosa, are two limestone depressions or bays very close to the shoreline (fig 3). The bay substrate is composed of sandy limestone and clay with open holes (figure 5).

5.1.2 Geology

Olango is a raised coral reef on top of another larger coral reef. It is composed of Plio-Pleistocene Carcar Formation and Quaternary Alluvium (DENR 1995). The Carcar Formation is composed mainly of shells, algae and other carbonate materials containing macro and microfossils. The Alluvium is found mostly in the coastal areas and made of calcareous sand from the weathering of limestone with fine to coarse grain sand and shell fragment (figure 4).

The south-eastern coast has a sandy substrate while the south-western isthmus has sharp limestone outcroppings. Both have a sandy shoreline.

On the southern part of Olango is a wildlife sanctuary with an area of about 920 ha. It is situated in a bay bordered by Barangay Sabang in the east; by Sitio Aguho in the north; and by the sitios of Basdaku and Bascoral in the west. The southern part of Olango Island, and the majority of the sanctuary, is composed of vast sandflat, flat limestone, seagrass bed and mangrove plantation (figures 4, 5 & 6).

5.1.3 Hydrology

There are no freshwater streams or rivers on Olango, but in the south of the island there are shallow channels through which seawater flows with the tides. Precipitation either evaporates or seeps into the sand to form a shallow freshwater lens.

The groundwater of Olango moves along the interconnected holes and systems of porous coralline limestone rock base in its substrate (Ligterink 1988). The groundwater recharges from June to December during the wet season. Close to the centre of the southern part of the island, water recharge is slow because of the poor permeability of the substrate to rainwater. In the southern part, near the sanctuary, the water lens extends far to the south because at low tide the sea level recedes farther. But between Aguho and Sabang, the groundwater level is much lower because of the sandy substrate in the area.

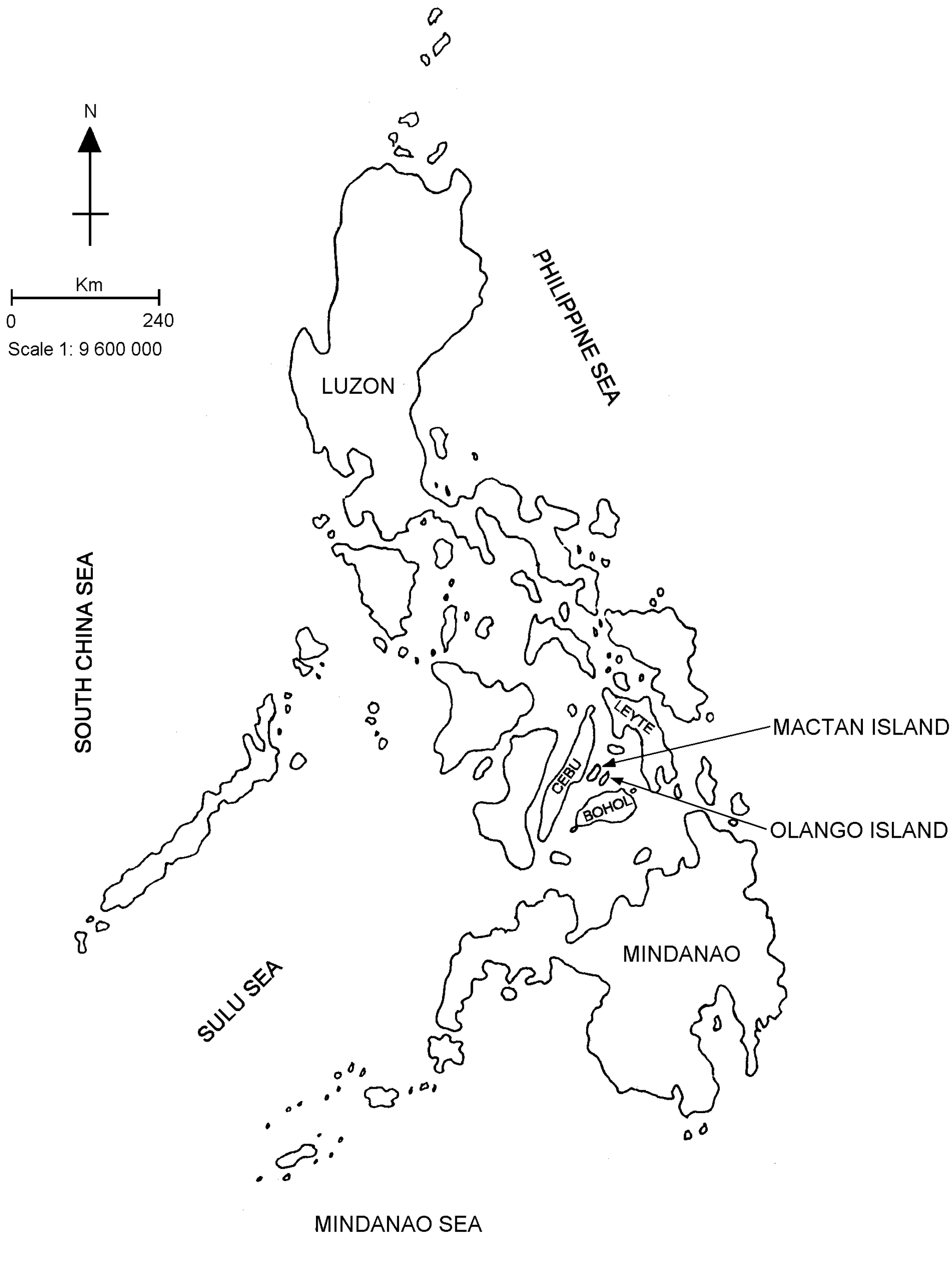

Figure 2 Map of the Philippines showing the location of Olango Island

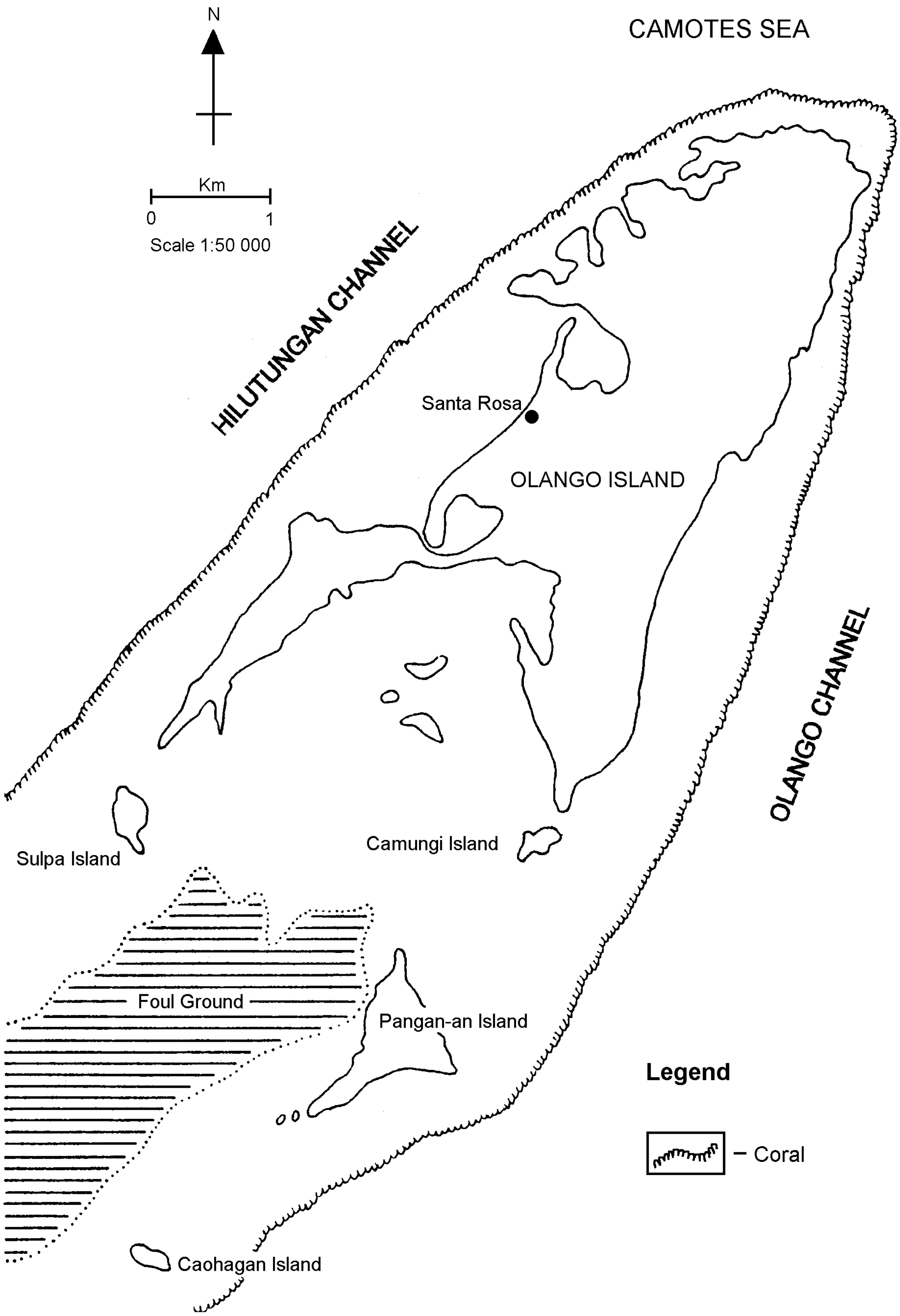

Figure 3 Map of Olango Island showing the major geographical features

Plate 1 Aerial photograph of Olango Island, looking southward, with the northern, rocky coastline in the foreground

Plate 2 Aerial photograph of the southern, sandy coastline of Olango Island, looking eastward. The Wildlife Sanctuary lies approximately within the delineated area. The jetty at Santa Rosa can be seen on the near (western) side of the island.

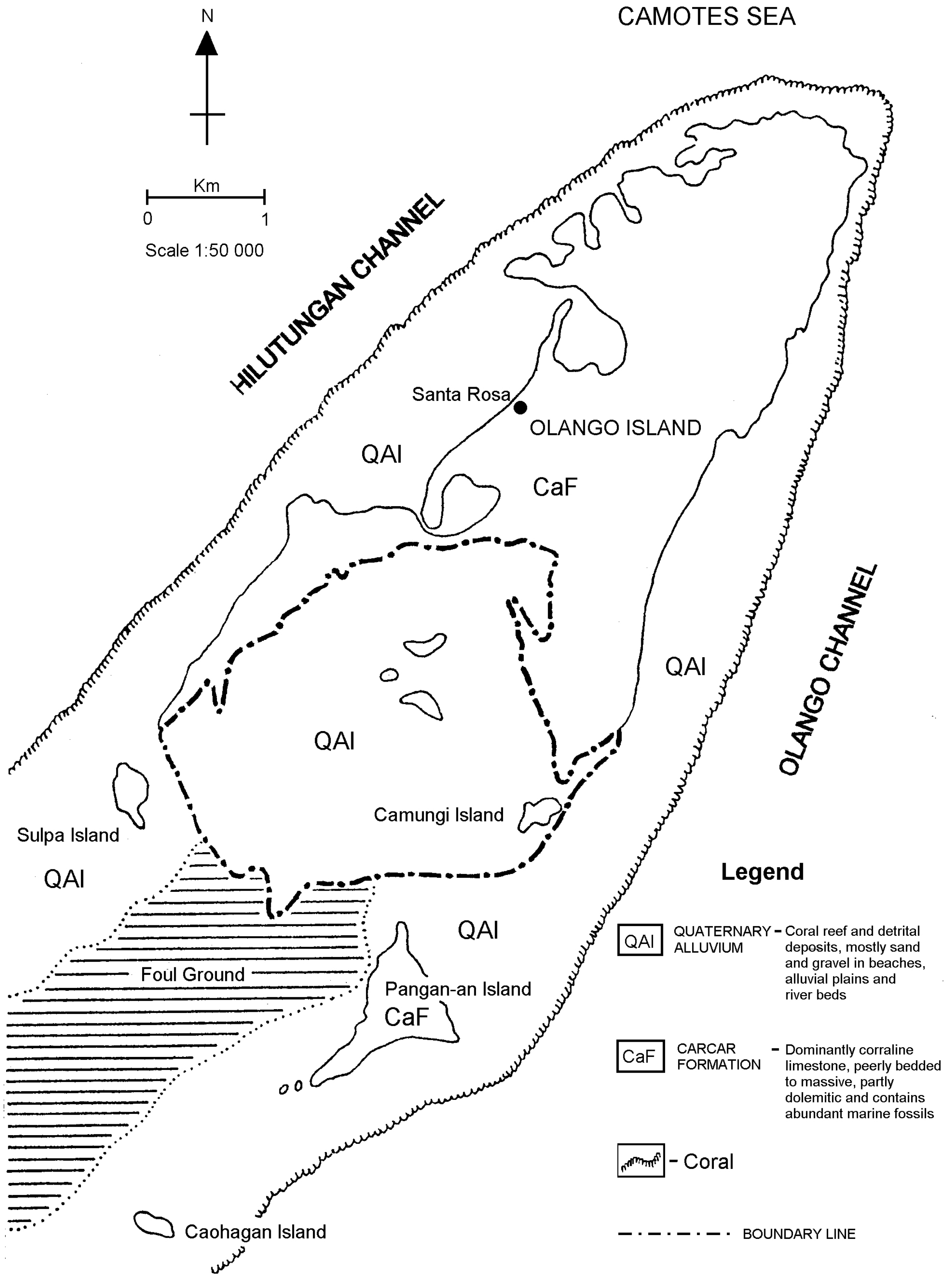

Figure 4 Geological map of Olango Island (Lapulapu City 1996)

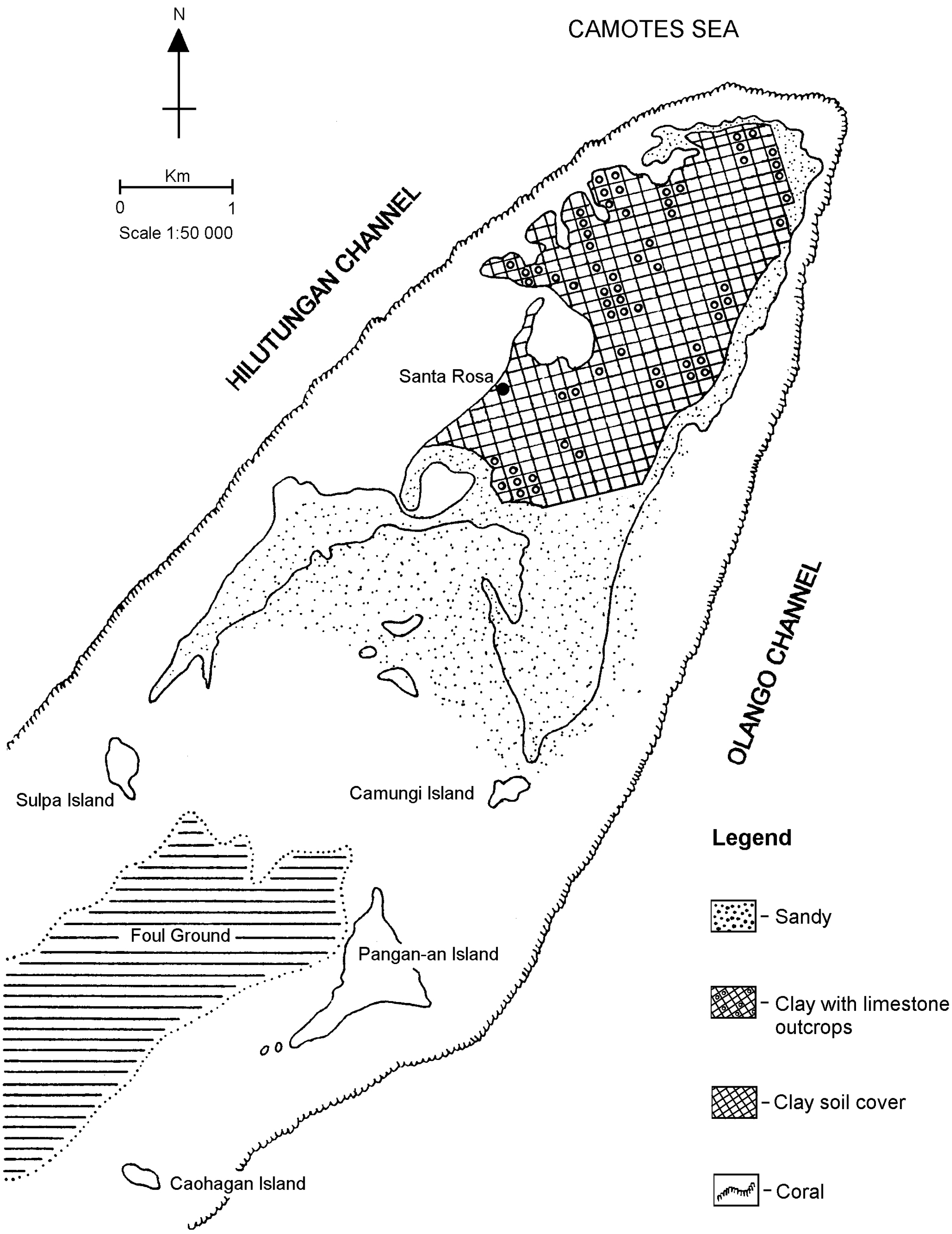

Figure 5 Soil map of Olango Island

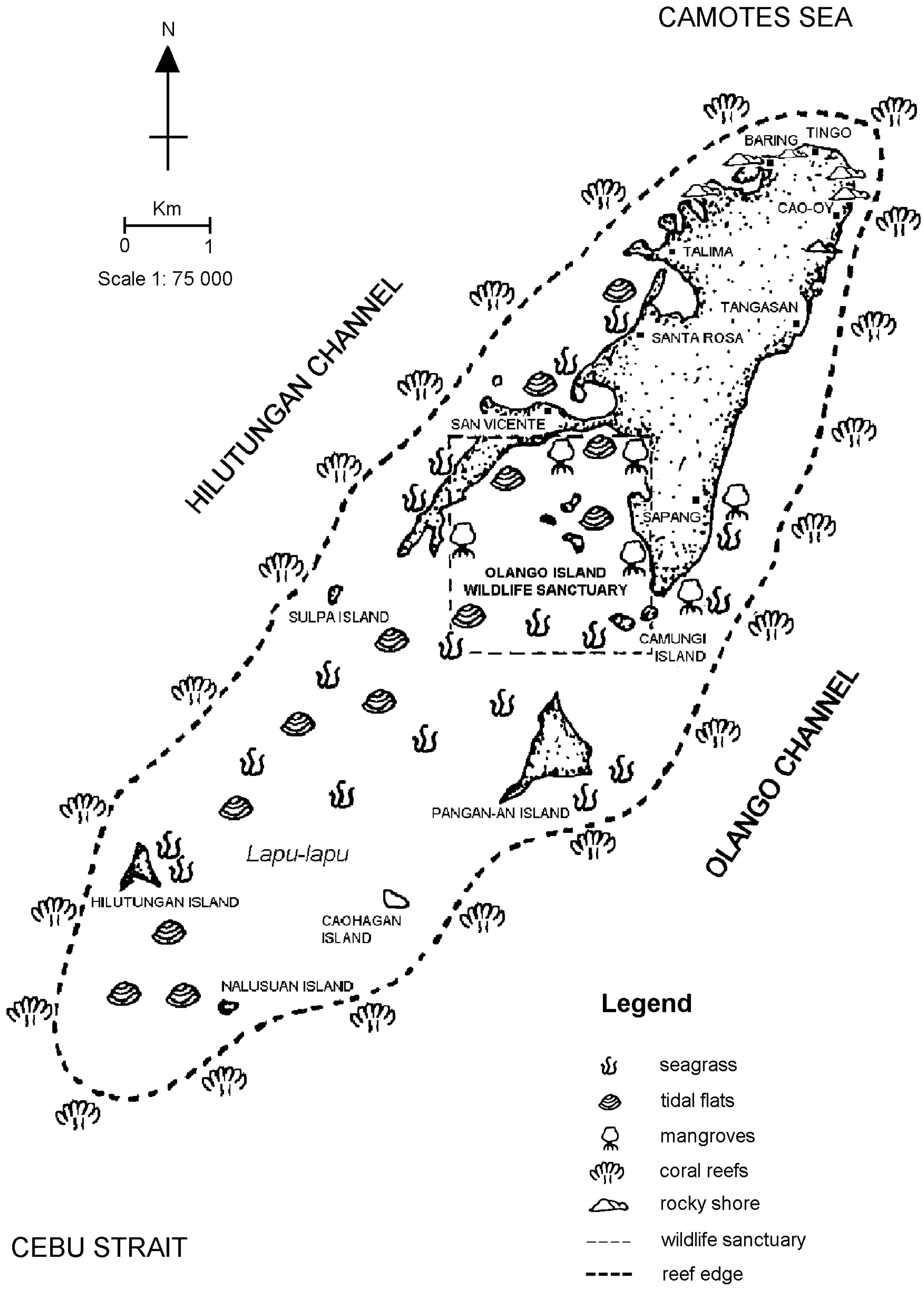

Figure 6 Map of Olango Island showing the distribution of various habitats (from Paras et al 1998)

In some areas, the groundwater extracted is brackish because of seawater intrusion particularly in the vicinity of the two bays. Freshwater wells are concentrated in the centre of the island although there are some that produce brackish water if there is over-extraction of freshwater. Measurements of water depths in the wells correlated with tidal gauge measurements show that freshwater is mixed with seawater during high tide from the force of the sea current and storm and when the wells are dug too deep.

5.1.4 Water current and tidal regime

The tidal regime around Olango is considered moderate with current measurements ranging from 0.19–0.36 m/s during peak flood tides and 0.09–0.23 m/s during ebb tide (Perez 1998). The water current along Olango Channel is non-reversing and flows in a south to south-eastly direction. In the Hilutungan Channel the water current is reversing, the direction being northerly during the flood tide and south-west during ebb tide.

The tidal range of Olango is about 1 m and as a result of its low topography, the island increases in area during low tide. Inundation is dependent on tidal fluctuation. During low tide only the shallow channels in the south of the island retain water.

From the dry months of February to May, spring tides occur during the day and neap tides at night. The reverse is true during the wet season from June to January. Highest tides occur in the early morning or late evening, fluctuating in the middle of the day, late afternoon or early evening.

From 1950–1969 and 1970–1989, the mean sea level in Cebu was measured at 1.728 m and 1.744 m, respectively, which are extremely high compared with the 23 October 1987 mean sea level of 0.714 m, 0.754 m and 0.770 m (tables 6 & 7). The latter measurements are lower as they only represent one measurement time.

Table 6 Mean sea level (m) for five stations in the Philippines (Perez 1998)

Station	Mean sea level (m)		40 year change
	1950–1969	1970–1989	
Manilla	2.228	2.541	+0.313
Legazpi	1.591	1.675	+0.084
Davao	1.887	2.020	+0.137
Cebu	1.728	1.744	+0.016
Jolo	1.993	1.988	-0.005

Table 7 Tidal ranges (m) observed at Olango Island on 23 October 1987 (Ligterink 1988)

Mean low tide	Mean high tide	Mean sea level
-1.437	0.10	0.714
-1.400	0.0109	0.754
-1.441	0.099	0.770

Table 8 presents the decadal trend in mean sea level rise in Cebu and four other stations in the Philippines (Perez 1998). There appears to be an increasing trend in the mean sea level rise from 1950 (-0.080 m) to 1989 (+0.069 m).

Table 8 Decadal trends in mean sea level rise (m) for five stations in the Philippines (Perez 1998)

Station	1950–1959	1960–1969	1970–1979	1980–1989
Manilla	-0.070	+0.083	+0.183	+0.142
Legazpi	+0.044	-0.071	+0.074	+0.165
Davao	-0.099	-0.024	+0.069	+0.165
Cebu	-0.080	0.078	+0.027	+0.069
Jolo	-0.090	-0.065	-0.020	+0.009

5.1.5 Soil

Olango has a very thin layer of topsoil. The soil is described as the Bolinao Clay type with a reddish colour underlain by Carcar limestone that can either be porous or cavernous. The intertidal substrate is a mixture of coralline limestone, soft, sandy mud and sand. On parts of Olango the limestone is exposed. Surface soil is created from weathering of limestone. Sediment in the channels near the western border of the sanctuary consist of coarse coralline sand and soft decaying vegetation matter of algae, seagrass and mangroves (SUML 1997, figure 5).

5.1.6 Climate and weather

Climate is the result of the interaction of precipitation, temperature, humidity, wind, sunlight and cloudiness over a certain period of time. The Philippines being located slightly north of the equator has a tropical climate, rain and temperature are the most important factors determining the weather.

Based on climatic charts for the Philippines, Olango has a Type III climate characterised by not having a pronounced wet season, but having a short dry season (Davies et al 1990). It is open to both south-west and north-east monsoons.

Olango has a tropical climate, hot and humid with mean daily temperatures ranging from 26°C, humidity ranging from 60–94% and daily rainfall ranging from 0 to 99 mm with an average daily rainfall of 4–5 mm. It is dry from February to May and wet in June until January with the heaviest rainfall in November and December.

Typhoons are climatic disturbances consisting of an eye of warm air that is surrounded by huge air masses that circulate counter-clockwise at low levels, and clockwise at the upper levels. The wind velocity increases towards the centre of the eye of the typhoon. Typhoons hit the country between June to December and form more often in the Pacific Ocean east of Bicol, Samar, Leyte and Surigao. At times, typhoons originate in the Pacific Ocean east of northern Luzon. Cyclonic storm and typhoons constitute the general climatic feature of the Philippines and approximately 19 typhoons pass by the country every year (PAGASA 1998). The strongest typhoons were super-typhoon Ruping in November 1990 and super-typhoon Besing in April 1994 (table 9).

The north-east and the south-west monsoons are the major wind systems that greatly determine the general climatic condition of the country. The south-west monsoon is formed by a low-pressure area over the northern part of Indo-china, while the high-pressure area over Celebes, Australia and New Guinea then blows to the country during the months of June to December. A high-pressure area forms the north-east monsoon over mainland Asia including Siberia and China, and blows to the country during January until March. During April and May, south-easterly and easterly winds prevail.

Table 9 Strongest typhoons to hit Cebu Province (1951–1995) (from PAGASA 1998)

Name of typhoon	Passage date	Maximum wind recorded (kph)	Typhoon diameter	Highest one day rainfall (mm)
Amy	Dec. 10, 1951	240	Unknown	195.3
Netang	Sept. 2, 1984	176	100	42.2
Undang	Nov. 5, 1984	90	200	70.6
Ruping	Nov. 13, 1990	205	250	276.1
Puring	Dec. 20, 1994	120	250	105.0
Besing	April 14, 1994	120	300	174.0
Goding	Dec. 21, 1994	60	100	16.0
Pepang	Oct. 28, 1995	90	100	166.1

The average annual precipitation for Olango is 1140 mm while the average annual evapotranspiration is 1100 mm (PAGASA 1998). For a period of 25 years from 1973–1997, the highest total annual rainfall recorded in Lapulapu City was 1860 mm in 1994. The driest year was 1987 with only a total annual rainfall of 859 mm, with March, April and May as the driest months with a total monthly rainfall of approximatelt 3 mm each. In 1997, the lowest total monthly rainfall of 30 mm was recorded in January, and the highest monthly rainfall was in July with 340 mm. The wet season is supposed to start during this month but did not; instead the monthly rainfall started to decrease and by December only 31 mm of precipitation was measured. This was actually the period when the El Niño phenomenon was influencing the country's climate. In 1998 the lowest total monthly rainfall of 1 mm was recorded in April, after which the rainfall increased to 443 mm in August, around the time when La Niña began to influence the Philippines (see section 5.1.7).

January appears to be the coldest month, with the hottest being May (PAGASA 1998). Night-time temperatures range between 18–20°C, and day-time temperatures between 28–32°C. Maximum temperature during the day may reach up to 38°C (Davies et al 1990). The lowest temperature recorded was 19°C in February 1976, and the highest temperature recorded was 36°C in May 1979.

5.1.7 El Niño–Southern Oscillation (ENSO)

This phenomenon has recently been the attention of many scientists worldwide because it has greatly affected the climate on a global scale (Perez 1998). El Niño was first detected as a large mass of water originating in South America which spread towards Asia, exhibiting changes in atmospheric pressure between the South Pacific and Indian Oceans. When there is low pressure in the South Pacific Ocean, there is high pressure in the Indian Ocean (Southern Oscillation). The El Niño is the warming of the ocean and the atmospheric disturbance is the Southern Oscillation or the ENSO. This phenomenon occurs every two to seven years and was observed to be intense until the increase of global warming.

The start of ENSO is signalled by the early onset of a prolonged dry season, very low precipitation, and weak monsoon rains.

5.2 Biological attributes

Olango is richly endowed with diverse natural ecosystems, which serve as habitats for various kinds of plants and animals (Paras et al 1998). Surrounding the island are mangrove forests, vast seagrass beds, tidal flats and coral reefs (figure 6).

5.2.1 Mangrove forest

The principal vegetation in the landward portion of the intertidal area around Olango is mangrove forest, with a total area of about 367 ha. A large area is found in the northern half of the sanctuary and some smaller patches are growing in the eastern and western shoreline. A mangrove plantation has been established on a seagrass bed on the southern border of the sanctuary.

A total of 33 mangrove species and associates have been identified in Olango (appendix 1). Barangay Tungasan has the highest percent mangrove cover of 84%, followed by Sabang with 72% (table 10).

Table 10 Percentage mangrove cover in some Barangays of Olango Island (CRMP 1998)

Area	Mangrove cover (%)
Santa Rosa	14
Talima	16
Tungasan	84
Sabang	72
San Vicente	36

In a 1989 study, the mangrove stand in the sanctuary had a maximum height of only 5.0 m and a minimum height of 0.6 m (Magsalay et al 1989a). *Avicennia lanata* attained a height of 3.0 m, while *A. officinalis*, *A. marina*, and *Xylocarpus moluccensis* reached a height of 2.0 m. *Lumintzera racemosa* and *Osbornia octodonta* attained a height of only 0.6 m. *Thespesia populnea* and *Terminalia catappa* attained a height of 5.0 m. The most dominant mangrove species are *Rhizophora* and *Osbornia* spp and both are found in the sanctuary (Magsalay et al 1989a). The stunted growth of most of the mangrove plants in the sanctuary is due mainly to the unsuitable sandy coralline substrate and overcutting for wood and forage by the local people. Under optimal conditions, *Rhizophora* species usually grow taller than 1.5 m.

The mangrove plantations outside the sanctuary respond very well to the planting spacing distance of less than 0.5 m. The trees are then subjected to thinning and rotational cutting to allow the trees to grow in diameter.

5.2.2 Seagrass beds

There are vast areas of seagrass beds around the island, but not in the northern part where the area for seagrass colonisation is limited (DENR 1995). In the southern part, just south of the vast sandy coralline flat of the sanctuary is a vast expanse of seagrass bed. It is in this area where a mangrove plantation was established in mid 1993.

A total of eight species of seagrasses and another 72 species of macrobenthic algae including Sargassum have been identified (appendix 2). *Cymodocea* and *Thalassia* are the most abundant seagrasses. The seagrass beds have been classified as altered and disturbed due to gleaning and shell collection with push nets.

5.2.3 Terrestrial vegetation

The terrestrial vegetation of the island includes patches of coconut palms, which are located relatively close to the shore, grasses and shrubs, which cover most of the island, and patches of trees in most of the Barangays except Baring, Tingo, Santa Rosa and Sabang (Ligterink 1988) (figure 7). A total of 16 species of terrestrial plants are cultivated and used as fuelwood in the island (appendix 3).

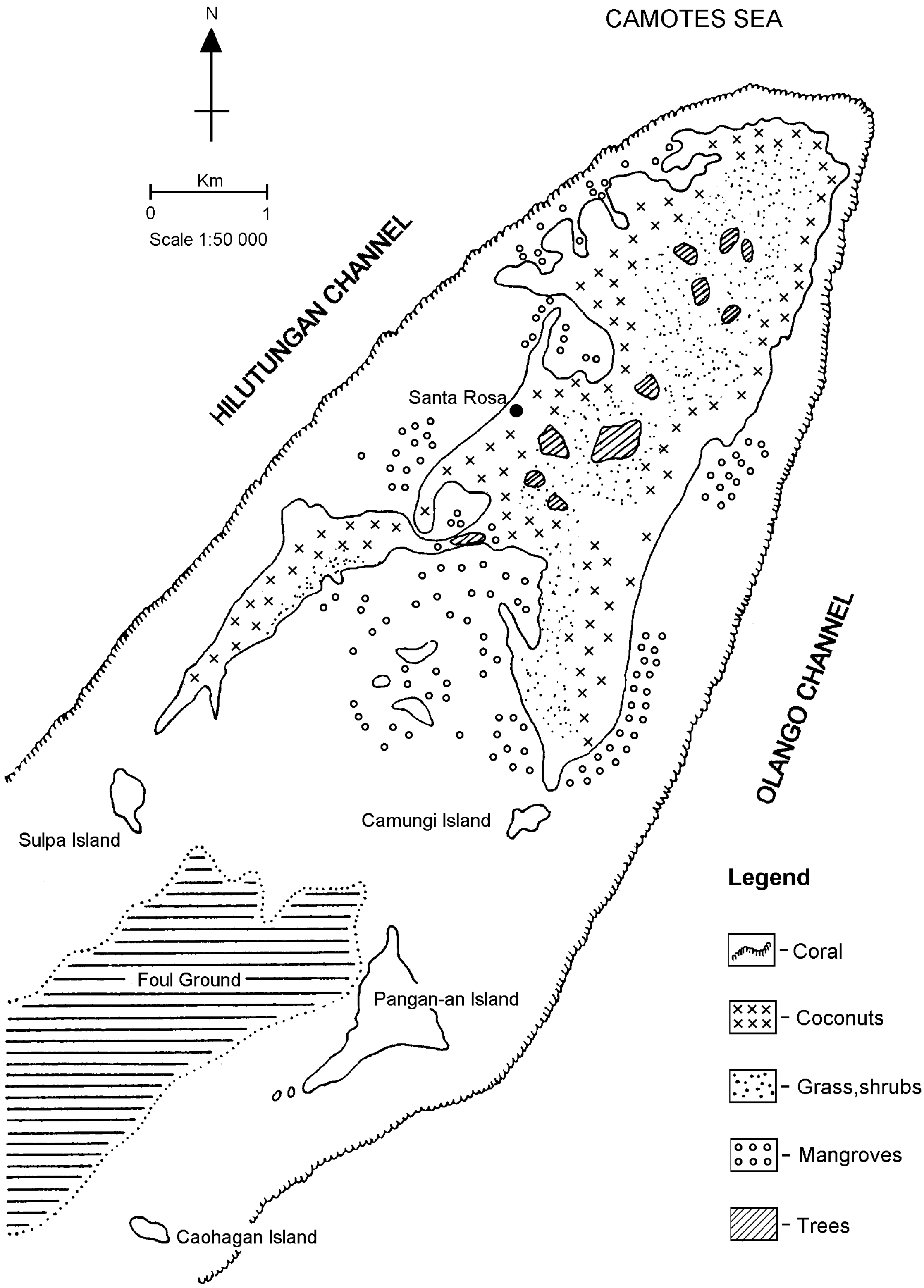

Figure 7 Vegetation map of Olango Island (Ligterink 1988)

5.2.4 Coral reefs

Coral reefs abound around Olango but not in the southern part where the sanctuary is located (CRMP 1998). The total reef area is estimated at 41.5 ha with a live coral cover of about 24%, which is considered a poor coral cover. A total of 117 coral species have been identified representing the reef building, non-reef building and soft corals (appendix 4). The seaward edges of the reefs in the deeper waters have a higher coral cover than the landward edges in the shallower waters. The reef cover in Olango was once considered fair, however, activities such as harvesting, and cyanide and dynamite fishing have led to the degradation of reef cover (SUML 1997). Barangay Sabang has the lowest coral cover of 9% while Santa Rosa has the highest live coral cover at 34% (table 11).

Table 11 Percentage live coral cover of some areas on Olango Island (CRMP 1998)

Area	Live coral cover (%)
Santa Rosa Site A	34
Santa Rosa Site B	10
Talima Site A	10
Talima Site B	20
Baring	15
Tinago	19
Cao-oy	13
Sabang	9
San Vicente Site A	27
San Vicente Site B	29

Coral reefs are used as fishing grounds, for aquarium fish collection, and as SCUBA dive and snorkeling sites. Coral heads are collected as decorative items. These issues are further discussed in section 6.2.2.

5.2.5 Aquatic fauna

A total of 23 families representing 137 species of fish have been identified around Olango, 33 species of which inhabit seagrass areas and the other 107 species are reef dwellers (SUML 1997) (appendix 5).

Of the three Barangays surveyed, San Vicente and Talima appear to support more species than Tungasan. Pomacentridae (damselfish) and the Labridae (masses) are the most abundant types of fish.

Species richness and fish density are highest at Barangay San Vicente and lowest at Hilutungan Island (table 12). The seagrass beds, coral reefs and the mangrove forest of Olango are important habitats for several macroinvertebrate species, some of which are economically important as food and as raw materials for the still craft industry.

A total of 63 species of macroinvertebrates have been identified in the sanctuary, representing 33 species of molluscs, 19 species of echinoderms, five species of sponges, four species of crustaceans and two species of cnidarians (SNS & WBS 1996). Brittle stars were most abundant followed by Nerites (appendix 6).

Table 12 Species richness and fish density in five reef sites on Olango Island and adjacent islets (SUML 1997)

Reef sites	Species richness (spp/500m^2)	Fish density (md/500m^2)
Tungasan	26	946
San Vicente	42	2140
Talima	37	1085
Pangan-an Island	27	1170
Hilutungan Island	27	357

In another study in Barangays San Vicente and Talima a total of 105 species of macroinvertebrates were identified representing 20 echinoderms, eight crustaceans and 77 species of molluscs (USC-MBS 1980; appendix 7).

5.2.6 Wildlife and birdlife

The terrestrial vertebrate fauna of Olango consists of one species of snake (*Lycodon aulicus*) four species of lizards including the monitor lizard (*Varanus salvator*) and the sail-tailed fin lizard (*Hydrosaurus postulosus*), a number of unidentified bats, and an estimated population of close to 50 000 shorebirds and seabirds during the peak migration months.

A total of 97 species of birds have been identified in various parts of Olango. The most researched area is the sanctuary where annual monitoring of birds is undertaken (PAWD-EMPAS DENR-7 1993). Of the total species, 48 are migratory, 42 are resident and the rest have uncertain status (Davies et al 1990) (appendix 8).

Olango Island has been considered one of the most important staging areas for migratory shorebirds in the Philippines, and it is for this reason that the southern coastal area of the island has been declared a sanctuary, the first and only Ramsar site in the country.

5.2.7 The wildlife sanctuary: values and benefits

The sanctuary is located in the southern part of Olango Island, bordered in the east by Barangay Sabang, Camungi Islet and Pangan-an Island; in the north by Barangay Santa Rosa, and in the west by Barangay San Vicente and Sulpa Island (figure 6). It has an area of 920 ha with both coralline limestones, and sandy and sand-silt substrates, which extend south where seagrasses, seaweeds and some coral formations are abundant.

The sanctuary consists of natural mangrove forests, vast intertidal flats, narrow and shallow water channels, seagrass beds, a patch of elevated ground planted with coconuts, and the newly established mangrove plantation. DENR-7 constructed a nature centre in the western section of the sanctuary that included a main building for the office and reception functions, and a bamboo boardwalk to the three strategically located observation hides.

There are very shallow areas linking the Sabang side of Olango to the southern islets of Pangan-an, Caohagan, Nalusuan and to Hilutungan. These are being used as foot bridges or trails by the residents of the three islets.

Olango became internationally known in the 1980s when bird surveys were conducted in major wetlands of the Philippines, with financial support from foreign agencies (Magsalay et al 1989, Davies et al 1990). Results show that the island supports a large population of migratory birds. Based on the criteria for listing sites as Wetlands of International Importance (the Ramsar Convention; table 13), Olango is an area of international importance for conservation. Thus, on 14 May 1992, the area was declared a wildlife sanctuary, and eventually, on 8 November 1994, the sanctuary was designated the first Ramsar site in the Philippines (DENR 1995).

Table 13 The Ramsar criteria for which Olango qualifies as a 'wetland of international importance' (DENR 1995)

Ramsar criteria*	Significant feature of Olango Island
Supports more than 1% (at least 100 individuals) of a flyway or biographical population of a species of waterbird.	The area supports more than 1% of the known population in the East Asian flyway, and up to 100 individuals of Chinese Egret.
Supports an appreciable number of rare, vulnerable endangered species.	The Chinese Egret and Asiatic Dowitcher are considered endangered species in the IUCN Red Data Book. A significant population of Chinese Egrets is present in the area.
It is of special value for maintaining the genetic and ecological diversity of a region because of the peculiarity and quality of its flora and fauna.	The area is a rich and diverse coastal habitat, including mangrove forest and supports a wide range of waterbird species.
It is of special value as the habitat of plant and animals at a critical stage of their biological cycle.	Olango is a nursery ground for many species of fish and prawns. It is a key staging and wintering area for migratory birds.
It is a particularly good example of a specific type of wetland characteristic of the region.	The extensive fringing sandy coralline, intertidal flats and the extensive mangroves are features not common in the Philippines. Olango is an intact example of a coastal wetland characteristic of coralline islands in the Indo-Malayan realm

* the criteria for listing sites as internationally important were revised in 1999 and reordered.

In the sanctuary, the mangrove forest confers a number of ecological and economic benefits to the island. During weather disturbance, the mangrove fringe around the island serves as a buffer against waves, strong water currents and winds. It is also a habitat to a number of important marine food items such as crabs, shells and other invertebrates. The elevated mounds and mangrove trees are the high tide roosting sites for many birds. Mangrove poles are used as firewood, fencing materials and house posts. They also serve as forage sources for domestic animals.

The seagrass beds are not only a habitat to many important marine organisms but also serve as an important feeding site for most wader birds. It is also a gleaning site for shells, crabs, sea cucumbers, sea stars, algae and fish.

The nearby coral reefs attract many tourists, skin and SCUBA divers. Corals are harvested in some areas. Fishing, aquarium fish and shell collection and lobster fry gathering are also carried out within the nature reserve.

5.2.8 RAMSAR site in the Philippines

Shorebird counts of up to 10 000 have been recorded on Olango (Davies et al 1990). Since then, the populations of these birds have become the main attraction for tourists on the island.

DENR (1995) and Magsalay et al (1989b) showed that the number of species recorded on Olango has increased from 42 species in 1987 to 97 species in 1995. More than half the species are observed every year. There are a number of species that are considered rare and threatened, and utilise the island either as a staging area, roosting or feeding site. These include the Asiatic Dowitcher (*Limnodromus semipalmatus*), Chinese Egret (*Egretta eulophotes*), Great Knot (*Calidris tenuirostris*), and the Far-eastern Curlew (*Numenius madagascariensis*).

Olango appears to be the most important site for the Asiatic Dowitcher in the Philippines (up to 45 birds).

Due to the importance of the sanctuary to migratory shorebirds, the site has been nominated for the East-Asian Australasian Flyway. Thousands of birds use this route as they migrate from the northern to the southern hemisphere during the winter migration, returning to the northern hemisphere during the summer migration (DENR 1998).

In a recent monitoring activity of DENR-7 in 1996 (A Mapalo, unpublished data), the total population of birds counted in the sanctuary was 18 962 (appendix 9).

5.3 Socio-economic attributes

5.3.1 Demography

In 1996, the island had a total population of about 22 324 distributed in eight Barangays. Santa Rosa with a population of 4787 is the most densely populated, followed by Sabang with a population of 3759 and Talima has a population of 3557. However, population density is highest in Barangay San Vicente with 34.44 individuals/ha, followed by Tingo with a density of 27.54 individuals/ha. Santa Rosa appears to have the least density with only 16.88 individuals/ha (table 14).

Table 14 Demographic data of Olango Island (CRMP 1998)

Barangay	Area (ha)	Population	No. of households	Population density (individuals per ha)
Santa Rosa	283.44	4 787	797	16.88
San Vicente	69.46	2 392	457	34.44
Talima	168.28	3 557	593	21.14
Tungasan	86.16	1 557	260	18.07
Sabang	195.28	3 759	627	19.25
Cao-oy	42.27	1 136	189	26.87
Tingo	96.28	2 652	442	27.54
Baring	91.44	2 484	414	27.16
Total	1029.61	22 324	3 779	

Studies show that the fertility rate of Olango is higher than 0.575 in terms of child/woman ratio (Fleiger 1994). Of the eight Barangays, Tungasan and Talima have the highest fertility rate. However, population growth surveys show that the island does not have a high population growth rate, and this is mainly due to the migration of labour age groups to the urban centres of Mactan and Cebu. Talima and Baring exhibited higher population growth rates of about 30%, because there was no net migration (Fleiger 1994).

Most of the families are the ‘so-called’ single families where no two families live together. Six appears to be the average family size (Remedio & Olofson 1988). The population of Olango has a very low level of education despite its proximity to the urban centres of Mactan and Cebu. About 70% have had some primary schooling but only 23% finished Grade six, and about 15% attended high school and only 20% tried college. About 1% had vocational training (SUML 1997).

There is one Barangay high school located in Santa Rosa, but elementary schools are found in most of the Barangays. Unfortunately, there is neither a college nor vocational school on the island. Most of those at labour age leave the island to seek employment. Those with some determination and ambition to succeed and the financial capacity, do attend college, either in Mactan or Cebu (Remedio & Olofson 1988).

In a recent interview of some 100 respondents from each Barangay in Olango, it appeared that the level of education of the islands has improved tremendously but a higher percentage of the population need to be encouraged to go to school (CRMP 1998). Generally, the population has attended grade school up to first year high school, but beyond that the numbers decrease dramatically (table 15).

Table 15 Educational profile of some Barangays in Olango Island (CRMP 1998)

	Barangay				
Educational Level	**Sabang**	**Tingo**	**Baring**	**Cao-oy**	**Tungasan**
None	4	3	4	60	50
Grade 1-3	20	17	12	20	50
Grade 4-6	48	22	31	20	0
Elementary Graduate	8	25	27	0	0
1st – 2nd year	12	6	4	0	0
3rd – 4th year	8	8	8	0	0
H.S. graduate	0	8	12	0	0
College level	0	8	4	0	0
College graduate	0	0	0	0	0
Vocational education	0	3	0	0	0
Total	100	100	100	100	100

Family income has been near or below the poverty line of Peso 4000 per annum, and this is far below the salary of those hired in Cebu or Mactan. Most families are generally poor and are used to living without the convenience of running water, bathrooms, and electricity. Most houses are made of bamboo, coconut lumber and nipa, and some are made of concrete with galvanised roofing. There are a few larger houses owned by government officials, aquarium fish financiers, commercial fish operators and those married to foreigners. Very few households have toilets (SUML 1997).

5.3.2 Livelihood

The people of Olango Island engage in a number of activities that provide them the needed income for survival. The main activities of the islanders are fishing, shell-craft, aquarium fish collection, lobster fry collection, rabbit-fish fry collection, seaweed collection, gleaning and shell collection. Some families are engaged in livestock and poultry raising, water selling, tricycle driving and boat hire. In some parts of the island, there are small boats that are loaded with shells, shell-craft, corals and some food items that are sold to tourists that go near the shore.

Fishing and fishing-related activities are major livelihood activities (CRMP 1998). The seagrass beds, coral reefs and waters around the island are the most important fishing grounds. Fishing is done almost daily in nearby areas and at times on the other islands of Mactan, Caubian, Bohol and Camotes. Fishing boats may simply be paddled or motorised and are used to carry fishing gear such as nets, hook and line, cyanide, dynamite, spear gun and hookah equipment. Fishing boats maybe rented or owned. In Cao-oy, about 90% of the fishermen own their boats (CRMP 1998).

Fishermen are classified as either ‘one day trip fishers’ for those who fish for a day or as ‘many day trip fishers’ for those who fish for several days in far away places like Palawan, Samar or Camotes. Studies show that about 83.8% of the fishermen are full time fishers, another 11.1% are part time fishers and fewer still are occasional fishers (SUML 1997). The majority of fishermen use cyanide and gill net fishing techniques, as they can yield more catch than other types of fishing (ie 200 kg/trip and 73.2 kg/trip, respectively). Hookah fishing can yield a gross income of 1.869 pesos/trip without considering the risk that goes with this type of fishing (SUML 1997).

Gleaning, or shellfish collecting, is an activity carried out around the island mostly by women and children while the male members of the family are out fishing. The importance of this activity cannot be overlooked because it provides both food and income for the family (SUML 1997).

Table 16 presents the annual average income in pesos of some respondents in the Barangays in Olango Island. In Barangay Cao-oy fishing appears to be the only livelihood in the community, generating an annual income of only Peso 12 192. In Barangay Baring, the community is engaged in more varied income generating activities including fishing and fishing-related activities, which have a combined annual income of Peso 59 585. In Barangay Sabang, business is the most lucrative occupation, generating an annual income of Peso 53 100. Employment also provided a yearly income of Peso 29 256. Fishing and fishing-related activities generated a combined income of Peso 28 050.

Table 16 Annual average income (pesos) of respondents in three Barangays of Olango Island (SUML 1997)

Livelihood	Baring	Cao-oy	Sabang
Fishing	27 840	12 192	17 940
Fishing-related activities	31 745	–	10 110
Salary	60 000	–	29 256
Business	27 000	–	53 100
Skilled Worker	14 700	–	16 320
Unskilled Worker	26 955	–	–
Farming	7 200	–	–
Others	–	–	2 640

The major fishing methods used in various Barangays in Olango include hook and line, spear fishing, cyanide fishing, blast fishing, bamboo traps and floating cages. Other fishing-related activities include abalone collection, shell collection, coral farming and ecotourism. Several types of fishing methods, and their respective catches, earning and use are outlined in appendix 10. Abalone collection appears the most lucrative form of fishing as it can yield an average daily earning of P100–160 with a catch per unit effort of 6–8 kg/day. This livelihood does not require as much capital from fishermen, simply time and labour. The least lucrative method is probably push net because it generally yields only Peso 14–21/day and an average catch per unit effort of 3–4 kg/day.

Families usually rent cultivated lots no bigger than a hectare. About 73% of the total land area is owned by 23% of the islanders. None of the families in Tingo and Baring own their lot. Three major crops are grown in Olango, namely coconuts, cassava and corn. Some 50% of the islanders are engaged in subsistence livestock and poultry raising (Remedio & Olofson 1988).

Other agricultural crops are cultivated but to a lesser degree and these include camote, banana, horseradish, okra, eggplant, tomatoes, ginger, squash, patola and bitter gourd. Ipil-ipil is also planted as a source of fuelwood and foraging (Remedio & Olofson 1988).

5.3.3 Infrastructure, transportation and communication

No large infrastructure exists on Olango Island, but there are two-storey buildings, churches, a small city hall, an emergency hospital and a jetty (more accurately this is a groyne but is referred to locally as a jetty).

The Santa Rosa Jetty is a very long solid structure with sides made of concrete and coral boulders. The jetty projects seaward from Santa Rosa, extending into the intertidal flat, seagrass bed and the coral reef edge. The jetty is constructed so that only two tricycles can pass at a time. It is a solid structure without provision for tunnels or culverts to allow water current to pass through from the northern to the southern side of the jetty, or vice versa.

The Nature Centre of DENR is constructed on low ground within the sanctuary, but it is elevated more than 1 metre above the ground. The boardwalk leading to the observation hides, though made of light materials, would probably last 5–10 years, but not until the predicted sea level rise of 1 metre by the year 2100. The boardwalk and the observation hide were established in areas with coralline limestone and sandy mud substrate. The prolonged submersion of the bamboo on wooden posts in seawater will lead to rapid decay and result in the weakening of the foundation of these structures.

The high school building in Santa Rosa is located at the very edge of the shoreline and can experience salt spray, particularly during high tides and storms and monsoons.

Olango is accessible by boat from Cebu City or at designated areas in Maribago and Dapdap on Mactan Island. The main jetty is in Santa Rosa, but there are other receiving sites in Baring, Tingo and San Vicente. The main mode of public transportation on the island is tricycle. There are bicycles although rarely are they used for public hire. A network of rough roads (about 21 km) links the various Barangays. Of the total road length, only 4.4 km is sealed.

There is no telephone system and the only communication link to Cebu or Mactan is through radio transceivers in some of the Barangay offices. The more affluent homes have their own cellular phones. About 44% have AM/FM radios, stereos, karaoke cassette players and television sets.

The Mactan Electric Company (MECO) supplies electrical power to the various Barangays of Olango Island, but only about 16% of households are served by the company. Power is made available only from 12 noon to 12 midnight. The power plant is located in Santa Rosa about 1 km from the shoreline. Street lighting is provided for in all Barangays.

In summary, Olango Island is still highly undeveloped in terms of infrastructure.

5.3.4 Freshwater supply

In a geo-hydrological survey conducted on Olango Island there was a general conclusion that the island has sufficient freshwater supply, particularly in the southern part between Sabang and Santa Rosa (Ligterink 1988, Walag et al 1988). This observation was based on the iso-conductivity and iso-potential map proposed for the island (figures 8 & 9). This freshwater lens is located in the Barangays of Tingo, Talima, Baring, Santa Rosa and Sabang. It was postulated by community members during the Olango Island vulnerability assessment workshop that the freshwater supply of Olango will be sufficient for the next 100 years if seawater does not intrude. How true this is remains to be confirmed by scientific studies (Ligterink 1988).

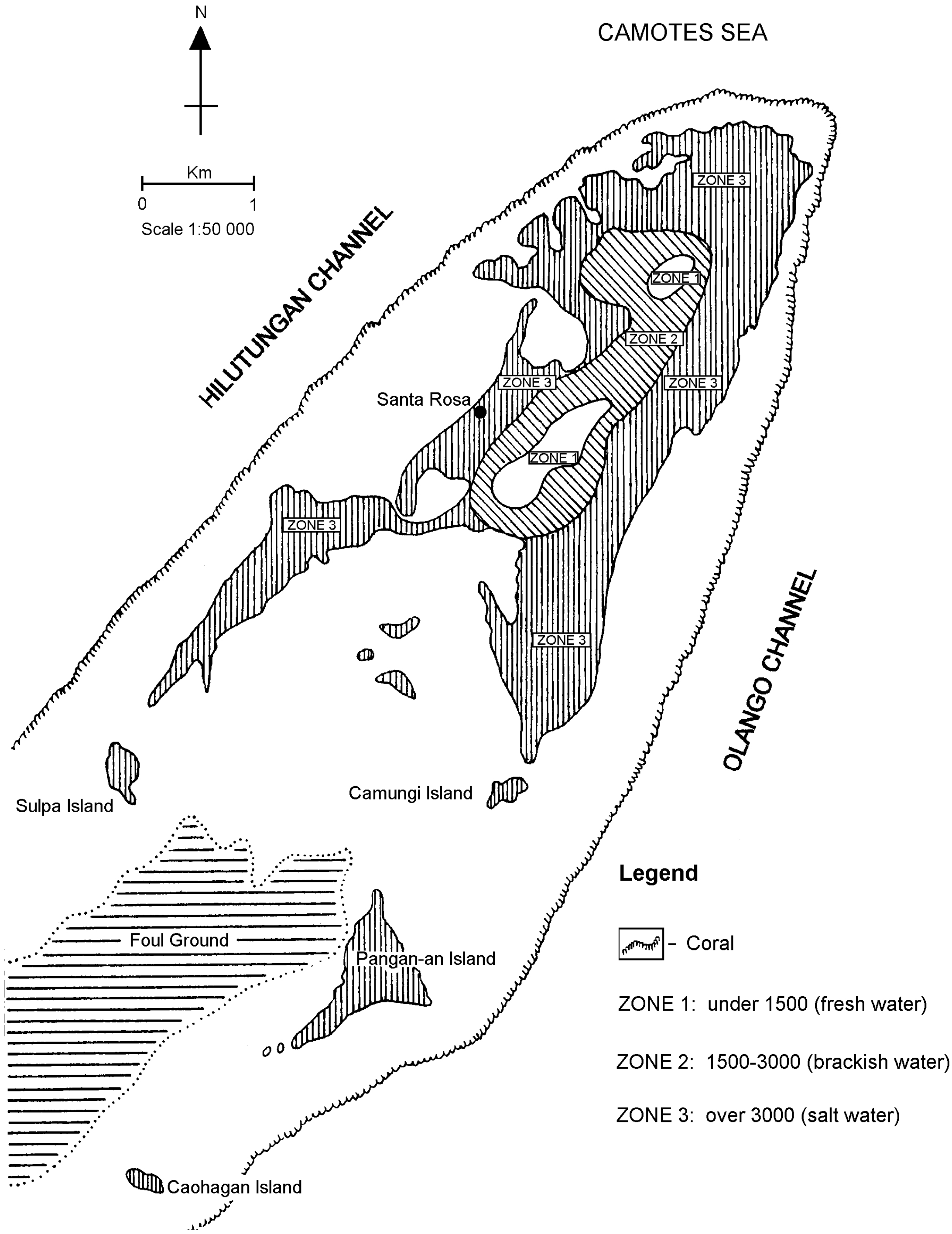

Figure 8 Map of Olango Island showing conductivity isobars (µS/cm) for groundwater based on well surveys (Walag et al 1988)

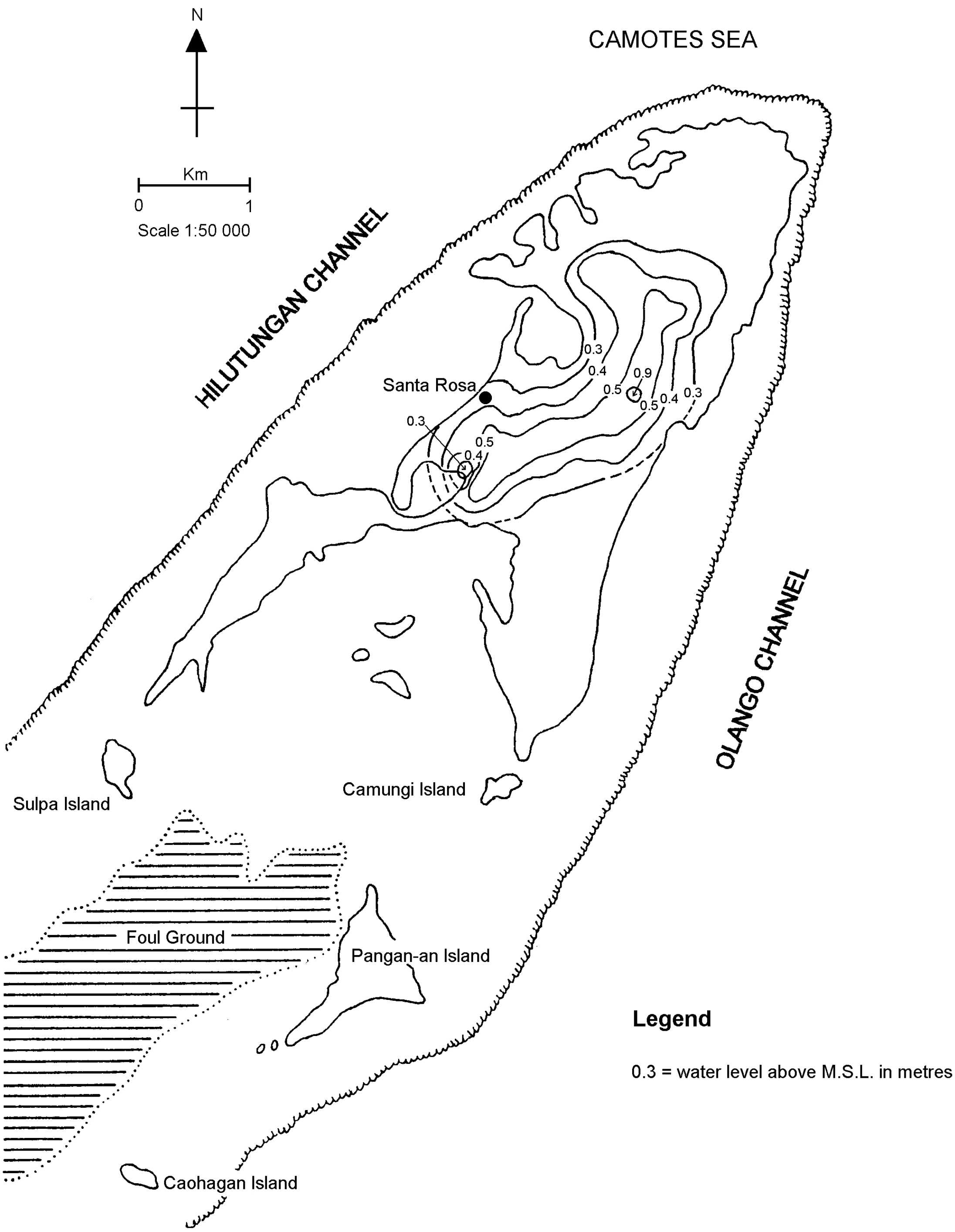

Figure 9 Isopotential map for groundwater on Olango Island (Ligterink 1988)

However, in the area around Sitio Aguho, freshwater over-extraction resulting in brackish water being collected has been observed. Figure 10 shows the location of existing water extraction facilities in Olango Island. At present, there are few settlements in the area directly above the freshwater lens. Maintaining this situation is important, and is discussed further in section 8. There are no streams or rivers on Olango with precipitation simply seeping through to the freshwater lens. However, because of its location and the small size of the island, this lens is threatened by seawater seepage from the nearby bays and wells (CRMP 1998). In a survey of 356 wells, only 31 extracted freshwater, with 54 and 271 extracting brackish and seawater, respectively (Walag et al 1988).

During the dry season, freshwater supply becomes scarce and people may be forced to drink brackish water. For those who have money, they buy freshwater at P3 per container of 20 litres of water. But for many, they have to walk to the source to collect water. To supplement their water supply, many households construct their own rainwater collectors in the forms of concrete or galvanised iron tanks. The scarcity of water supply is also a major constraint to tourism-related development.

5.3.5 Tourism

Olango was proclaimed a tourist zone and marine reserve in 1978, but until now the island still awaits full-scale tourism development. It has beautiful white sandy beaches that are ideal for recreation. A number of beach resorts are now in operation and provide the basic amenities for tourists such as food, freshwater, power and entertainment.

An estimated 2000–4000 tourists, both local and foreign, visit the sanctuary every year and this is expected to increase next year if promotional projects succeed. In addition to bird watching, tourist activities include photography and snorkeling. Eco-tours are being organised in coordination with the Association of Travel Agencies, Department of Tourism, Coastal Research Management Project and the Department of Environment and Natural Resources. A number of tourism establishments exist on Olango, but most are privately owned, including Tingo by the Sea, Malansyang Beach Resort and Baring Beach Resort.

5.4 Political attributes

5.4.1 Local political boundaries

The island is divided into eight component Barangays namely Tingo, Baring, Cao-oy, Tungasan and Talima in the northern half, and Santa Rosa, San Vicente and Sabang in the southern half (figure 11; Lapulapu City 1996). There are other sitios though like Aguho between Santa Rosa and Sabang; sitio Suba south of Sabang; and the sitios of Basdaku and Bascoral south of San Vicente.

5.4.2 Local government structure

A chairman and seven council members head each Barangay. The chairman represents the Barangay at the Association of Barangays Council (ABC) which elects a representative to the city council. The ABC meets on a monthly basis. The city of Lapulapu, which is headed by the mayor, has the political jurisdiction over Olango Island and its eight component Barangays. A city board or Sangguniang Panglungsod has the legislative function under which are various committees, which handle specific legislative concerns. The management of the coastal resource of Olango is under the Committee on Environmental Protection and Sanitation. Lapulapu City also has political jurisdiction over the sanctuary, but the administrative supervision is vested in the DENR-Region 7.

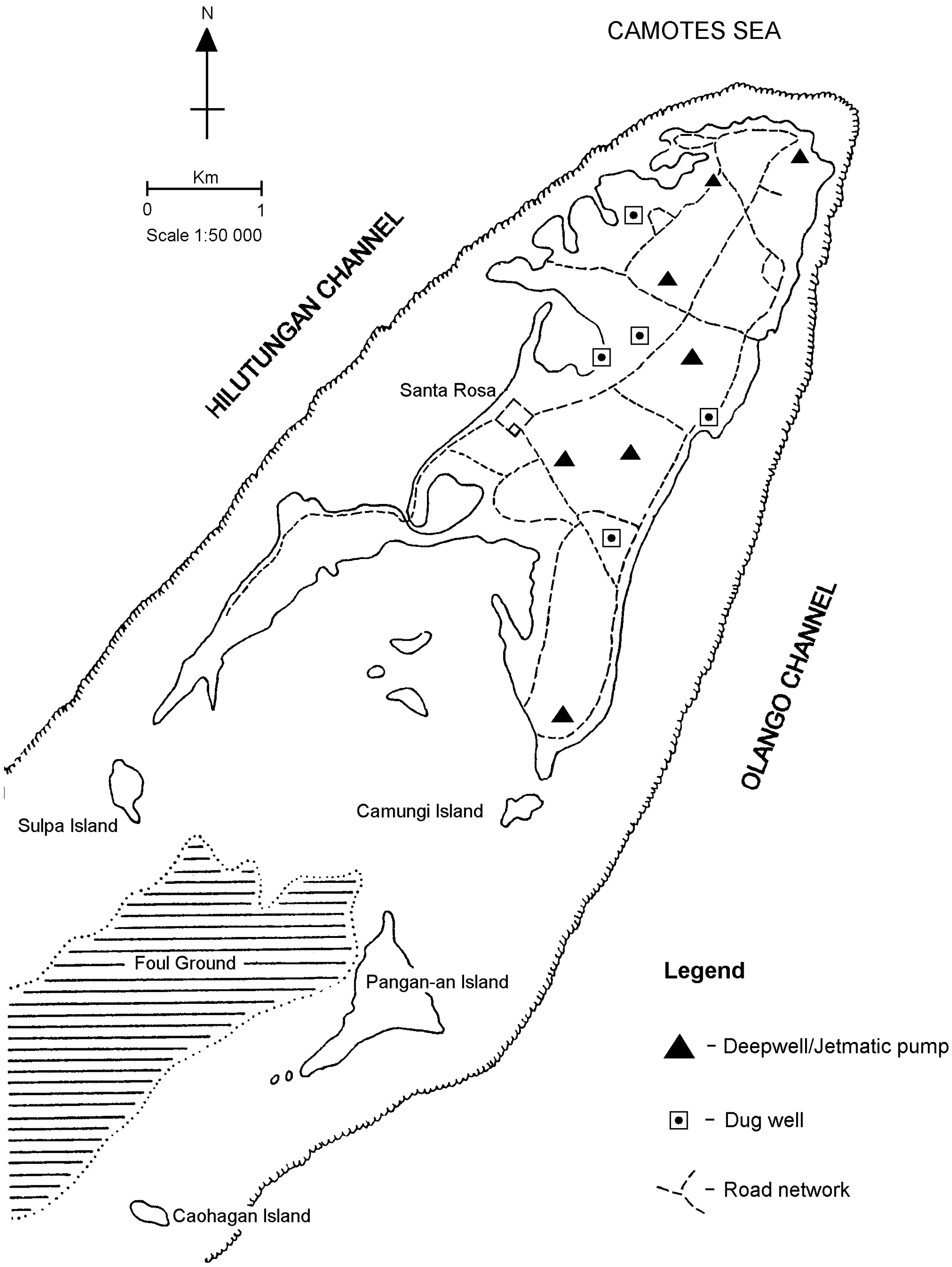

Figure 10 Location of existing water extraction facilities on Olango Island (Lapulapu City 1996)

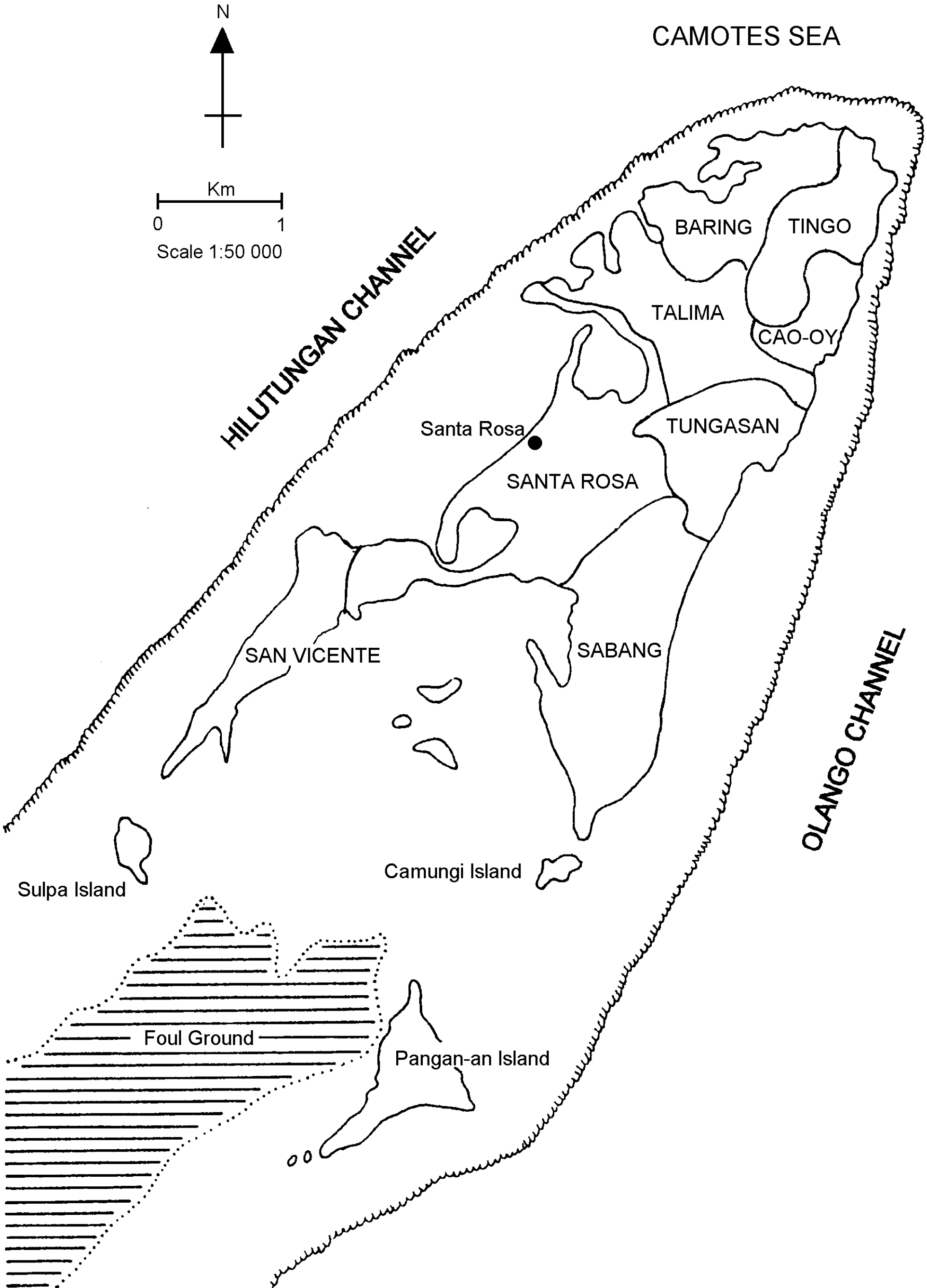

Figure 11 Map showing the Barangay political boundaries of Olango Island (*Mactan Integrated Master Plan* Lapulapu City 1996)

The Protected Area Management Board, with representatives from the various sectors of the island together with the Protected Area Superintendent from the DENR, constitutes the direct management and governing body of the wildlife sanctuary.

The authority to manage, protect and utilise the various coastal resources of Olango and the country at large are vested on several national and local agencies including the Department of Agriculture, Local Government Unit, Philippine Coast Guard, Philippine Navy and the Department of Justice. The health and social welfare needs of the islanders are under the administration of the Department of Health and the Department of Social Services and Development.

5.4.3 Non-governmental and governmental agencies

There are a range of non-governmental organisations (NGOs) that help in the local development of the natural and human resources of Olango. These are described below (CRMP 1998):

- The US-AID funded Coastal Resource Management Project (CRMP) has selected Olango as one of its ‘learning sites’ where a participatory coastal resource assessment is being implemented to identify strengths and weaknesses that are of importance for the sustainable management of the island. Positive results have been noted since the project started in 1996.
- The International Marine Alliance is involved in the management of collecting live coral fish including the training on the proper and sustainable techniques of collecting aquarium fishes. The same NGO noted the significant reduction of cyanide fishing in the island in its 1996 report.
- The Japan International Cooperation Agency (JICA) and the Wildbird Society of Japan provide funding and technical assistance to the on-going research and monitoring of the flora and fauna of Olango.
- The University of San Carlos–Water Resources Centre is studying the development of the two bays as important water reservoirs for the island. At present, a solar powered water pump supplies water to a cooperative that sells the commodity to the community. Another unit of the university, the Marine Biology Section, studies the marine resources, initiates alternative livelihood projects and conducts an education campaign on the dangers of hookah diving. One volunteer from the US Peace Corps is assisting the campaign.
- The Lihok Filipina Foundation, an NGO for women, trains women and minors in methods of fish and meat processing. This foundation was a recipient of funding assistance from the US Embassy Women’s Club.

Other NGOs and people’s organisations involved in the future development of Olango include the Save Nature Society, Philippine Wetland and Wildlife Conservation Foundation, Island Ventures Incorporated, Cao-oy Women’s Group, Suba Women’s Group, Fishermen’s Foundation of San Vincente, Cao-oy Fishermen’s Association, Cao-oy Consumers Cooperative and the San Vincente Water Association.

Several national agencies are involved in local development of Olango including the sanctuary. These include the Department of Environment and Natural Resources, Department of Tourism, Department of Agriculture, Department of Interior and Local Government, The Bureau of Fisheries and Aquatic Resources, the Philippine Coast Guard and Navy, Department of Health, Department of Social Services and Development, and the Philippine

Atmospheric, Geophysical and Astronomical Services Administration, which monitors climatic disturbances, temperature and rainfall of the country.

5.4 4 Bantay Dagat

Bantay Dagat is a task force whose main function is to protect and guard the coastal waters and resources of Olango against destructive forms of fishing and indiscriminate disposal of garbage. This became inactive a few years after its creation in 1979 but was revived again in 1987. The task force had many loopholes in its implementation, including the lack of police powers in apprehending illegal fishermen. The task force cannot arrest violators, and it is difficult to enforce and manage the confiscation of dynamite and other illegal fishing equipment. At present, Bantay Dagat is recognised as one vital force in the rehabilitation of the already damaged coastal zone of Olango Island.

6 Identification of current forcing factors and their impacts

Forcing factors are those natural and man-made processes, events, activities and even structures that can have negative, harmful or destructive effects on the biological, social, cultural, physical and political attributes of an island, ecosystem or habitat. These factors were identified from the above mentioned reference sources and/or elaborated during the consultation and workshop phases of the project. A summary of the workshop was prepared (Vulnerability assessment of major wetlands in the Asia-Pacific region 1999) and is available as an unpublished report.

6.1 Natural forcing factors

On Olango Island, the most important natural forcing factors are the monsoons, typhoons, storm surges and the El Niño phenomenon, as summarised below and in table 17.

Table 17 Summary of major impacts of existing natural forcing factors on Olango Island

Forcing factor	Impacts
Monsoons	Inundation, flooding, saltwater intrusion, coastal erosion, aquatic and terrestrial habitat damage, property damage
Typhoons	Inundation, flooding, saltwater intrusion, coastal erosion, aquatic and terrestrial habitat damage, property damage, business/livelihood interruption, loss of lives, loss of biodiversity
Storm surge	Inundation, flooding, saltwater intrusion, coastal erosion, aquatic and terrestrial habitat damage, property damage, business/livelihood interruption
El Niño	Property damage, freshwater shortage, loss of crops

6.1.1 Monsoons

Monsoons have both positive and negative effects for Olango. The south-west monsoon with its strong winds and heavy rain can greatly affect the southern and western coasts of Olango. The waters in these parts can become very rough particularly in the area south of the sanctuary and the foul ground, a shallow area with limited water and sediment movement, non-navigable by large boats. If the south-west monsoons coincide with the high spring tides, inundation and flooding may result. The strong winds result in storm surges that can erode the shoreline as the wave retreats back to the sea. The south-west monsoon has caused some coral damage in Carcar (Bagalihog & Redentor 1996).

The north-east monsoon strikes the northern and eastern coast of Olango. The northern coast has a slightly elevated rocky shoreline and impacts are generally limited to the effects of salt spray. At times inundation occurs along the eastern coast. Coral breakage in Bohol has been attributed to the north-east monsoon (Bagalihog & Redentor 1996).

A positive effect of the monsoons is that the rains recharge the groundwater and enable the community to collect rainwater.

6.1.2 Typhoons

Typhoons, with their wind velocities of 60–240 kph can be more devastating than monsoons. The continuous rainfall for several hours that tends to accompany typhoons can inundate and flood low as well as slightly elevated areas. This flooding can cause contamination of the freshwater lens. Tidal surges will result in erosion of the shoreline. The eastern coast of Olango is most often directly hit by typhoons. Property damage is always reported after a typhoon. In rare cases, there will be loss of lives. Super-typhoon Ruping in 1990 destroyed many houses in Talima. In 1960, Typhoon Amy hit Olango Island during high tide and water moved inland for about 15 m from the shoreline.

Strong winds and storm surges may result in the breakage of seagrass blades, seaweed thalii and branches or trunks of mangroves and other trees. This was observed in Baring and Tungasan. In Pangan-an Island, Bohol, and Carcar, Cebu, a high percentage of damaged corals have been attributed to storm surges and typhoons. Although there are no reports of this kind in Olango, it is still probable that typhoons can inflict serious damage to the reef areas of the island.

6.1.3 Storm surge

Storm surge can exert adverse impacts on Olango particularly when coinciding with typhoons. The strong and rushing water current can cause erosion and siltation along water channels in the south of the island (including the sanctuary) and shoreline.

6.1.4 El Niño

The El Niño phenomenon results in lower rainfall on Olango. This adversely affects ground water levels and salinity. This reduction may even allow seawater to intrude into the groundwater. During the El Niño of 1997, some wells dried up, while others produced brackish water. In Sabang most of the cultivated crops died because of a lack of water during the peak of El Niño.

6.2 Anthropogenic forcing factors

A number of anthropogenic forcing factors have been identified for Olango, these being overpopulation, unregulated and destructive forms of natural resource utilisation, infrastructure, tourism and the physical proximity of Olango to the urban centres of Cebu and Mactan. These are outlined below and in table 18.

6.2.1 Over-population

Foremost of these anthropogenic factors is the increasing population of the island, which is exerting extreme pressure. The higher the population the more is the demand for resources and space to meet the survival requirements. This factor has flow-on effects for all other forcing factors.

A corollary to overpopulation is the concentration of population and settlements along the coastal areas that exacerbate the problem of shoreline erosion. Subjecting the sandy shoreline to human activities, vehicles and other heavy objects breaks down the structure of the sand resulting in increased erosion.

Table 18 Summary of major impacts of existing anthropogenic forcing factors on Olango Island

Forcing factors	Impacts
Over-population	Increased demand for resources resulting in depletion (see remaining forcing factors), domestic pollution
Natural resource utilisation:	
Fishing	Loss of biodiversity, habitat destruction
Groundwater extraction	water shortage, saltwater intrusion
Mangrove cutting and forestation	Habitat destruction
Sand and coral extraction	Habitat destruction, erosion, inundation
Infrastructure	Habitat destruction, obstruction of natural water currents
Tourism	Habitat destruction, erosion, bird disturbance
Proximity to Cebu urban centre	Pollution, wildlife disturbance

The higher the population, the greater is the demand for freshwater. As the rate of extraction increases and the ground water is depleted each year so does the number of wells that become brackish.

6.2.2 Natural resource utilisation

Fishing is an activity that should be encouraged to improve the living standard of the people of Olango. However, if it involves illegal methods, and becomes destructive and unsustainable, then it should be stopped. In Olango, the most notorious and destructive fishing methods being practised are cyanide-fishing, blast-fishing and poison-fishing, all of which are illegal.

Cyanide-fishing uses sodium cyanide, a chemical that can disable, stun or kill not only the target fish but also other marine organisms. This method is used particularly for the collection of tropical aquarium fish. Two other chemical extracts, known locally as 'tubli' and 'lagtang', are used for the same purpose, and the destruction these method can cause is great. Coral reefs are particularly susceptible to cyanide poison.

Blast-fishing has occurred around Olango for several decades, with attempts to stop the practice being ineffective. Blast-fishing not only kills non-target marine organisms, but also destroys the habitat provided by the reefs and seagrasses.

Fine-mesh net fishing is another destructive fishing method because it catches almost everything from the bigger, mature fish to the smallest and immature fish. The nets are dragged over reef areas and seagrass beds breaking coral heads and uprooting seagrasses.

The unhealthy condition of the mangroves in Olango, particularly in the sanctuary, is attributed partly to over-cutting and the unsuitable sandy substrate. If over-cutting remains unchecked, mangroves will not be able to recover and may die. The loss of mangroves in Olango would also mean the loss of a buffer zone against strong waves and storm surges. Mangrove forestation in itself is a worthwhile undertaking if it is aimed at rehabilitating a denuded mangrove area, but if it is established on an ecosystem that is entirely distinct from it, the result can be just as devastating and can eventually lead to the loss of another habitat. Such is the case with the mangrove forestation project inside the sanctuary in the middle of a seagrass ecosystem. Should the mangrove plantation survive, the seagrass will die out resulting in the loss of feeding grounds for many bird species.

One of the major viable industries on Olango is shellcraft, because the raw materials are readily available and the demand is very high. However, to meet this demand, over-harvesting may occur and could become a problem. The use of push-nets over intensive areas of seagrass bed to collect shells not only destroys the seagrass, but also indiscriminately collects non-target species.

Coral and sand extraction are human activities that can destroy the stability of the coral reefs and shoreline. The short-term economic benefits are far outweighed by the negative environmental impacts. The coral reef habitat and associated marine organisms may be lost as a result of coral extraction. Sand extraction on the other hand increases the rate of soil erosion and shoreline retreat.

Sand extraction was occurring in Tingo, Baring, Sabang and San Vicente in the mid 1990s but has now stopped. Barangay Tingo has lost its sandy beaches because of sand quarrying, while in San Vicente the shoreline has retreated due to sand extraction.

6.2.3 Infrastructure

The only infrastructure that has a potential to cause some degree of damage to the coastal ecosystem is the 'jetty' in Santa Rosa. This structure is close to 2 km long and nearly 2 m wide and extends across the intertidal flat, seagrass bed and coral reef of Santa Rosa. The jetty has no culverts and completely inhibits the natural water movement along this section of the coast. The construction of housing on the island could also destroy natural habitat, however, there is little of this remaining anyway.

6.2.4 Tourism

Tourists and tourism facilities are recognised as having some negative influences on the coastal resources of Olango. While revenues are generated from tourism it can also cause coral damage, erosion, and habitat destruction and bird disturbance. Mooring of tourist boats more often over coral reef and seagrass bed can be damaging. In addition, some tourists bring air rifles and shoot birds.

6.2.5 Proximity to Cebu urban centre

Olango Island is just a few kilometres from the urban centres of Mactan Island and Cebu City, where human and industrial activities have intensified. These centres have a combined population of about 850 000 people. Tourism facilities, an export processing zone and other industries discharge pollutants into the air and water that may eventually reach Olango Island and degrade its immediate environment and critical habitats.

Mactan is the site of an international airport and a military air base. From time to time aircrafts hover close to the ground over Olango and in some instances land in the intertidal flat inside the sanctuary. The landing of aircraft may not disturb the vegetation but can cause disturbance to the wildlife, particularly the birds.

7 Assessment of vulnerability

In assessing the vulnerability of Olango Island to climate change and sea level rise, it is important to place it within the context of current vulnerability to existing coastal hazards (forcing factors). Thus, the first part of this section examines the current vulnerability of the various attributes of Olango to existing coastal hazards. Following this, the vulnerability to climate change and sea level rise is considered. In addition to using information from existing literature, outcomes arising from the three separate workshop discussion groups for biophysical, biological and socio-economic attributes were used to determine vulnerability (see summary in Vulnerability assessment of major wetlands in the Asia-Pacific region 1999). As a result, the following discussions for each of the above three attributes vary to some extent due to the adoption of slightly different approaches and priorities by the workshop discussion groups.

7.1 Vulnerability to existing forcing factors

7.1.1 Geophysical attributes

Olango Island is in the heart of Central Visayas. In certain months of the year monsoons and typhoons pass over the area with strong winds and large amount of precipitation. A summary of the vulnerability of Olango Island to existing natural and anthropogenic forcing factors is shown in table 19.

Table 19 Summary of the vulnerability of major geophysical attributes of Olango Island to existing forcing factors (- negative impacts, + positive impacts, 0 no impacts)

Attribute	Forcing factor						
	Monsoon	Typhoon	Storm surge	El Niño	Over-population	Coral/sand extraction	Ground-water extraction
Topography	0	–	–	0	0	–	0
Hydrology	+	+	–	–	–	0	–
Geology	0	0	0	0	0	0	0
Water current	0	0	–	0	0	0	0
Tidal regime	0	–	–	0	0	0	0

The north-east and south-west monsoons do not have significant impacts on the topography of the island. The monsoon rains and wind are not strong enough to change the shape and configuration of the island. The magnitude of soil erosion may not be sufficient to affect the topography of Olango. The positive impact of the monsoon and typhoon rains is the increase in the amount of groundwater due to precipitation. It was reported in the Olango Island vulnerability assessment workshop that no soil erosion has been observed in Barangay Baring after the north-east monsoon season.

During the north-east monsoon season from November to April, the northern portion of Olango is the most affected, including the coastal areas of Tingo, Baring, Cao-oy and Santa Rosa. Small-scale erosion may occur in the sandy beaches of Olango because of the onslaught of strong winds and amplified waves that are associated with the monsoons.

During spring tides, the high water level inundates the low-lying coastal areas. The wave surges also increase soil erosion as they break and retreat in the sandy shoreline. At low tide during the south-west monsoon, there is a localised attenuation of waves as they pass the 'foul-ground' just south of the sanctuary. At high tide, the monsoon winds may amplify the prevailing wave situation, which can greatly increase the rate of coastal erosion.

Olango is one of the many islands in the region affected by typhoons. Although typhoons occur as short weather disturbances from two to three days over a specific area, the devastation they can inflict can be immense. The winds can have a velocity of up to 160 km/h and are associated with heavy rainfall. Waves and currents generated by cyclonic winds can cause soil erosion particularly in areas with a sandy shoreline. Thus, the major portion of the southern half of Olango is most vulnerable to coastal erosion.

Typhoons are likely to cause destructive effects on the topography and tidal regime of Olango but a positive impact on the water storage capacity of the island. Typhoons are not known to have significant impact on the water current, but can bring about a shifting of sand and large scale erosion. These two processes may lead to changes in the topography of the island.

Monsoon and typhoon winds amplify the waves and render the coastal waters very rough and risky for small fishing boats. High tide waters surge over the intertidal areas reaching as far as the high grounds in the middle of the sanctuary. The south-western sections of the island are also affected by the wave surges over the coral reefs and seagrass bed up to the shoreline. Storm surge can also cause intrusion of saltwater into the freshwater lens.

Of the five geophysical attributes of Olango, the water regime is the most vulnerable to the El Niño phenomenon. The most obvious impact of El Niño of 1997 was the shortage of freshwater supply in almost all of the Barangays. In Baring and Santa Rosa, most of the wells dried up, while others only extracted brackish water. Even in Talima, which is the main source of freshwater, the water from the wells was brackish.

Several of the geophysical attributes of Olango are also vulnerable to a number of anthropogenic forcing factors, and these are summarised below and in table 19. The growing population of Olango is considered a forcing factor that can affect its geophysical attributes. Based on the assessment during the vulnerability workshop, it was concluded that over-population has had, and will continue to have an impact on the topography and particularly the hydrology of Olango. Population settlements and their associated activities cause soil erosion thereby altering the topography of the island, while the over-extraction of fresh groundwater for domestic and agricultural use is well documented. Excessive water extraction resulting from increased population demand can only exacerbate the serious problem of water shortage brought about by the El Niño phenomenon.

Island topography, being influenced by sand displacement and deposition, is highly vulnerable to sand extraction. For example, the sandy beach in Barangay Tingo disappeared many years ago due to large scale, illegal sand extraction. In addition, in Barangay Sabang, a portion of the shoreline retreated because of sand quarrying, while a beach resort in San Vicente experienced significant shoreline retreat because of sand extraction. The intertidal and subtidal topography of the island is vulnerable to coral extraction and blast fishing, with these activities already having significantly damaged the reefs.

7.1.2 Biological attributes

Table 20 presents a summary of the vulnerability of various biological attributes of Olango Island to natural and anthropogenic forcing factors. The anthropogenic forcing factors have been grouped as one general factor, namely *human disturbance*. In addition, the current extent of disturbance of each attribute is indicated.

Table 20 Summary of the vulnerability of major biological attributes of Olango Island to existing forcing factors (- negative impacts, + positive impacts, 0 no impacts)

Attribute	Extent of disturbance	Forcing factor Monsoon	 Typhoon	 Storm surge	 El Niño	 Human disturbance
Fishery	very high	–	–	–	0	–
Corals	very high	–	–	–	0	–
Seagrasses	very high	–	–	–	0	–
Mangroves	low	–	–	–	–	0
Land Vegetation	very high	+/–	+/–	0	–	–
Sanctuary	low	–	–	–	0	0/–

Of the six attributes, the mangroves and the sanctuary are the least disturbed, due to their protected status. Unlike fisheries, corals, seagrass and land vegetation that can be direct sources of food and materials for the islanders, a presidential proclamation declares the cutting of mangroves, and any other exploitative activities within the sanctuary, punishable by law. Assessment of the biological attributes indicated that all six are vulnerable to the north-east or south-west monsoons. For instance, in Baring, fishing activities using bamboo traps and hook and line come to a halt during the north-east monsoon and typhoon. Large masses of seagrass washed up onto the beach are evidence that seagrasses are also uprooted during the north-east monsoon. In Cao-oy, fishing is affected only by typhoons. Tungasan also experiences seagrass damage along the coastline after the south-west monsoons.

All biological attributes are adversely affected by typhoons and storm surges. Impacts of typhoons and storm surges on fisheries include loss of biodiversity and destruction of habitats for the fishes. Another possible impact of typhoons is coral destruction, as reported in Bohol and Cebu, where coral rubbles have been attributed to such events.

Some important seagrass areas that were lost due to human disturbance include those that were displaced by the mangrove plantation in the sanctuary, and a part of the jetty site in Santa Rosa. Mooring of boats can also be damaging to seagrass beds. Seagrass beds may also be damaged by inundation with diluted waters as a result of typhoons and storm surges.

The mangroves of Olango particularly those in the eastern and western coasts are growing well compared with those inside the sanctuary where the plants have stunted growth. Natural factors such as typhoons and monsoons appear not to have significantly affected the survival of this type of ecosystem. Overcutting of mangroves in the sanctuary has been checked and the plants are exhibiting remarkable recovery compared with their growth prior to its proclamation as a protected area.

The sanctuary is considered vulnerable to monsoons, typhoons and storm surges. The south-west monsoon is more destructive to the sanctuary than the north-east monsoon, because of its location in the vast open southern coast of Olango. Flooding and longer inundation periods may occur in the sanctuary during storm surges and south-west monsoon. The water channels and their associated seagrass beds may experience longer inundation periods. Dilution of seawater with rain may occur, conferring some advantage to the mangroves. Longer inundation periods for seagrasses also results in the birdlife having reduced access to their feeding areas. Erosion along the channels and sedimentation in the seagrass bed and mangrove plantation may result during storm surges, monsoons and typhoons.

Typhoon and monsoon winds directly affect the activities of the birds in the sanctuary. When the high tide roosting sites are flooded, the roosting birds may have to look for other sites on higher ground, or they may roost on branches of mangrove trees. Normally, during fine weather the birds are seen everywhere, however, when there is a climatic disturbance, the birds respond by roosting in elevated grounds under mangrove trees.

Storm surges can have negative impacts on the fishery, corals, seagrasses, mangroves and sanctuary but not to any great extent on the land vegetation. In contrast, the El Niño phenomenon will affect the mangroves and the land vegetation, but not the fishery, corals, seagrasses or the sanctuary to any great extent. The mangroves of Olango survived the long dry spell brought about by the El Niño phenomenon of 1997–1998. While there were no reports of mangrove trees having died of heat stress, the growth and development of the mangrove plantation was observed to have slowed during the drought, indicating some form of adverse effect.

The terrestrial vegetation of Olango is considered vulnerable to monsoons and typhoons, with impacts ranging from minor structural damage to felling of entire trees. However, the increased precipitation during typhoon and monsoon events can be considered a benefit to the vegetation. The vegetation is also vulnerable to El Niño and the associated shortages of freshwater.

In summarising the vulnerability of the biological attributes of Olango to natural forcing factors such as typhoons, monsoons and storm surges, it should be recognised that in many cases the biology has a capacity to recover and/or adapt to these types of periodic or episodic stresses. In contrast, they are far less likely to be able to recover from long term, continuous exploitation by the population of Olango and surrounding regions. Thus, the vulnerability of the biological attributes to anthropogenic factors is likely to be far greater than to natural factors.

7.1.3 Socio-economic attributes

Table 21 presents a summary of the vulnerability of the major socio-economic attributes of Olango Island to natural and anthropogenic forcing factors.

Table 21 Summary of the vulnerability of major socio-economic attributes of Olango Island to existing forcing factors (- negative impacts, + positive impacts, 0 no impacts)

Attribute	Forcing factor							
	Monsoon	Typhoon	Storm Surge	El Niño	Over-population	Resource utilisation	Infra-structure	Tourism
Population	+/–	–	–	0	–	–	+	+
Livelihood	–	–	–	0	–	–	+	+
Infrastructure	0	–	0	0	–	0	+	+
Transportation	–	–	–	0	–	0	+	+
Tourism	–	–	–	–	–	–	+	+

The monsoons affect the Olango population both negatively and positively. Many aspects of the lives of the islanders are affected when the island is experiencing either north-east or south-west monsoon. Practically all domestic activities, from vending to washing and gleaning cannot be fully undertaken during monsoon rains and winds. However, the increased precipitation associated with the monsoons recharges the island’s freshwater supply, offering benefits to the local population. In Barangays Baring and Tingo, fishing activities using traps and hook and line cease during the north-east monsoon. Tungasan is similarly affected by the south-west monsoon, while Santa Rosa can be affected by both north-east and south-west monsoons.

Sea transport is also vulnerable to monsoons. Trips leaving and going to Olango may be cancelled, reduced or postponed depending on the intensity of monsoon. Docking can even be hindered. The coves in Talima become a common docking area for many pumpboats during the north-east monsoon. The jetty in Santa Rosa can provide safe docking sites for many boats during both north-east and south-west monsoons, while the wharf in Tingo has previously been damaged during the north-east monsoon. The difficulties in transport to the island, and the general inclement weather during the monsoons discourages tourists from visiting Olango, which in turn reduces revenue on the island.

All socio-economic attributes are vulnerable to typhoons, with very little escaping from the harsh impacts of strong winds and rains. In Baring, tidal waters during a typhoon can inundate houses located about five metres from the shoreline. In Talima, many houses were reportedly destroyed during the height of super typhoon Ruping in November 1990. During Typhoon Amy, the tidal waters moved inland and inundated an area about 15 metres from the shoreline during low tide. Barangay Tungasan also experiences flooding as the tidal waters rise to about 5 metres from the shoreline during typhoons. Barangay Santa Rosa experiences less flooding as a result of typhoons. Most types of livelihood activities are affected by typhoons. For example, fishing activities in Cao-oy and Sabang cannot be undertaken during typhoons.

Storm surges can also render population, livelihood, transportation and tourism vulnerable. Storm surges can slow down business activities including sea travel to and from Olango, and this has a negative effect on the number of tourists that visit the island. Storm surge can also prevent the people from gleaning, shell collection, and other livelihood activities. Infrastructure, communication and power are not thought to be a risk from storm surges, although houses and other buildings close to the shoreline may be affected.

Human activities also have major impacts on the social and economic structures of Olango (table 21). Over-population of Olango will by far have the greatest impact on the socio-economics of the island. As mentioned above, over-population can result in many negative impacts including habitat loss and an increase in demand for resources. Further pressure on the already over-exploited natural resources could lead to major social conflict within and between the communities of Olango. Over-population will also place stress on, and most likely reduce the sustainability of many livelihood activities. Infrastructure will also be affected. School buildings will be over-crowded, potentially resulting in less efficient education programs. Hospitals may experience similar stresses. The road system, already in poor condition, will deteriorate further. Many of the impacts of over-crowding, including those listed above and others such as increased sewage and garbage disposal issues will have adverse consequences for the development of a profitable tourism industry on Olango.

Destructive resource utilisation practices such as dynamite, cyanide and poison fishing place unnecessary stress on livelihood activities and tourism development on Olango. In addition, these practices are a hazard to individuals, with a number of islanders having been victims of dynamite explosions and hookah diving accidents. While dynamite and cyanide fishing initially yield good catches, this decreases dramatically to the point where the majority of fish life has been caught or destroyed. Similarly, push net fishing has almost depleted the shell resources of Olango, which are used as raw materials for the shellcraft industry. As the coastal resources of Olango are its main tourist attraction, destructive fishing methods are a serious and current threat to tourism development.

Infrastructure and tourism can be seen as forcing factors as well as attributes. As forcing factors they will have mostly positive impacts on the socio-economic status of Olango Island. Population, livelihood, transportation and tourism will generally benefit from existing and future infrastructure and tourism activities.

7.1.4 Summary

It is clear that Olango Island is already under significant stress from a number of natural and anthropogenic forcing factors. First and foremost among these is the increasing population and the associated over-exploitation of the island's natural resources. In terms of biological resources, legal and illegal fishing and fishing-related activities have greatly diminished the fish life in the waters surrounding the island. This is demonstrated by the increased distances travelled by the local fishermen in recent years in order to ensure sufficient catch. The limited freshwater supply also appears to represent a constraint on the further development of Olango. However, current recommendations for the management of groundwater extraction and freshwater supply should assist in ensuring the long-term sustainability of this resource (see section 8). With regards to natural forcing factors, Olango is particularly vulnerable to typhoons and storm surges, given its low elevation above sea level, and poorly constructed infrastructure.

7.2 Vulnerability to climate change and sea level rise

The geophysical, biological and socio-economic attributes of Olango are constantly interacting with each other and will be constantly responding to regional climate change and sea level fluctuations. The impact may be categorised as either negative if the response elicited is harmful or damaging to a particular attribute, or positive if it confers some advantage or benefit. Alternatively, no impact may be observed or perceived at all. However, it is generally considered that predicted climate change and sea level rise will result more often in adverse than beneficial impacts.

The underlying rationale for these types of assessment are that ecosystems and human development activities located in low lying, coastal regions will be vulnerable to climate change and sea level rise. An understanding of the extent of vulnerability will depend on knowledge of the predicted changes in climate and sea level at the site of interest. Since information on climate variation for Olango is lacking, data from various sources including the IPCC (Houghton et al 1990) and CSIRO (1994) were used as points of reference for discussion of the assessment.

Two predicted scenarios of sea level rise were used for the assessment of Olango Island, one for the year 2030, being a sea level rise between 8–30 cm, and another for 2100, being a sea level rise between 15–95 cm. In assessing vulnerability, a sea level rise of 30 cm by 2030 and 95 cm by 2100 were assumed.

The predicted climate change scenario for Olango included a 20% increase in the intensity of typhoons with an associated increase in wind velocity, rain intensity and storm surge. In addition, average precipitation is predicted to increase in the form of more precipitation events or an increase in the intensity of precipitation (Fowler & Hennessy 1995).

7.2.1 Geophysical attributes

Sea level rise constitutes the most important manifestation of climate change that can significantly affect the coastal attributes of an island, and in the case of Olango it is a major concern that can have substantial implications on its natural and social resources. The potential impacts on Olango are varied and may include the physical processes of inundation, flooding, erosion, change in the salinity of groundwater through saltwater intrusion, biological effects such as habitat loss, wildlife displacement and population dislocation. Table 22 presents a summary of the vulnerability of the major geophysical attributes of Olango Island to predicted climate change and sea level rise.

Table 22 Summary of the vulnerability of major geophysical attributes of Olango Island to predicted climate change and sea level rise (- negative impacts, + positive impacts, 0 no impacts)

		Sea level rise	
Attributes	**Climate change**	**80 cm by 2030**	**95 cm by 2100**
Topography	–	–	–
Geology	0	0	0
Hydrology	+	–	–
Water Current	–	–	–
Tidal regime	–	–	–
Soil	–	–	–

Olango Island's low topographic relief and elevation render the island vulnerable to climate change and sea level rise. Intense typhoon winds will increase the intensity of storm surges resulting in greater erosion and displacement of sand and sand bars on the shoreline along Tungasan, Sabang, Santa Rosa and San Vicente. Erosion may result in shoreline retreat and widening of water channels in Sabang and San Vicente. As there are no rivers on Olango to augment sedimentation during intense rain and storm surge, accretion will most likey not be sufficient to counteract the changes in the topography of the shoreline resulting from erosion.

The low relief of Olango makes the island relatively vulnerable to the predicted sea level rise of 30 cm by the year 2030, and extremely so for a rise of 95 cm by 2100. A rise of this magnitude could inundate a significant portion of the island's land area. Slightly elevated areas in the north and central parts, western isthmus and the southern coast near the sanctuary will be slightly above the water. All the outlying areas of Tungasan, Sabang, Santa Rosa and San Vicente will be vulnerable to inundation. As the sea level rises, the seaward portion of the intertidal area will be partly inundated even during low tides, and the inner low-lying area will become a part of a new inland intertidal zone that is inundated only during high tide. Unfortunately, as there exists no adequate topographical map of Olango Island, it is difficult to quantify the area of land that will be inundated by the above predicted scenarios. Given the island's mostly low topographical relief and a maximum height above mean sea level of around 9 m, it is estimated that more than 10% of the island's current land mass would be lost in the event of a 95 cm rise in mean sea level.

The rate of erosion and sedimentation along the shoreline will most likely increase as sea level rises, however, this may take some time before a change in topography at this scale could be detected.

The water regime of the island may be affected by climate change, but it is likely to be a positive impact. An increase in rainfall intensity and frequency will increase the rate of groundwater recharge and also probably the size of the groundwater lens. In addition, if the two bays are closed at their entrances to the Hilutungan Channel as proposed, the freshwater resource will be further enlarged. An expected increase in the use of rainwater collectors will also increase the freshwater supply. Thus, it is more likely that the yearly freshwater supply will increase, and that it will be available for longer periods.

However, predicted sea level rise and storm surge associated with monsoons and typhoons may offset some of the benefits bestowed on the freshwater supply by increased rainfall. Sea level rise and increased storm surge will combine to increase the interaction between the fresh groundwater and saltwater, particularly during high tides. As reported above, water from a number of the wells on Olango currently turns brackish during high tides during the dry season, suggesting this problem will only worsen with increased sea level and storm surge. In addition, the bays, with a height above sea level of 0–0.75 m, if closed off, may experience significant saltwater intrusion, rendering them ineffective for freshwater storage. This is so for the predicted sea level rise scenarios for both 2030 and 2100. Thus, the net effect of climate change and sea level rise on the hydrology/freshwater supply of Olango remains somewhat uncertain.

Water current will likely be enhanced by sea level rise as well as stronger winds associated with typhoons and monsoons. Predictions reveal an increase in the current velocity as monsoon and typhoon winds and waves amplify. Consequently, erosion along water channels and the sandy shoreline will also likely worsen. As sea level rises, more landward areas will be subjected to the impacts of intensified water current.

Tidal inundation will be greater during intense storms, monsoons and typhoons, with the associated storm surge potentially resulting in increased erosion and flooding. The degree of tidal inundation can also be exacerbated by intense precipitation during typhoons. In addition, major inundation and flooding would be likely to occur at night, when spring tides occur during the wet season. In 1951, Typhoon Amy hit Olango Island during high tide, resulting in storm surges that flooded the coastal area up to 15 metres from the shoreline. A similar event happened during Typhoon Pepang in 26 October 1995, when storm surge during high tide resulted in the flooding of several coastal areas in Cebu including Olango Island. Sea level rise will also have an impact on the tidal regime. The prevailing tidal range of Olango, which is about 1 m, will increase as the sea level rises. In addition, the mean high water level will also increase, resulting in longer or permanent inundation of some areas that are currently exposed during low tide.

Olango has a very thin layer of topsoil and this can be very vulnerable to impacts such as erosion, flooding and storm surge. The predicted intense rain will result in increased run-off in slightly elevated areas, but in areas that are flat runoff maybe minimal because water will simply seep through the aquifer. Erosion brought about by runoff is only a minor problem in slightly elevated areas. Sea level rise will result in inundation of previously dry land, and subsequent erosion of topsoil as tidal waters recede, bringing along with them silt and other debris that can settle down in seagrasses and coral reefs.

The impact of sea level rise and the associated wave action on the elevated rocky cliffs in Tingo, Baring, Cao-oy and San Vicente will most likely be minimal. Perhaps an increase in salt spray and slight inundation, to a level that can be considered not damaging, will occur. Thus, this particular attribute of Olango is not expected to be vulnerable to sea level rise.

Evidence of sea level rise affecting the geology of Olango over a period of 30 years is unlikely as the geological processes require time scales that are much longer than 30 or 100 years. Therefore, the geology of Olango was not considered vulnerable to sea level rise by the year 2030.

7.2.2 Biological attributes

Assessment of the major biological attributes of Olango indicated that all are vulnerable to climate change, but only four are vulnerable to sea level rise (table 23). This is discussed below.

Table 23 Summary of the vulnerability of major biological attributes of Olango Island to predicted climate change and sea level rise (- negative impacts, + positive impacts, 0 no impacts)

		Sea level rise	
Attributes	**Climate change**	**30 cm by 2030**	**95 cm by 2100**
Mangrove Forest	–	–	–
Seagrass bed	–	0	0
Terrestrial vegetation	–	–	–
Coral reef	–	0	0
Aquatic fauna	–	0	0
Wildlife	–	–	–
Sanctuary	–	–	–

Mangrove forests

The mangrove forests were considered vulnerable to climate change because their survival and distribution are determined in part by climate. Thus, any change in climate will potentially influence their health and survival. The predicted increase in precipitation will dilute the seawater, which favours mangrove growth. Predicted intensification of typhoons, strong winds and heavy rain is likely to cause more damage to the plants. Mangroves are highly specialised plants that prefer stable, warm and calm conditions. If the site cannot provide these because of change in climate, extreme inundation, typhoons, storm surges, strong winds and waves, the mangrove forest will have difficulty establishing itself, resulting in less dense stands with stunted growth. The adverse weather conditions will not favour seedling establishment and growth. The predicted increase in air temperature will most likely slow down mangrove growth. This is more likely to happen as El Niño is predicted to become more severe.

A rise in sea level of either 30 or 95 cm will also have a major impact on the mangrove forests. Mangroves are able to tolerate partial inundation during high tide and emergence during low tide. They do not grow well in permanently flooded areas and they require air above the water for at least three hours; any shorter than this can retard their growth. For example, in Carcar, Cebu, where the mangrove plantation has been established in subtidal areas, the mortality of the mangrove was very high and the growth very slow. The current mangrove stands are not likely to be able to withstand a sea level rise of 95 cm. The mangroves in the eastern and western sections of the island may die out or they may spread inland if the rate of suitable substrate formation is sufficiently rapid. Such establishment would take some time, but if the community sustains its mangrove forestation program inland, then some mangroves might yet survive in Olango. Landward mangrove colonisation due to sea level rise may be restricted by infrastructure along the shoreline. The mangrove stand planted in the seagrass bed in the wildlife sanctuary will eventually die out due to longer inundation period. It cannot move inward because the shoreline is too far away, with a limestone flat and outcropping further restricting its landward movement.

An important implication of the decline in mangrove habitat is the loss of roosting sites for migratory birds and also a source of fuelwood and forage.

Seagrasses

Seagrasses are affected by various environmental factors including temperature, salinity, substrate, water depth, waves, currents and turbidity. Edwards (1995) suggested that intertidal and shallow seagrass beds (<5 m depth) are most likely to be impacted by freshwater run-off from land and elevated sea surface temperature. This was considered to be the case for the seagrass beds surrounding Olango Island. An increase in precipitation could dilute the salinity of the shallow waters surrounding the island, potentially altering the distribution and abundance of seagrass species. With decreased salinity, new species may emerge replacing the previously dominant species. For example, *Enhalus* sp. can tolerate low salinities and may become dominant, replacing *Cymodocea* and *Thalassia*, both of which are halophylic.

Associated with seagrasses are some species of seaweeds or algae that are sensitive to changes in water temperature. *Enteromorpha*, a species of seaweed that given appropriate environmental conditions can rapidly proliferate (bloom), is abundant in the waters surrounding Olango. With the predicted increase in sea surface temperature by 2100 of 1–2°C (Watson et al 1996), algal blooms will most likely be a common occurrence in the waters surrounding the island. Thus, increased water temperature could also have major impacts on the abundance, distribution and community structure of the seagrass beds. Another response of seaweeds to increased water temperature is discolouration. This can cause heavy economic losses to some highly desirable seaweeds such as *Eucheuma.* Other reactions of algae to enhanced changes in salinity, water current and temperature include growth rate reduction, tissue softening and death. Other effects of climate change on seagrass beds include breakage of individual plants and destruction of whole natural stands due to intense typhoon winds, waves and storm surge. Seaweed farms are at risk from damage and destruction, as occurred on Hingutanan, Bohol, and Hilutungan, Cebu.

Terrestrial vegetation

The terrestrial vegetation of Olango will also probably be impacted by climate change and sea level rise. The predicted increase in air temperature and the intensification of El Niño will result in more extreme droughts that will most likely cause mortality of many of the terrestrial plants. While coconut palms may survive El Niño events, they will not yield good harvest. Terrestrial vegetation close to the shoreline may also be vulnerable to flooding and erosion due to sea level rise and increased storminess. Intense typhoon winds will result in more plant damage, breakage and felling.

Coral reefs

It is thought that coral reefs are particularly sensitive to increases in seawater temperature and increased irradiance (Watson et al 1996). In addition, an increase in the intensity and frequency of typhoons and monsoons is also considered to pose a significant hazard to coral reefs around Olango Island. As observed elsewhere, the most important response of corals to increased seawater temperature is bleaching (Watson et al 1996). Given that predicted increases in sea surface temperature are realised, effects such as bleaching, reduced growth and reproductive impairment may occur. Coral bleaching was observed in the early half of 1998 as a result of increased sea temperature due to the El Niño phenomenon (Chou 1998).

If present day typhoons and monsoons can break coral heads, then it is likely that predicted intensified typhoons will result in greater damage to coral reefs. With the predicted increase in frequency of typhoons, coral reefs will also be subjected more regularly to typhoons and consequently may have less time to recover. Furthermore, intense typhoons may hit Olango during low tide, resulting in storm surges damaging exposed and shallow coral reefs.

There are several other potential impacts of climate change and sea level rise on coral reefs, however, their significance for Olango Island may not be great. Dilution of seawater below 35 ‰ due to predicted intense precipitation may result in adverse effects on the distribution and survival of coral reefs (Engemen & Hegner 1981). Storm surges and amplified local wave climates can increase soil erosion and sub-tidal sediment disturbance, resulting in sedimentation on reefs and subsequent adverse effects on coral growth, reproduction and survival (Panutakul 1973, Sudara et al 1991). Sedimentation due to run-off from the regions of Mactan Island and Cebu is not considered a problem due to the spatial separation. These impacts are anticipated to be minor because of the small size of the island.

Aquatic fauna

Mean seawater temperatures around the reefs of Olango, including Danajon reef in Northern Bohol, range from 26–31°C, this being favourable for growth and development of most marine organism in the region. With the predicted increase in sea surface temperature, there is a possibility that the abundance, composition and distribution of marine species will be altered. Such community changes will most likely be a result of physiological and behavioural changes on individual organisms due to factors such as an increase in sea surface temperature or decreased salinity. Responses to such factors could include changes in egg incubation times (eg the fish, *Siganus*; Duray et al 1986), osmotic stress, impaired swimming/feeding ability, and even avoidance.

Wildlife

Wildlife, particularly the birds of Olango will most likely be affected both directly and indirectly by climate change and sea level rise. The birdlife is not thought to be vulnerable to predicted increase in air or sea surface temperature, but they are vulnerable to the predicted increase in storminess, intense typhoons and monsoons. Strong winds and rains during extreme events can force them to cease feeding and seek shelter and refuge. Storm surges may inundate and damage feeding grounds, thereby affecting bird feeding habits. In addition, strong winds are capable of causing injury to the birds especially during flight. A rise in sea level, even of 30 cm by 2030, could adversely affect birdlife by decreasing the exposed area of the major feeding grounds, the intertidal mud flats and seagrass beds. In addition, the mangrove, which provide roosting sites for the birdlife may also be greatly reduced. Such effects may result in many of the bird species not using the island as a stop-over site during migration.

Wildlife sanctuary

Given the above, it is obvious that the wildlife sanctuary as a whole is also vulnerable to the impacts of climate change and sea level rise. Impacts will include erosion, inundation, flooding, changes in habitat distribution or even habitat destruction, and changes to animal and plant species abundance, diversity and distribution. In addition, intense typhoons and storm surges may damage or destroy the nature centre, boardwalk and observation hides. Sea level rise will have a major impact. For example, a 95 cm rise in sea level by the year 2100 will result in long-term inundation of more than 50% of the sanctuary, particularly during high tide.

7.2.3 Socio-economic attributes

Impacts on the geophysical and biological attributes of Olango Island will ultimately impact upon the local people and their lifestyles. Given this, it is obvious that the socio-economic attributes of Olango will be vulnerable to climate change and sea level rise. In addition, direct impacts to socio-economic attributes would also be observed. The expected vulnerability of the major socio-economic attributes of Olango to climate change and sea level rise is shown in table 24.

Table 24 Summary of the vulnerability of major socio-economic attributes of Olango Island to predicted climate change and sea level rise (- negative impacts, + positive impacts, 0 no impacts)

		Sea level rise	
Attributes	**Climate change**	**30 cm by 2030**	**95 cm by 2100**
Population	–	–	–
Livelihood	–	–	–
Fishing	–	0	0
Aquaculture	–	–	–
Infrastructure	–	–	–
Communication	0	0	0
Power	–	0	–
Transportation	–	–	–
Tourism	–	–	–

Population

In the densely populated areas of Malabon and Navotas in Metro Manila, it is predicted that the population may survive the increase in sea level rise but not the increased intensity of storm surges, and even typhoons and monsoons. The population centres of Olango are situated in coastal locations making them extremely vulnerable to climate change and sea level rise. Inundation and flooding due to storm surge and sea level rise may inundate and damage human dwellings and other property, while lives may also be lost. Those families which cannot move to higher grounds may be forced to migrate either to Mactan, Cebu or elsewhere.

Livelihood

Livelihood, fishing and agriculture will also be affected. Increased storminess, intense typhoons, monsoons and storm surges will result in interruptions to, and even cessation of business operations, such as small stores, fishing and plant cultivation. Gleaning in the seagrass beds and collection of fry and edible seaweeds will also be hindered. Sea transportation to and from Olango will be more restricted, and this will have flow-on effects on tourism and other business activities. Tourism will most likely suffer from climate change and sea level rise, particularly if the rich biological resources such as the coral reefs and other marine life are damaged. In addition, the erosion of sandy beaches due to storm surge and sea level rise will also adversely affect the tourism industry. Damage to agriculture will most likely result from intense typhoons as more coconut trees, kalamungay, breadfruit trees and other cultivated plants are damaged or destroyed. In addition, the intensification of El Niño may also cause damage to agricultural crops during these periods, through water shortage and heat stress. In contrast, increased rainfall and CO_2 levels could serve to increase plant productivity. The extent to which such factors counteract each other, and the ultimate extent of impacts on crops and other plants remains uncertain and needs to be assessed.

Inundation of the seagrass beds, mangroves and reefs due to sea level rise will reduce their accessibility for livelihood activities, such as shellfish collection (gleaning), coral collection, and mangrove and seagrass harvesting. Small businesses close to the shoreline will need to relocate to higher ground, or alternatively to Mactan or Cebu. Fishing and fishing-related activities will be adversely affected by sea level rise. Fishing methods will become less efficient with the rise in sea level, and will need to be adapted. Fishing is usually done during low tide when the water is shallower and fish are easier to catch. Thus, unless fishing methods can be adapted, reef fish and other reef-associated catch, such as lobster fry, are likely to decrease. On a positive note, illegal fishing methods such as cyanide-fishing and blast-fishing might be reduced due to increased water depth and the migration of fishermen to other regions. In addition, inundation and possible loss of mangroves in the sanctuary may have adverse effects on rabbitfish recruitment, resulting in subsequent decreases in rabbitfish fry catch.

The effect of climate change and sea level rise on local water supply is uncertain. Increased rainfall due to increased intensity of storms and monsoons will most likely result in an increased supply of freshwater for domestic uses. However, the effects of sea level rise may result in increased saltwater intrusion into the fresh groundwater lens, rendering the water less suitable for domestic use. Again, the extent to which these factors will counteract each other is yet to be understood.

Infrastructure

Increased intensity of typhoons, monsoons and associated wind, rain and storm surges, and sea level rise will greatly affect the infrastructure on Olango Island. Some of the major infrastructure at risk includes the churches, school buildings, the emergency hospital, the power plant and associated electricity poles, the beach resorts and the jetty in Santa Rosa. The 'jetty' could be extremely vulnerable to sea level rise during the south-west monsoon, when strong winds, currents and high tides combine to increase the wave action on the 'jetty'. Similarly, the nature centre, observation hides and boardwalk will also be particularly affected by sea level rise during the south-west monsoon, when strong winds, tidal currents and high tides combine to produce storm surges that can be destructive to these facilities. The church building in San Vicente, which is located near the shoreline will likewise be inundated. In addition, some segments of road, such as that along the coastal sections of Santa Rosa, San Vincente and Sabang may be damaged by sea level rise and storm surge. Consequently, transport mechanisms will be impaired, unless new roads are constructed. Disruption of the infrastructure will have flow-on effects on transport links and tourism on the island.

7.2.4 Significance of vulnerability

Previously, it was emphasised that in order to evaluate vulnerability of Olango Island to climate change and sea level rise, an understanding of the vulnerability to existing forcing factors, or coastal hazards, was required. The degree of vulnerability to each of these will depend on a number of factors, including the proximity to the coastline, elevation and the degree of human exploitation.

Attributes which are located along or very near the coastline, and have a higher degree of human exploitation, are vulnerable to existing and future anthropogenic forcing factors. Their degree of vulnerability to climate change and sea level rise will be greater than their vulnerability to existing natural forcing factors since it is predicted that there may be increases in the intensity and even frequency of present day typhoons, monsoons, storm surges, El Niño and La Niña. As a result of predicted climate change, the magnitudes of impacts and their effects on the various attributes will likewise intensify.

Therefore, the degree of vulnerability to current natural forcing factors will increase with the intensification of the physical factors related to climate change and sea level rise. Higher vulnerability will mean greater damage that the impact can inflict on the resource. Knowing which attributes will be vulnerable to climate change and sea level rise, and their effects on the resources, is very important in determining what mitigating responses and preventative measures should be developed and implemented so that damage may be avoided or minimised.

8 Current responses to coastal hazards

8.1 Planning and policy

Appropriate management of the resources on Olango requires a concerted effort, not only by the barangays, but also provincial, regional and national agencies. The coastal hazards facing Olango are substantial and they are taking their toll on the condition of its resources. Being an island of international importance for biodiversity, Olango needs to be proactive in addressing the various sustainable management issues so that the rate of resource degradation can be arrested and hopefully reversed.

Some of the best approaches in the control and management of the resources of Olango are to formulate policies, regulations and management plans that can address the various issues that confront Olango today. Several resolutions and ordinances have already been passed at the barangay level, which provide for the proper development of the coastal resources of Olango (table 25). Both at the regional and national levels, a number of Republic Acts, Presidential Decrees, Executive Order Memorandum of Agreement, and other policies have been passed and approved that govern the control and utilisation of the coastal resources of the country, including the island of Olango (table 26).

The management of the coastal attributes of Olango, particularly water, wildlife, mangroves, seagrass beds and coral reefs, will need the concerted effort of the barangay leaders and the community, technical experts and decision makers from the city, provincial governments, national agencies and non-governmental organisations. However, one thing that should be recognised is that these agencies, government and non-government, have concerns other than coastal development, so that it is important to re-channel some resources toward this end. It is therefore proper in perspective to review some policies and regulations pertinent to the development of the coastal environment of the island in particular and the country in general.

Table 25 Barangay resolutions and ordinances related to coastal resource management of Olango Island (CRMP 1998)

Barangay	Ordinance #	Date	Description
Santa Rosa	Ord. # 03-97	09-Sep-97	Levying wharfage fee to all boat owners/operators docking in causeway port for business transaction.
	Ord. # 34-96	02-Jun-96	Interposing vehement objection against application of foreshore lease on Mr. Antonio Dy, along the shore of Santa Rosa wharf.
	Res. # 17-93	10-Oct-93	Favourably endorsing the application of Mr Samuel Regual to the Office of Provincial Governor of Cebu to extract sand from seawater of Santa Rosa.
San Vicente	Ord. # 06-95/	06-Sep-95	Declaring the fishing ground of San Vicente as Fish Sanctuary and Marine Reserve and imposing penal sanctions for violation prohibitive acts thereof. 1st offense – P50, 2nd offense – P1000 and 3rd offense – P1500 or 1 mos. Imprisonment or both.
Sabang	Res. # ?	Oct. 1995	Imposing no objection on the foreshore lease application of Alenter Resort Hotel Corporation over a 200 Ha. Foreshore area situated between Sulpa Is. and Hilutungan Is. and within territorial waters of San Vicente, Lapu-lapu City.
Tungasan	Ord. # 24	18-Apr-95	Enforcement of Bantay Dagat to implement rules.
	Ord. # 28	Jul. 1995	Landing fee. Selling of colon –P5, nipa – P10, fruits – P5 and wood – P5.
	Ord. # 27	27-Jun-95	Planting of coastal trees for environmental concerns.
	Ord. # 10-96	Mar. 1996	Prohibiting any illegal fishing activities.
	Ord. # 12	02-Aug-97	Prohibiting other barangays to glean in the intertidal waters of Tungasan.
Cao-oy	Ord. # 02	10-Aug-97	Prohibiting all residents in throwing garbage inside the territorial seawater and seashore of Barangay. Cao-oy. Penalty P200.
Baring	Res. # 1	07-May-89	Prohibiting the transport of sand to another Barangay. Penalty of P100 per violator.
	Res. # 3	07-May-89	Prohibiting the weeding of seaweeds ‘lumot’ at the seashore of Barangay. Baring. Penalty of P30 plus confiscation of seaweed.
	Res. # 07-95	09-Oct-95	Obstructing the application for preliminary approval and location clearance of Alenter resorts and Hotel Corporation. Relative to their offshore lease application on the shoreline belonging to Barangay. San Vicente.
	Res. # 09-95	29-Oct-95	Imposing no objection on the foreshore lease application of Alenter Resort Hotel Corporation over a 200 ha foreshore area situated between Sulpa Is. and Hilutungan Is. and within territorial waters of San Vicente, Lapulapu City.
Pangan-an	Res. # 5	20-Oct-95	Imposing no objection on the foreshore lease application of Alenter Resort Hotel Corporation over a 200 ha foreshore area situated between Sulpa Is. and Hilutungan Is. and within territorial waters of San Vicente, Lapulapu City.
	Res. # 30-94	09-Sep-94	Authorising the Barangay. Chairman to execute contract with Pangan-an constituents for the deepening of the passage boundary of the Olango Channel near Sulpa Is. towards the extending ‘Awo’ within the jurisdiction of Barangay. Pangan-an and for other purposes.
Caohagan	Res. #?	21-Oct-95	Imposing no objection on the foreshore lease application of Alenter Resort Hotel Corporation over a 200 ha foreshore area situated between Sulpa Is. and Hilutungan Is. and within territorial waters of San Vicente, Lapulapu City.

Table 26 Laws, proclamations and policies relevant to the control and use of coastal resources in the Philippines

Republic Act 6541 – An act regulating the use of electric fishing.
P.D. 704 as amended by P.D. 1058 – A decree banning the use of dynamite and cyanide fishing.
Fishery Administrative Order 155 – Regulates the use of fine mesh nets.
P.D. 1219 – regulates the gathering of corals.
Local Government Code – Authorises the local governments to enact ordinances pertaining to the utilisation of the coastal resources.
Executive 240 – mandates the creation of fisheries and aquatic resources management councils.
Conservation on the International Trade of Endangered species.
DA-DENR Joint General Memorandum of Agreement Order No. 3, series of 1991 – prescribes the guidelines to the reversion of fishpond lease agreements into mangrove forestlands.
DA-DAR Administrative Order November 18, series of 1991 – prescribes the guidelines in the redistribution of cancelled and/or expired FLAs to agrarian reform beneficiaries.
R.A. 7586 – The National Integrated Protected Areas System Act provides for the proclamation of marine protected areas.
DENR Administrative Order No. 54 – provides for the established of a National Bird Banding System.
Department Administrative Order No. 03, 1991 – provides for the guidelines for the award and administration of the mangrove stewardship agreement.
DENR Administrative Order No. 15, 1990 – provides for the regulation governing the utilisation, development and management of mangrove resources.
Memorandum Circular No. 15, 1989 – prioritises the reforestation of mangrove areas.
Fishery Administrative Order 163, 1996 – regulates the use of Moro-ami and shoreline fishing.
FAO 156. 1986 – provides for the guidelines in the use of trawls and purse seine within 7 km from shoreline of all provinces.
Presidential Decree 1081 – decree designating Olango as a tourism zone.
Republic Act 8550 – provides for the policies pertaining to fisheries and fisheries related activities.
Ordinance No. 8 – passed in Lapulapu City regulating the hunting of birds in Lapulapu City, Olango Island, Calubian, Pangan-an and Caugan Island.
ABC Resolution No. 1 – 1998 – resolving that Olango is protected from any form of hunting, collecting and exploitation that would endanger the wildlife.

The provisions are not presented in detail, but rather a general statement is presented to describe briefly the policy. However, many policies do not have provisions on what measures to take should there be any rise in sea level, and how it should be addressed. If there is no provision that can fully or even partly address sea level rise, in what condition will the coastal environment find itself? The community cannot deal with it alone. Thus, it requires interaction and cooperation between the local community, the city government, the Philippine Tourism Authority and the DENR. It is imperative that a multi-sectoral planning effort be organised to deal with the problem holistically, not piecemeal.

A number of management plans have been proposed for Olango by concerned agencies including the Lapulapu City Government, the Department of Environment and Natural Resources, and the Coastal Resource Management Project. It is only a matter of time before these plans are literally translated into some visible and realistic structures together with financial resources and committed leadership.

The proposed land use plan for Olango Island lists four major items (Mactan Integrated Master Plan, Vol. 1 1996):

- Establishment of a commercial district in Santa Rosa to expand later to the northern and southern parts of Olango.

- Establishment of a tourism area in the eastern part of the island to promote ecotourism for the sanctuary.
- Establishment of high level and low-level residential areas in the centre of the island.
- Some areas in Olango shall be declared protected including the Olango wildlife sanctuary. This will remain as such ‘to keep the natural character of the island’.

The residential area in the proposed land use plan is located at the site where the freshwater lens is situated (figure 12). This might not be compatible with the proposed plan to protect the freshwater lens and its major catchment area.

A total of four reclamation projects have been proposed for Mactan and Cebu City. It is anticipated that these development activities may directly or indirectly affect the various attributes of Olango Island. The projects are:

- *South Mactan Reclamation Project:* This area is about 1600 ha in size. A part of this will be converted into a container port for domestic and international vessels. The western coast will be the site of the proposed industrial zone.
- *North Mactan Reclamation Project:* This is a 120 ha project site for the expansion of the Mactan Export Processing Zone.
- *East Mactan Reclamation Project:* A strip of land 200 metres wide and six kilometres long where some 170 hotels and resorts will rise.
- *Cebu City South Reclamation Project:* This will cover an area of about 400 ha to accommodate the proposed coastal road.

One of the participating agencies in the vulnerability workshop conducted in December 1998 was the Coastal Resource Management Project (CRMP), a USAID funded project that is being implemented in Olango Island. Five interventions have been proposed for Olango as follows:

- Develop various alternative enterprises – ecotourism, seaweed farming, fish-cage culture, handicrafts
- Create an island-wide Coastal Resource Management Council
- Designate zones for specific uses
- Intensify information, education and communication campaign.
- Intensify law and policy enforcement.

In a workshop conducted by the Department of Environment and Natural Resources – Region 7 in October 1998, ten proposed management activities for the sanctuary were drafted and will be prepared for implementation. Their aim was to achieve a better environment and sustainable development of the island’s coastal resources. The proposed activities are as follows:

- Widen and elevate the jetty and consider impacts of sea level rise.
- Require jetty contractor to turnover the jetty to the Lapulapu City Government for repair, rehabilitation and improvement.
- The Department of Public Works and Highway may introduce measures to improve the usefulness of the jetty.
- Implement provision of Presidential Proclamation 1081.
- Formulate a better water distribution system in Olango.

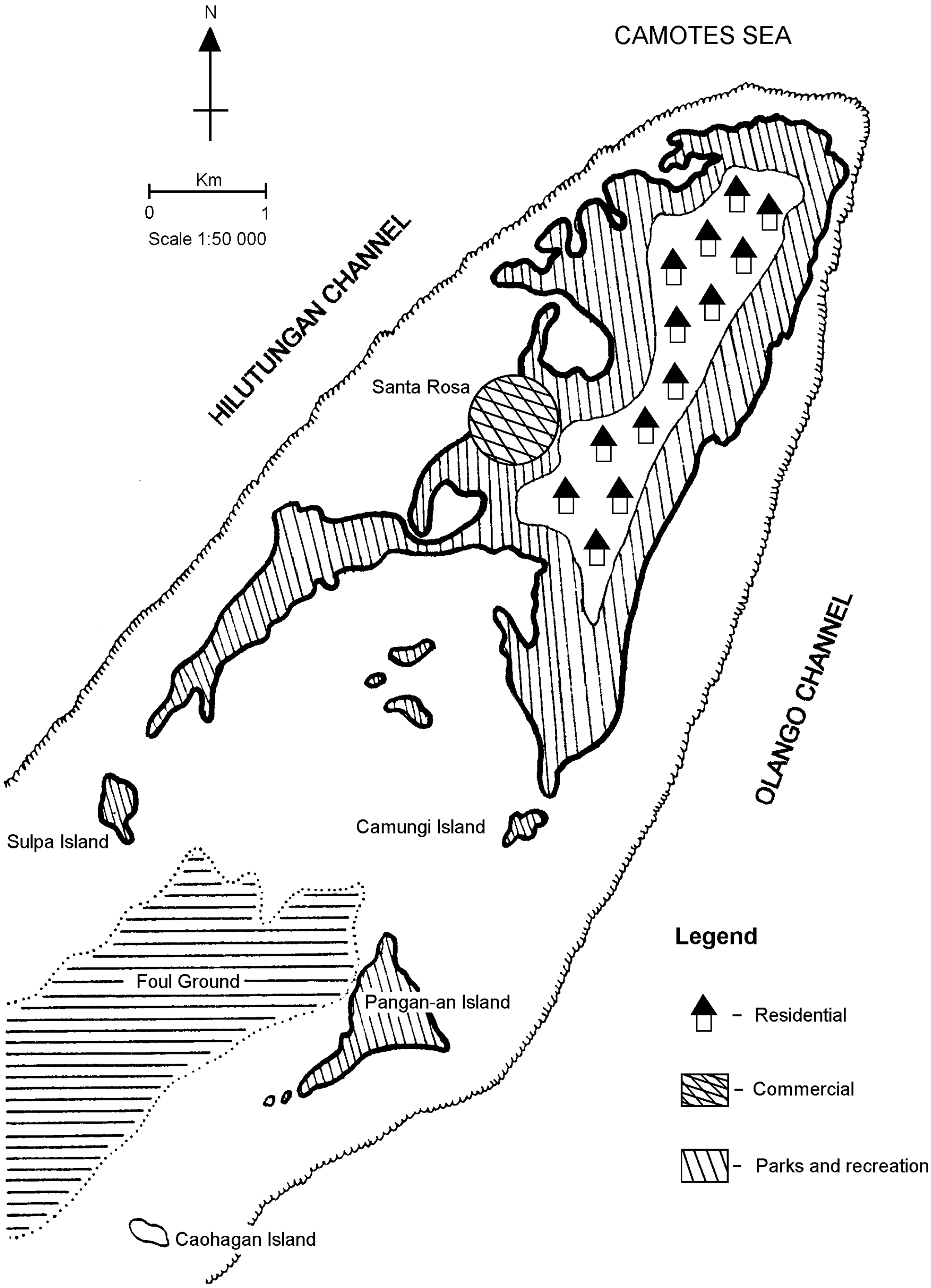

Figure 12 Proposed land use plan for Olango Island (Lapulapu City 1996)

- Avoid installing water pumps close to the sea to prevent seawater intrusion.
- Ban of construction/dwellings in areas above the freshwater lens.
- Create a people's organisation to protect the freshwater lens area.
- Plant ipil-ipil to facilitate water usage and as fuelwood source.
- Require small voluntary monitoring donation from water users.

Included in the policy action plan for the Philippines are eleven policy options that have been proposed for adoption by the coastal resource sector. These are as follows:

- Formulation of guidelines and legislation for the implementation of an integrated coastal zone management for all coastal zones in the Philippines. Land use planning in coastal zones will help reduce vulnerability to a rise in sea level. Mechanisms for coastal zone management must include: requirement of setbacks, allocation of low-lying vulnerable land to lower value use such as parks rather than housing, requirement of compliance with construction standards or post-storm reconstruction standards. These policies reduce the risk of living in coastal areas from current climatic variability and protected against potential sea-level rise.
- Formulation of guidelines and legislation for the implementation of an integrated coastal zone management for all coastal zones in the Philippines.
- Mangrove resources development should be institutionalised through the formulation of additional policies and regulations (like DAO No. 15, S1990) or amending existing policies and regulations to allow effective and sustainable mangrove management highlighting the massive reforestation of degraded mangrove systems through a community based approach.
- Public easements and buffer strips should be treated as separate lots during land surveys. These should be excluded from tilling or private ownership. However, to avoid large losses, flexible land-use policies maybe opted such as presumed mobility which do not completely prohibit development but allows markets to avail of climate change information to determine whether development is economically feasible. Variation of this policy include: requiring property owner to remove threatened coastal structures if sea level rise is observed, provision to adjust land ownership on the basis of tidal regimes according to the changes in the tides and/or, provision in coastal land deeds that revert the land back to public ownership if in so many years if the sea level rises to a specified amount.
- LGUs should be required to reserve foreshore areas, which are critical for recreation/tourism purposes, and other public uses and are excluded from disposition.
- Inclusion of wetlands/swamps/marshes in the NIPAS with a category of wildlife sanctuary or unique ecosystem. Preservation efforts should be made to maintain wetlands/swamps/marshes that are more likely to withstand a sea-level rise. Wetlands/swamps/marshes are valuable natural areas that are difficult to recreate; therefore, current and future efforts are warranted to protect the area. Protecting these areas will also improve water quality, flood control and habitat under current climate conditions. Concerning these, guidelines for the proper use and management of wetlands/swamps/marshes must be drawn up and funds provided for their implementation.
- A multi-hazard mitigation/protection plan for natural coastal hazards must be developed with priority on the maximum reduction in threat to life, structures and economic production. This must include the provision of or improvement of and/or increase of

existing networks of collecting/observing platforms for monitoring these hazards, prediction, warning and system of communication to disseminate such warning. Funds for disaster relief could be tied up to the implementation of long-term hazard reduction policies. Benefits are independent of climate change as risks from current disasters are likewise reduced.

- Formulation and strict implementation of mining laws, reforestation of denuded watersheds to reduce river/coastal erosion.
- Requirement of geological, hydro-meteorological and structural engineering evaluation as part of the environmental impact assessment prior to coastal development. This will allow also to redirect growth away from sensitive lands and move towards less vulnerable area to reduce the risks of sea-level rise as well as from severe coastal hazards that occur in the present climatic conditions. Engineering standards may provide the incorporation of marginal increases in the height of coastal infrastructures, such as bridges, ports, sewage outflow treatment plants or sea walls, to offset a sea level rise. Such provisions are less expensive to make while construction is in progress rather than after initial work has been completed.
- Limitation of government subsidies or tax incentives to develop land sensitive to sea-level rise, such as barrier islands, coastal wetlands, estuarine shorelines and critical wildlife habitats. Additionally, insurance and banking industries maybe encouraged to factor risks of climatic variability into investment decisions, thereby, reducing reliance on government subsidised insurance and disaster relief.
- Climate change impacts on coastal zone systems are not well understood by the public or decision makers, promotion of awareness about erosion sea level rise, flooding risks and storm/earthquake standard building code, could be a cost effective means of reducing future expenditures.

8.2 Infrastructure

Olango Island lacks infrastructure that is solely for providing shelter and protection against coastal hazards. There were concrete rock structures in what used to be Santa Rosa Bay. In addition, there is a sea resort in south-west Olango but this has been abandoned and damaged.

In the south-west, toward the north and northwest, the rocky coast has been reinforced with concrete structures primarily to prevent damage on the shoreline.

It is not likely that the existing infrastructure in Olango has been designed and constructed with some consideration on the rise of sea level in the future. In most instances government infrastructure is made to last 20–25 years but other structures do not last that long. Most structures collapse and are destroyed even before they outlast their usefulness. The Santa Rosa 'jetty' was continually extended until the seaward edge of the coral reef was reached. The end portion has been damaged with the concrete structure cracking due to impact from the wave action. Its height is just within the reach of salt spray and this has produced giant potholes on its platform.

8.3 Monitoring

In 1996, the Save Nature Society, with financial assistance from the Wildbird Society of Japan, monitored the population of the birds, the rate of soil deposition and displacement, mangrove growth, the zoobenthos, and water quality in the sanctuary. Unfortunately, the monitoring activities ceased because of some changes in the DENR Policy regarding the conduct of monitoring status within a protected area.

The Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) regularly monitors the rate of precipitation, temperature, and humidity and the direction and velocity of typhoons and other weather disturbances. The National Mapping of Resources Information Agency (NAMRIA) through its tide station in Cebu City monitors and predicts tidal currents, levels and time of occurrence.

The Department of Environment and Natural Resources Region 7 conducts monitoring of bird populations and sea level in the sanctuary.

The City Disaster Coordinating Council and the Department of Social Welfare and Development are given the authority to conduct assessment and evaluation of the extent of damage the typhoons, monsoons, and other climatic distribution can inflict on Olango. A team is normally sent to typhoon damaged areas to determine the kind and cost of the damage after each typhoon. The result of the visit is used to determine the allocation of emergency goods and services that will be provided to typhoon victims. In general, they are given canned goods and a few kilos of rice and used clothing.

9 Future monitoring requirements and management strategies

Monitoring is a valuable tool in effective coastal management because without it departures from normal or average conditions cannot be detected. The sea level for instance may be suspected to remain at a certain point imperceptibly, but if there is a scientific means of measuring any fluctuation in the sea level, one may be able to conclude that sea level indeed is rising. Following is a list of major parameters that need to be monitored in the future to be able to support or reject the predictions of climate change and sea level rise, and also to further understand the processes of change on Olango Island:

Geophysical Attributes: Soil deposition/displacement rate, sand bar shifting, mean sea level fluctuations, storm surge, water current, shoreline erosion, water and air temperature, groundwater salinity, rate of groundwater extraction, capacity of freshwater lens, transmissibility, limestone porosity.

Biological Attributes: Bird populations, mangrove growth and distribution, seagrass cover, impact of mangrove plantation on seagrass beds, zoobenthos population, substrate temperature in the mangrove forest, location and type of roosting sites, coral cover, reef fish biomass, fish catch/shell catch.

Socio-Economic Attributes: Population structure, standard of living, health condition, educational attainment, number of resorts/tourists, number and type of infrastructure.

Management strategies to help achieve sustainable development of Olango and also to effectively manage for the effects of climate change and sea level rise have been proposed previously by DENR as well as the CRMP and other organisations/agencies involved in the management of Olango. In particular, proposed management activities for the wildlife sanctuary include:

- Habitat maintenance for bird protection
- Zoning of the wildlife sanctuary
- Identification of allowable activities

- Education of local communities on natural resource management
- Maintenance of buffer zone
- Provision of livelihood projects
- Endorsement of ecotourism
- Creation of job opportunities
- Provision of additional income for local government
- Community development
- Institutional linkages

In addition, the workshop on the vulnerability assessment of Olango Island proposed a number of other management strategies and monitoring requirements for some of the major attributes of Olango Island. The proposed measures are aimed at managing to mitigate impacts of climate change and sea level rise, and are summarised in table 27.

10 Links to regional and national policy

The impacts of the anthropogenic forcing factors may be specific for Olango but those due to natural forcing factors, and regional climate change and sea level rise will be broader ranging, affecting the surrounding islands and the Philippines as a whole. While Olango does not contribute significantly to the elevation of greenhouse gases compared with the urbanised cities of Mandaue, Cebu and Manila, the island will still experience the consequences, being increased sea level due to global warming and the associated impacts.

It is important to integrate the concept of sea level rise in the management plans of all agencies concerned at the local, regional and national levels. The more important aspects of the plan should incorporate strategies on the sustainable use of the resources, 'disaster preparedness and emergency responses'.

In the country, the management of coastal resources of low-lying islands is not only governed by policies legislated at the barangay level, but also by laws and regulations approved at the national levels. Whatever national legislation there is can be promulgated at the local level.

11 Identification of information and research gaps

Although Olango Island has been very well studied compared to other islands in Central Visayas, further information on the coastal and social attributes needs to be gathered. A review of the literature pertaining to Olango showed that many studies have been undertaken by various agencies, covering a wide spectrum of subjects from salinity measurements to bird species monitoring. Even the coastal profile of the island, which could be the most comprehensive publication on Olango, is not as comprehensive as it should be. In the course of preparing this assessment, it was discovered that much information could not be incorporated in this report because it is either incomplete or missing. The following are information and research gaps that need to be addressed in order to make the data for Olango as complete as possible to give future researchers the advantage of access to a more comprehensive literature survey:

- Storm surge data
- Volume and location of sand and corals extracted

Table 27 Proposed management measures to mitigate impacts of climate change and sea level rise on Olango Island

Attribute	Management measures
Geophysical:	
Topography	Construction of wave breakers
	Review policies on mangrove establishment
	Ban the harvesting of erosion resistant vegetation
	Ban the extraction of soil along shoreline
	Intensify information and education campaign
Hydrology	Regulate groundwater extraction
	Intensify information and education campaign
	Review proposal to close the bays
	Installation of rain collectors
	Declare area over freshwater lens as protected
Biological:	
Fishery	Shift to other livelihood
	Intensify law enforcement
	Intensity information and education campaign
	Establish fish sanctuaries
	Install fish attraction devices
Coral Reefs	Implement proper solid waste disposal
	Intensify law enforcement
	Intensify information and education campaign
	Encourage 'reef tourism'
	Identify more recreational dive sites
Seagrass Beds	Intensify information and education campaign
	Try seagrass planting
Mangroves	Enrichment planting in natural stands
	Intensify information and education campaign
Land Vegetation	Enhance planting of salt tolerant species
	Encourage planting of fruit trees
	Intensify information campaign
	Revegetate water catchment area
Wildlife Sanctuary	Intensify mangrove cluster planting around nature centre
	Intensify information campaign
	Update management plan
	Develop community-based ecotourism and livelihood options
Socio-economic:	
Coastal Population	Retreat for about 10 m from the highest tide level
	Toilets must be installed away from freshwater source
Agriculture/Livelihood	Protect and accommodate
	Shift to other alternatives
Transportation/Roads	Protect and elevate road level
	Retreat for about 10 m from highest tide level
Freshwater distribution system	Protect, implement Water Resources Centre recommendations

- Typhoon damage on property, lives, coral reefs, seagrass beds
- Biology and ecology of endangered species in the island
- Water current studies
- Substrate deposition and displacement data
- Groundwater salinity and transmissibility data
- Limestone porosity to water seepage studies
- Water pollution pathway from urban pollution sources
- Duration of inundation of seagrass beds
- Economics of the tricycle industry
- Cost of dynamite, cyanide and poison destruction
- Impacts of mangrove forestation on the seagrass beds in the sanctuary
- Detailed topographical information for Olango Island.

12 Conclusions

The island of Olango with its limited coastal and terrestrial resources is in a critical period of its development, survival and progress. Its future does not depend so much on the industrial investment that the concerned agencies may put into the island, but on how well the islanders are able to sustainably develop their natural resources. Should the rate of exploitation remain unregulated and uncontrolled, the time will come when all that is left are mangrove trees, seagrasses and coral skeletons. The overall poor condition of the island is lamentable and is compounded by the harsh impacts of some natural disturbances and the predicted impacts of climate change and sea level rise. Being a small and low lying island, its vulnerability to both anthropogenic and natural forcing factors is realistically high. Therefore, any imbalance that is imposed on the resources can severely affect and deplete them. The higher the degree of depletion the greater is the vulnerability to the impacts of forcing factors, including climate change and sea level rise. Recognising that Olango is indeed vulnerable, it is imperative that existing policies and regulations are enforced and new ones formulated to mitigate possible impacts on both natural and man-made interventions. As a strategy to help minimise the rate of resource degradation, agencies have devised their respective management plans for the island. These plans integrate proposed land use, infrastructure, tourism and livelihood opportunities, but one component that has not been considered in these plans is the aspect of climate change and sea level rise. It is therefore important to integrate climate change and sea level rise in the management plans on both local and national levels.

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