Vulnerability Assessment of the Belize Coastal Zone

Enabling Activities for the preparation of Belize's Second National Communication (SNC) to the United Nations Framework Convention on Climate Change (UNFCCC) Project

UNDP/GEF Climate Change Project

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List of Acronyms

AR4	Fourth Assessment Report (IPCC)
APAMO	Association of Protected Areas Management Organizations
AVVA	Aerial Video-assisted Vulnerability Assessment
BCC	Belize Climate Committee
BNTF	Basic Needs Trust Fund
BTGA	Belize Tour Guide Association
BTB	Belize Tourism Board
BTIA	Belize Tourism Industry Association
BZD	Belize Dollar
CARICOM	Caribbean Community
CCCCC	Caribbean Community Climate Change Centre
CARDI	Caribbean Agricultural Research and Development Institute
CZMAI	Coastal Zone Management Authority and Institute
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
GoB	Government of Belize
EIA	Environmental Impact Assessment
IPACC	Intergovernmental Panel on Climate Change
Met	Meteorology (Department)
MBRS	Mesoamerican Barrier Reef System
NFP	National Forest Policy
NGO	Non-Governmental Organization
PCB	Pesticide Control Board
SIB	Statistical Institute of Belize
SIF	Social Investment Fund
TAR	Third Assessment Report (IPCC)
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
WGI	Working Group I
WGII	Working Group II
WGIII	Working Group III
WMO	World Meteorological Organization
WRI	World Resources Institute

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Executive Summary

Global climate change is a phenomenon that is not new to science. Since the formation of the earth it has gone through several heating and cooling periods. However, data from paleontological sources suggest that the present warming trend is happening at a much faster rate than in the past, and that the increased rate of warming is due to anthropogenic drivers, primarily the burning of fossil fuels, which increases the concentration of greenhouse gases (GHGs) on the planet.

The United Nations Framework Convention on Climate Change was presented in1992 at the Rio Summit and came into force in 1994. The Convention has been signed by 194 countries and sets the framework for intergovernmental collaboration on responding to the impacts of climate change. The Intergovernmental Panel on Climate Change was set up by the World Meteorological Organization (WMO) and the United Nations Environmental Programme (UNEP) to provide scientists and policy-makers with an objective source of information on the matter of climate change. The panel has concluded that climate change is a reality and that it is driven in part by anthropogenic factors. Work done by the various Working Groups of the IPCC have provided evidence that sea surface temperatures have increased by a mean of 0.13°C per decade since the mid 1800s. Mean sea level has risen 2 mm per year in the Mesoamerican region. The panel also projected an increase in the frequency and severity of storms. Under the terms of the Convention, Belize has a commitment to prepare, implement and regularly update national initiatives to mitigate the effects of global climate change. This report is in partial fulfillment of that commitment.

The country of Belize is on the southern half of the Yucatan Peninsula and share geo-morphological features with the northeastern section. It is predominantly flat limestone that rises in the south and west of the country. There are 23 major watersheds that empty onto the barrier platform. The northern 2/3 of the coast is between 0 – 1m above sea level and rises gradually to between 1 – 3 m in the south. The barrier reef is located 14 – 35 km off the coast. It forms a barrier lagoon that varies in depth from a mean of 5 m in the north, to 60 m in the south. Numerous mangrove and shingle cayes are found within the barrier platform and the atolls, and range from 0 – 2 m in elevation. Coral, sea grass and mangrove are the predominant habitat types within the barrier lagoon and the atolls.

The Belize coastal zone is of social and economic importance. Belize has an open economy with a per capita GDP of over $8,000. The three major industries, in the coastal zone, tourism, aquaculture and fisheries, account for some $600 million Belize Dollars in 2006. Tourism is the largest income earner, averaging $500 million of the $600 million BZD. Fisheries and Aquaculture earn $25 and $70 million BZD respectively. Belize has a young and diverse population. Approximately 58% of Belize's 311,400 are below 25 years of age. The country has a labour force of 112,000 and an employment rate of 9.6%. The population of the country is divided almost equally between males and females. Thirty eight percent of the population resides on the coast and on the cayes.

This report was put together using information from two main sources, available literature and interviews with key stakeholders. The coastal zone is defined in the Coastal Zone Act, Chapter 329 of the Laws of Belize Revised Edition 2000, as the area extending from the mean high water mark along the coast, to the limits of the territorial sea, including all coastal waters. For the purposes of this report the coastal zone boundaries were extended to include lowland areas susceptible to flooding. The most recent IPCC report recommended that vulnerability assessments include socioeconomic and biophysical vulnerability to climate change. As recommended by the IPCC a scenario developed by the National Meteorological Service (NMS) was used to provide socioeconomic context for the report. It attempts to provide an idea of what the social and economic driver will be in the future and it predicts Belize as being more self-reliant and with increasing technological capacity in a heterogeneous world that has consolidated into the series of autonomous regions. Belize will continue to rely on its natural resources.

Major impacts on biophysical resources will be from sea level rise, increased sea surface temperatures, changes in weather patterns and increased storm activity. Corals are the most susceptible to increased sea surface temperature and frequent storm events. Corals will be lost due to bleaching, disease and physical damage. Mangroves and sea grass beds will be most susceptible to changes in weather patterns and storm events that will result in physical damage and changes in biological processes such as reproduction. Mangroves are expected to retreat sequentially to maintain their position within the ecosystem. Coastal areas, beaches and cayes will be most susceptible to increasing sea levels and increase in storm events. These areas would suffer from inundation, erosion and storm surges. The socioeconomic impacts will be from loss of habitat and coastal areas which in turn will directly affect the tourism and fisheries industries. Impacts to the Aquaculture are expected to be minimal.

Using the recommendation of the second vulnerability assessment done by Gibson and Ariola in 1999 as a baseline, an evaluation of the capacity to adapt to climate change was done using four criteria: governance, social, economic and ecosystem. Based on that evaluation it was concluded that the necessary structures are in place to reduce the country's vulnerability to climate change, but there was a need to streamline and improve certain things. As a result the following recommendations were made:

- Revitalize and reconstitute the Belize Climate Committee.
- Revitalize and strengthen the Coastal Zone Management Authority through a revised mandate and with increased staff.
- Bring back the Annual State of the Coastal Zone Symposium or some similar forum for the presentation of technical information on the work that is being done within the coastal zone.
- Conduct a series of country-wide Baseline Assessments within the major habitats.
- Develop an incentive programme that encourages the private sector to actively participate in adaptation to climate change.
- Establish a functional Information Clearing House.
- Revise and streamline the current legislation and policy that relate to the management of the coastal zone to eliminate overlaps and close existing gaps.

- Improve the coordination of interagency cooperation and exchange of information.
- Undertake measures to increase compliance particularly with regard to coastal development.

- Develop a Public Awareness and Education Strategy.
- Consolidate and Strengthen the MPA system.
- Expand and Streamline the Ecosystem Monitoring Programme.

1.0 Introduction

1.1 Climate Change

The United Nations Intergovernmental Panel on Climate Change (IPCC) defines climate change as "*…a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods*."

The concept of Global Climate Change is not new to science. Paleoclimatology is a well established branch of climatology and is the study of climate change taken on the scale of the entire history of Earth. It uses records from ice sheets, tree rings, sediment, and rocks to determine the past state of the climate system on Earth. Through the use of the various methods outlined, science has been able to show that there have been major changes in climate over the period of the existence of the earth. These changes generally occur over periods that span thousands or millions of years.

The presence of ice fields and ice caps is, and has always been, a significant feature of global climate. The science has shown that for much of Earth's history, the world has been ice-free but these iceless periods have been interrupted by several major glaciation periods, generally referred to as glacial epochs, and the planet is currently in one now. Individual glaciation periods are characterized by multiple advances and retreats of the ice fields. The ice fields tend to wax and wane in cycles that have a periodicity of approximate 100,000, 41,000, and 21,000 years. The advances of the ice sheets are popularly known *ice ages,* but the distinction must be drawn that these multiple events are just variations of the same glacial epoch.

The present climate system is part of an interglacial period that occurs when the ice retreats during a glacial epoch. The current Plio-Pleistocene Glacial Epoch is probably linked to the tectonic construction of the Isthmus of Panama, which prevented the circulation of Atlantic and Pacific waters, and ultimately triggered a slow sequence of events that eventually led to cooling of the atmosphere. This may have eventually led to the formation of new ice fields by about 2.5 million years ago. Although there have been some short interruptions, the last major advance of glacial ice peaked about 18,000 years ago and since that time the ice has generally been retreating. Figure 1 provides information on global temperature (and by extension climate) changes over the last 18,000 years.

While the basic causes of climate change are still not fully understood, substantial data

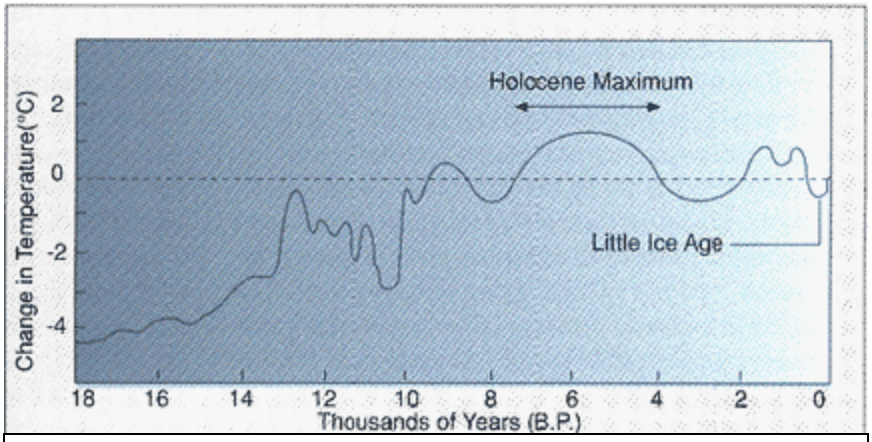

Figure 1: Mean Global Temperature Changes over the last 18,000 years.

have been collected to indicate possible causes. These include Tectonic, Astronomical and Atmospheric and are measured in Long term (millions of years); Medium term (thousands of years); and Short term (decades to hundreds of years). Current studies have revealed another form of climate change that is being referred to as *abrupt transitions*, where major shifts in some components of the Earth's climate are accomplished on time scales of decades or less. This is believed to be the major reason for the changes that are currently occurring.

1.2 United Nations Framework Convention on Climate Change (UNFCCC)

The UN Framework Convention on Climate Change was developed by an Intergovernmental Negotiating Committee (INC) over a period of two years, and presented at the Rio Summit in 1992. It entered into force on 21 March 1994 with the signature and ratification by 166 countries. The Convention sets an overall framework for intergovernmental collaboration to address the challenge posed by climate change. It recognizes that the global climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide and other greenhouse gases. To date the Convention enjoys near universal membership, with 194 countries having ratified it.

Under the terms of the Convention, Country Parties commit to:

- gather and share information on greenhouse gas emissions, national policies and best practices
- launch national strategies for addressing greenhouse gas emissions and adapting to expected impacts, including the provision of financial and technological support to developing countries
- cooperate in preparing for adaptation to the impacts of climate change

In December of 1997 the Kyoto Protocol was presented at the Kyoto Conference on Climate Change. The Protocol came into force in February of 2005 and is an integral part of the Framework Convention on Climate Change (FCCC). While the Convention encourages the developed countries to participate in activities designed to ameliorate the impacts of global climate change, the Protocol commits them to a particular series of actions. This is in direct recognition of the fact that current climate change is due in part to effects of human activities on the planet. (UNFCCC website, Dec 2007)

1.3 Intergovernmental Panel on Climate Change (IPCC)

The Intergovernmental Panel on Climate Change (IPCC) was set up jointly by the World Meteorological Organization and the United Nations Environment Programme in 1988 to provide the decision-makers and others interested in climate change with an objective source of information on the subject. Since its formation the Panel has provided coherence and direction for the efforts to determine cause, vulnerability and adaptation to climate change through the work of its three Working Groups. The IPCC has indicated support for the concept that while global climate change is a natural phenomenon, recent changes are being exacerbated by drivers that are anthropogenic in nature. To this end,

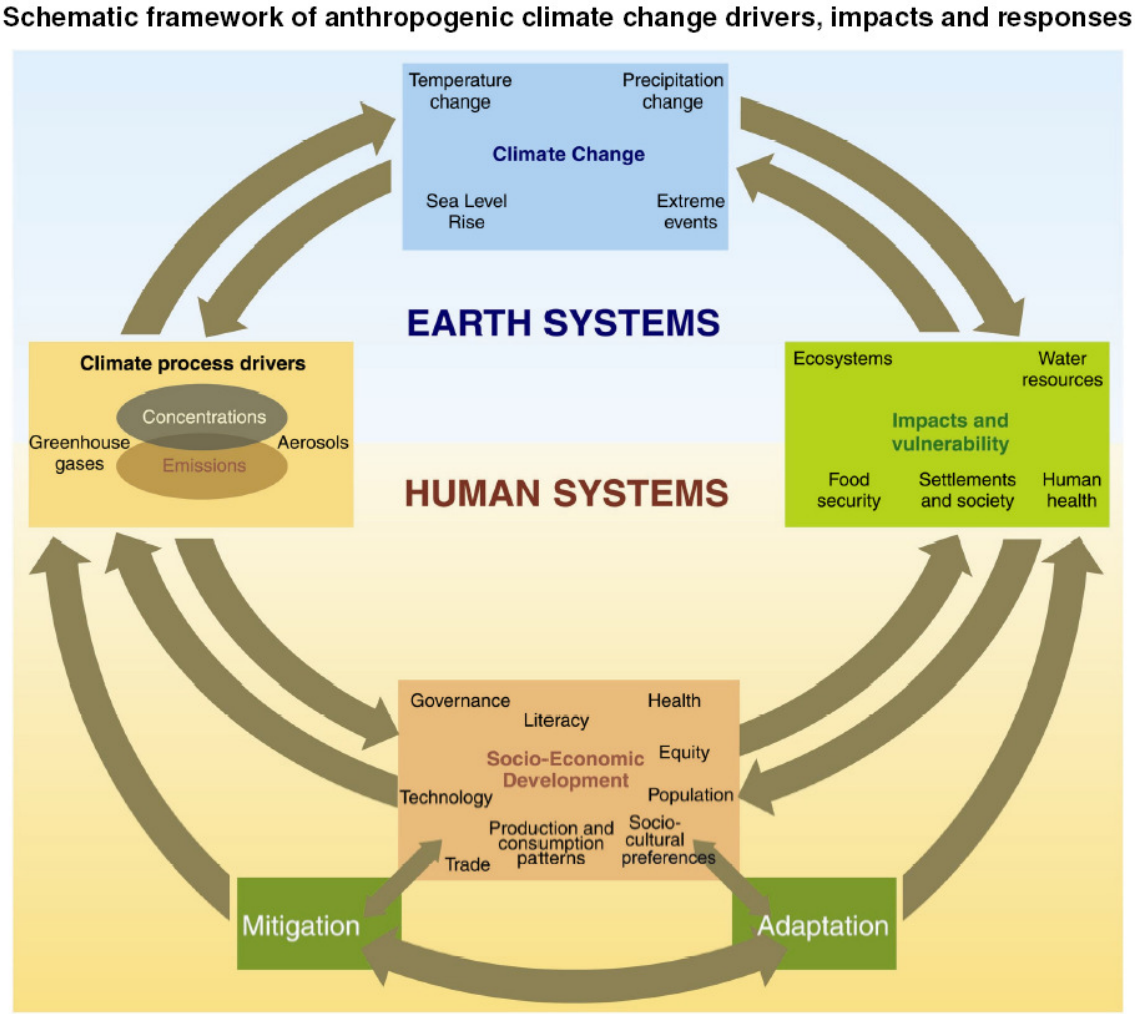

Figure 2: Impact of human actions on global climate change
(source IPCC 4th Assessment Report – Nov 2007)

the IPCC has proposed a framework that outlines the process through which human actions impact the global climate system (Figure 2)

1.4 Global Climate Patterns

Starting in 1990, the IPCC has prepared four Assessment Reports that detail the state of climate change, possible causes, vulnerability and the impacts that result. The most recent report, submitted in November 2007, concludes that there is evidence of warming of the climate system from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level. Temperature records taken since 1850 indicate that the last eleven years have shown the warmest global surface temperatures. While temperature increases are widespread, the highest increases are seen in the higher northern latitudes. In addition, Land areas have warmed faster than the oceans. The warming trend over the last 50 years, from 1956-2005, show a mean increase of 0.13 (0.10 to 0.16) °C per decade that is almost twice that for the 100 year period 1906-2005.

The 4th Assessment Report (IPCC) indicates that observations since 1961 show that the average temperature of the global ocean has increased to depths of at least 3000 m and that the ocean has been taking up over 80% of the heat being added to the climate system. In addition, global average sea level rose at an average rate of 1.8 mm per year over 1961 to 2003 and at an average rate of about 3.1 mm per year from 1993 to 2003. There is some uncertainty as to whether the faster rate for 1993 to 2003 is a reflection of decadal variation or an increase in the longer term trend. Of note is that since 1993 thermal expansion of the oceans has contributed about 57% of the sum of the estimated individual contributions to the sea level rise, with decreases in glaciers and ice-caps contributing about 28% and losses from the polar ice sheets contributing the remainder. The average for the Mesoamerican region is estimated at 2 mm per year and is expected to continue at that rate for the next 25 – 30 years, given present conditions. (IPCC WGII AR4, 2007)

The net effect of all this is to conclude that there is some 'speeding up' of the rate of global climate change, which is primarily evident in global warming and sea level rise, and that these all have anthropogenic drivers.
Some of expected effects of these changes are:

- It is *very likely* that cold days, cold nights and frosts have become less frequent over most land areas, while hot days and hot nights have become more frequent
- It is *likely* that heat waves have become more frequent over most land areas.
- It is *likely* that the frequency of heavy precipitation events (or proportion of total rainfall from heavy falls) has increased over most areas.
- It is *likely* that the incidence of extreme high sea level has increased at a broad range of sites worldwide since 1975.
- There is observational evidence of an increase in intense tropical cyclone activity in the North Atlantic since about 1970

This current assessment report is being done in partial fulfillment of the country's commitment under Article 4 (1) b, d and e of the Convention (UNFCCC) which requires that all parties to the Convention prepare, implement and regularly update national

initiatives to mitigate the effects of global climate change, promote sustainable management and cooperate in the conservation and enhancement of sinks of green house gases, and cooperate in the adaptation to the impacts of global climate change. All interpretations are in accordance with the definitions provided in Article 1 of the Convention.

2.0 Background to Belize

2.1 Geophysical - Mainland

Belize is located on the southern half of the Yucatan Peninsula and shares most of the geomorphological features of that portion of the North American block. The southern portions of Belize lie on the eastern edge of the boundary between the North and South American blocks that collided when the Central American Isthmus was formed some 3.5 million years ago. (Gold, 2007)

The northern half of the country shares geomorphology with southeastern Mexico. It is comprised primarily of Cretaceous limestone that is characteristically flat, possible evidence of it being part of an ancient seabed. This flattish landscape occurs on the central and northern parts of the coastal plains, built up during the Quaternary by the deposition of alluvium carried down from the mountains. Large amounts of quartz sand and silica in dissolved form were deposited on, or within the calcareous sediments on the coastal shelf. Over the northern half of the country, the pattern of sedimentation suggests alluvial deposition in the form of a delta. The main rivers originally flowed northward but gradually deflected in a more easterly direction as the northern part of Belize was subject to gentle uplifting. Presently there are only three river systems that still flow north, Rio Hondo, New River and Fresh Water Creek 1. (Annex 1).

The most prominent physiographic feature of the Belize mainland is the mountainous region in the south-central part of the country generally referred to as the "Maya Mountains." The core of this mountainous block consists of granite and ancient (Palaeozoic) sediments, exceedingly low in minerals capable of providing nourishment for growing plants. The Maya Mountains is surrounded by major faults that are the results of a cumulative process of uplifting which began some 180 million years ago. The "Mountain Pine Ridge" plateau is a remnant of this ancient land surface. (Country Environmental Profile 2006)

There is a sharp boundary between the Cretaceous limestone and the younger Tertiary sediments. The Tertiary sediments form landscapes of subdued relief, seldom exceeding 225 m above present sea level. In the Toledo district these Tertiary calcareous sediments are mostly shale, limestone, marl, 'reef rock' and beach gravel. Advanced karstic features are not found in this Tertiary limestone. The mountains and hilly landscapes of the west, south-west and south (Cayo and Toledo districts) are formed from cretaceous limestone and show typical karstic land forms. Minerals probably derived from volcanic ash (which may have drifted from distant sources) occur in some of the Cretaceous limestone and in a few of the Tertiary limestone**.** Volcanic material was deposited on the reef limestone before it was uplifted in the Quaternary. Volcanic ash from contemporary volcanic

activity seldom reaches Belize in any significant quantity, despite relative proximity of volcanoes in Guatemala and southern Mexico.

Some 23 watersheds are found within the country of Belize and all impact the coastal zone of the country. See Annex 1. The Belize River watershed is the largest and is the only river system in the country that flows west for a portion of its length. The two main branches rises on the western divide of the Maya Mountain block, flows west and north draining the northwestern portion of the range. They then make a 90 degree turn and flow east, draining most of the midsection of the country, and eventually entering the Caribbean Sea near to Belize City. Three watersheds, the Rio Hondo, New River and Fresh Water Creek (1), in the north of the country flow north and empty into Corozal Bay, while all the remaining watersheds flow east. All the watersheds in Belize eventually empty into the Caribbean. The rivers in the north tend to be slow flowing, and estuarine for a significant portion of their lengths. The river systems in the centre and south of the country tend to be shorter and fast flowing. At the point where these systems enter the coastal plain they begin to show characteristics of the systems to the north.

2.2 Geophysical - Marine

The Belize Barrier Reef System is one of the most diverse ecosystems on earth, and the varieties of coral formation are unsurpassed in the Caribbean (Figure 2). It lies on the rim of a continental shelf approximately 160 miles (257 km.) long and 10-25 miles (15-40 km) wide. Within half mile (800 meters) of the reef crest, the seaward edge of the shelf drops steeply to 9,000 ft. (3,000 m) into the Caribbean. The shelf is predominantly shallow (<10m) north of Belize City; forming a flat that runs from Corozal Bay to the Drowned Cayes. This area is characterized by an extensive sea grass bed that runs from the reef crest to the coast. With the exception of Ambergris Caye, the cayes in this area are mangrove in origin, being the result of colonization of shoals by red mangroves in the first instance and being built up by sedimentation over the years.

South of Drowned Cayes, the shelf begins a slow descent to depths of 180 ft (60m.) at the southern end of the reef near Sapodilla Cayes (Rath, 1996). There is a gradual widening of the back reef lagoon while moving towards the south. The Central back reef province runs from Belize City to Dangriga and is characterized by a deep channel running in a north-south direction from Belize City to the Gulf of Honduras, which bounded on the east by shallow shelf and on the west by the mainland coast. Average depth along the channel is 25m. The seaward shelf terminates at the reef crest and has an average depth of 3 – 5m. This shelf has numerous patch reefs and a few mangrove cayes. Grass flats cover most of the shallow bottom between the cayes and patch reefs.

The Southern reef shelf or province is a broad section of the lagoon, filled with a variety of reef structures that stretches from Blue Ground Range, just south of Dangriga, to the Sapodilla Cayes. Coral communities near shore are dominated by *Porites* and *Siderastrea* both of which have high tolerance for low salinity. The shelf in this area is cut by two deep channels, the Main Channel and Victoria Channel, both of which reach depths of 30 m. There are numerous shoals, banks, ribbon and patch reefs found in this area. Numerous shingle and mangrove cayes are found within the shelf lagoon. A

characteristic feature of the southern shelf lagoon is the formation of faros. They are large limestone structures and consist of an outer rim that encloses other reefs and lagoons. Rim walls are narrow and steep. Inner reefs are highly variable in size and form. This complexity leads to a remarkable diversity of habitats and organisms (Rath, 1996). On the seaward side of the southern reef complex the Cayman Trench has its southwestern end some 10 - 16 kilometers east of Gladden Spit. This is believed to have an effect on current and nutrient patterns in the area, although no conclusive scientific evidence has been provided. Three atolls lie just outside the reef.

2.3 Social

With a land mass of 8,800 square miles, the country of Belize has a population of 311,480 persons, split almost evenly between males (154,665) and females (156,815) (SIB, 2007). The population is comprised of five major and several minor ethnic groups. The population of Belize is a young one, with 50% of the population being below the age of 20 years and approximately 58% being below the age of 25 years. The country has a population density that is one of the lowest in the region at 34 persons per square mile. Presently 51% of the population resides in one of the nine urban centres, while the remaining 49% is spread out in the rural areas. The literacy rate is estimated at 77% and the net enrollment in primary and secondary schools is 85% and 40% respectively. Primary education is mandatory. The country has a labour force of approximately 112,800 of which 102,230 persons are employed. The unemployment rate stands at 9.4% overall with a 19% rate among the youths. Statistics show that 91% of the population has access to electricity, while 40% has access to piped water. Currently an estimated 120,000 persons or some 38% of the population lives on the coast or cayes, with approximately 100,000 residing in one of the urban centres. (SIB 2007) Figure 3 shows political boundaries and the distribution of the larger communities within the country.

2.4 Economic

Belize has what is referred to as an open economy. At the end of 2006 the country had a Gross Domestic Product (GDP) of $2.45 Billion and a per capita GDP of $8,141.00. The country was also showing an economic growth of 5.8%, which was an increase from the 3.5% in 2005 but a decrease from the 9.3% in 2003. Tourism was the largest income earner in 2006, accounting for some $505.7 million Belize dollars. This is a doubling of the earnings from this sector in 2000 when it accounted for some $240.1 million dollars. Exports were the next largest income earner in the economy, accounting for some $554.5 million dollars in 2006. Of this number, sugar, citrus, banana and papayas accounted for some $272.54 million, marine products accounted for $98.2 million and petroleum accounted for some $88 million dollars in exports in 2006. (SIB, 2007)

Over the last six years there has been a consistent increase in the income earned from tourism. Statistics show that overnight arrivals have increased steadily from 195,766 in 2000 to 247,309 in 2006. Cruise tourism has not been so consistent. There was a remarkable increase in cruise visitation from 48,116 in 2001 to 319,690 in 2002. There was a more gradual increase to 851,436 in 2004 and then a gradual decline to 655,931 in 2006. The recent surge in tourism growth has resulted in substantial investment and development. However, despite the fact that cruise tourism accounted for only $31.01

million dollars in 2006, the bulk of the investment and infrastructure development in the industry over the last six years has been to accommodate the cruise industry. It is estimated that 80% of all tourism visitors head to destinations within the coastal zone. (Tourism Board 2007)

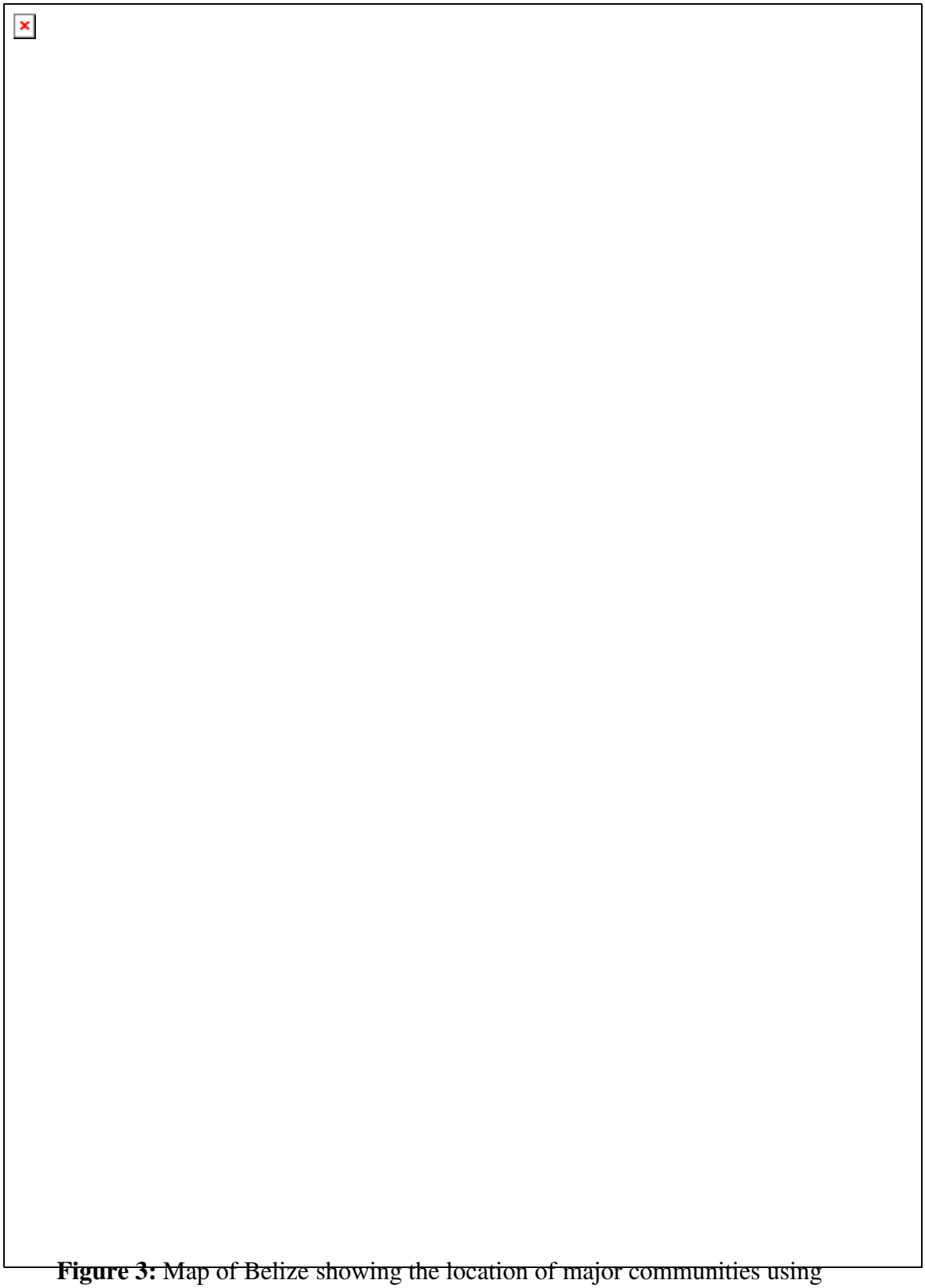

Figure 3: Map of Belize showing the location of major communities using 2004 data

3.0 Methodology

The goal of this report is to provide information on the vulnerability status of the coastal zone and low-lying coastal areas of Belize and the adequacy of the adaptations and interventions to address impacts due to climate change. To this end a complete review of all available literature was undertaken. Given the cross-sectorial nature of current vulnerability assessments proposed by the IPCC, attempts were made to review documents from all sectors that currently impact the Belize Coastal Zone. Interviews were also held with key stakeholders and agencies operating in the various sectors identified. Where possible, visits have been made to various locations to verify information provided either through the documents or the interviews. The IPCC reports and website have been relied on heavily to provide reference and scope for this document. This report attempts to integrate the socioeconomic and biophysical aspects of vulnerability to climate change in the Belize Coastal Zone. The report focuses on i) vulnerability by habitat and sector, ii) Evaluation of Adaptation efforts and activities, and iii) Recommendations for improving adaptation and mitigation efforts.

3.1 Definition of the Coastal Zone

In Belize the Coastal Zone Management Authority and Institute is the agency that has been mandated to advise on policy, research and activities related to the development and utilization of the coastal zone; coordinate, collaborate on and implement activities related to public awareness and regional cooperation; and develop and maintain national coral reef, coastal water quality and other technical monitoring programmes.

The Coastal Zone Management Act defines coastal zone as "… *the area bounded by the shoreline up to the mean high water mark on its landward side and by the outer limit of the territorial sea on its seaward side, including all coastal waters*". The Authority and Institute has as a working definition the "…*shoreline, coastal alluvial plains and watersheds, lagoons, estuaries, cayes, atolls, the subtidal area within the 12 mile territorial limit and the 200 mile EEZ*".

The coastal zone as officially described is a rather extensive area and, of necessity, was reduced for the purposes of this assessment by excluding the 200 mile EEZ, and inland portions of the watersheds that are above the 20 meter contour. This was difficult to do sometimes as in the northern part of the country the 20m contour extends inland a significant distance, in some areas almost to the western border.

3.2 Definition of Vulnerability

The IPCC defines vulnerability as "*The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity*" (IPCC, 2001b, Glossary). This is further complicated by recent decisions to include social vulnerability. Vulnerability assessment now no longer is restricted to assessing the biophysical response to climatological changes, but needs to include the vulnerability to current climate, the vulnerability to climate change in the absence of adaptation and

mitigation measures, and the residual vulnerability when the capacity to adapt and mitigate has been met.

As proposed by the IPCC's Working Group II in the Fourth Assessment Report, any assessment of vulnerability to climate change needs to take into consideration the different states of vulnerability that exist. These include i) vulnerability to current climate, ii) vulnerability in the absence of adaptation and mitigation measures, and, iii) residual vulnerability, when the limits of adaptive and mitigative capacities have been reached. After the completion of the TAR in 1995 it was realized that because of the overwhelming evidence of anthropogenic drivers in global climate change, it would be difficult to separate biophysical and socioeconomic vulnerability. Therefore, of necessity, both aspects need to be taken into consideration when considering vulnerability. (IPCC WGII, 2007)

Since 1995, several scenarios, projections and global circulation models have been developed in an effort to predict changes in climate and possible impacts. Ideally it would have been beneficial to have access to these tools to remove some of the uncertainty from the present assessment. Unfortunately these tools were developed to predict global impacts are not yet available on a scale to make predictions at the level required for Belize. (National Meteorological Service, 2007)

3.3 Prediction Scenario for Belize

The IPCC has developed a number of scenarios to predict possible effects and responses to global climate change. The scenarios incorporate a number of geophysical, economic social and governance components to arrive at the final prediction. A scenario as defined by the Panel is "*…a coherent, internally consistent, and plausible description of a possible future state of the world."* They are not predictions or forecasts, but are alternative images, without any likelihoods ascribed, of how the future might unfold. They may be qualitative, quantitative, or both.

The scenario that was selected by the NMS, as the Belize Focal Point for Climate Change, is the A2 Scenario. The A2 scenario refers to a very heterogeneous world. Belize promotes the preservation of the Belizean identity and makes every effort to be self-reliant. In Central America and the Caribbean fertility patterns are expected to converge very slowly resulting in high population growth in Belize and the regions. Economically, Belize moves primarily towards the regional common markets, such as the Caribbean Common Market (CARICOM) and Central American Common Market (MCCA), however regionally per capita growth is fragmented and technological changes are slow.

The A2 world "consolidates" into a series of major economic regions. CARICOM and MCCA merge into a regional market. International disparities in productivity, and hence income per capita, are largely maintained or increased in absolute terms. Economic growth is uneven and the income gap between now industrialized and developing parts of the world does not narrow.

Belize becomes more reliant on its resources and places fewer emphases on economic, social, and cultural interactions between regions. People, ideas, and capital are less mobile, so that technological changes are much slower. The Belizean way of life becomes more family- and community oriented, fertility rates decline very slowly and population growth is at its greatest.

In the A2 world, social and political structures diversify; some regions move toward stronger welfare systems and reduced income inequality, while others move toward "leaner" government and more heterogeneous income distributions. Belize's political Democracy is strengthened with greater accountability and transparency and the middle class begins to grow again.

Global environmental concerns are relatively weak. Potential local and regional environmental damage continues to occur although it is not uniform across regions. Central America and the Caribbean attempt to bring regional pollution under control. Belize maintains its environmental amenities and intensifies efforts to further reduce local environmental pollution.

Technological change in the A2 scenario world is heterogeneous. It is more rapid than average in some regions and slower in others, as industry adjusts to local resource endowments, culture, and education levels. In the new technological world more Belizeans are better educated and are now more capable of identifying and managing the country's natural resources for the benefit of all Belizeans. Belize develops its hydroelectric potential and through technological innovations utilizes fossil fuels to provide sufficient and cleaner local energy for the growing industrial sector.

The mineral and oil industries boom and Belize's economy evolves into a more resource-intensive one and through import substitutions Belize reduces its dependence on imports.

4.0 Vulnerability by Habitat and Sector

Vulnerability to climate change is generally defined as the degree to which a state can plan and implement adaptation to climate change. It is believed that Small Island Developing States and small Non-market economy states are particularly vulnerable to the impacts of climate change because of their limited capacity to implement adaptation measures. By virtue of its status as a developing country with low-lying coastal areas, Belize is particularly vulnerable to climate change. As a signatory to the UNFCCC, Belize has an obligation to meet the commitments in Article 1 of the Convention.

In 1995 Belize undertook the first vulnerability assessment of the coastal zone using Visual Aerial Assessment techniques. Unfortunately no complete copies of the document could be found. In a 1999 a second report was done by Gibson *et al* as part of the enabling activities for the preparation of Belize's First National Communication to the UNFCCC. That report provided information on the impacts and possible adaptation strategies for coastal habitats, with an emphasis on tourism and fisheries, and for coastlines and cayes, with emphasis on settlements, agriculture, aquaculture and water resources. The information presented in that report will provide the baseline for the current report.

Data from the Belize National Meteorological Service indicate that there is no doubt that there has been an increase in mean surface temperature in Belize over the last 47 years. Data provided by the Met Service shows that the decade of the 70s had some of the coolest temperatures on record while the 90s were the warmest. Figure 4 below provides a graphic of mean temperature changes over the last 47 years, while Figure 5 shows the projections for the next 90 years.

Average Temperatures

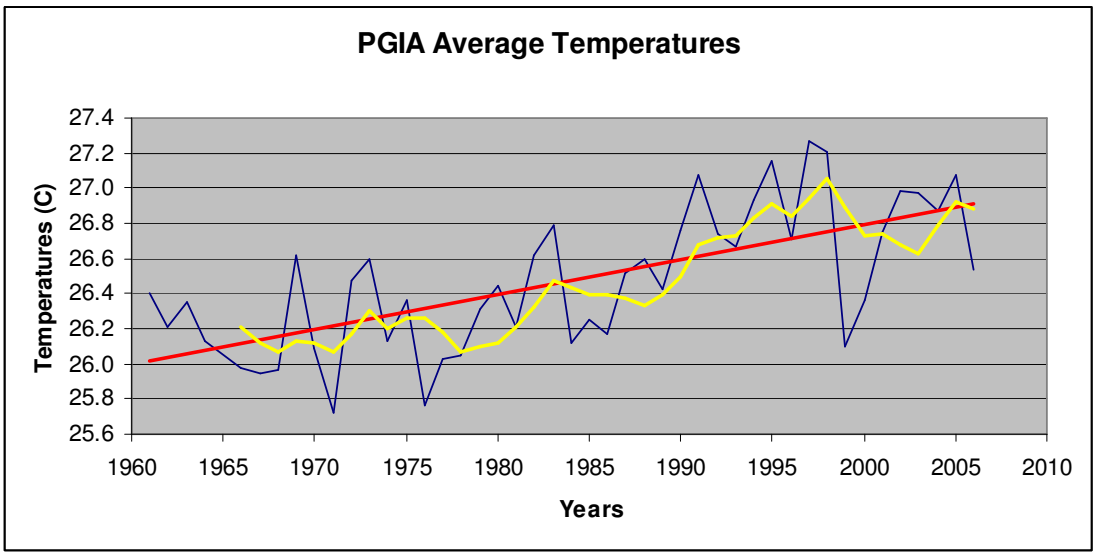

Figure 4: Time series plot of average temperatures at PGIA along with linear trend (red) and 5-year moving average (yellow) (Courtesy of the NMS)

Temperature

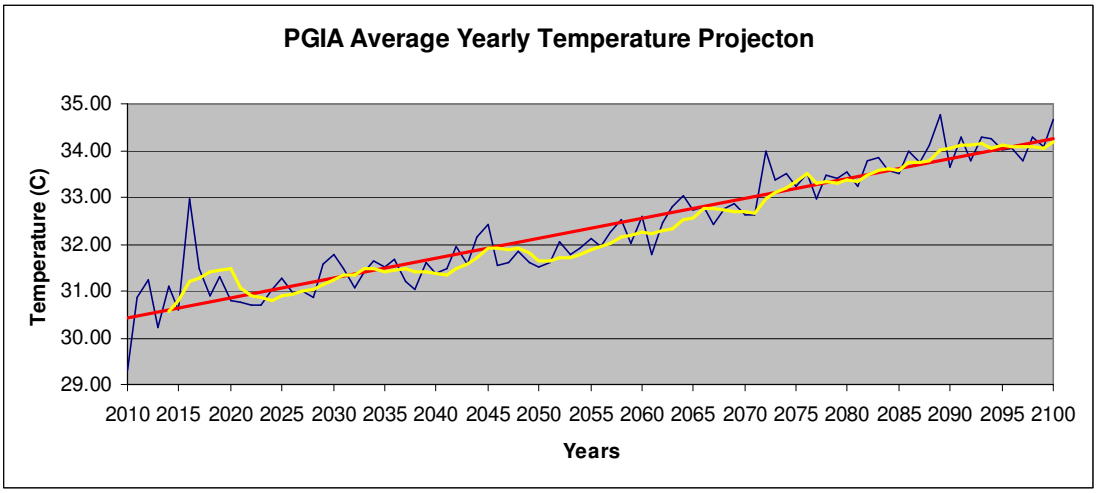

Figure 5: Projections of average yearly temperatures. Linear trend (red) and 5 –year moving average (yellow) (Courtesy of the NMS)

The coastal zone of Belize plays an important role in the economy of the country. It is estimated that industries within the coastal zone account for some $700 million BZD in income earnings in 2006. Sectors present in the coastal zone include tourism, fisheries and aquaculture, and agriculture. In addition, approximately 38% of the population lives on or near the coast, or on the cayes.

4.1 Coral Reefs

The Belize Barrier Reef system is a prominent part of the coastal zone in Belize. At 300 km in length it forms the largest contiguous section of the Mesoamerican Reef system. The reef system is comprised of the near shore barrier platform and three offshore atolls. The main reef crest is an average of 14 km from the coast in the north and 40 km in the south of the country. The barrier lagoon platform starts shallow in the north, 5 – 7m and deepens towards the south, eventually reaching a depth of 65m in the Gulf of Honduras. Of the three atolls, Lighthouse Reef is the most easterly, and is 40 km long by 10 km wide. Glovers Reef is the southernmost atoll and is approximately 30 km long by 12 km wide. Both atolls have numerous patch reefs in the shallow central lagoons. Turneffe is 52 km long and 17 km wide. It is located some 8 km east of the main barrier platform and the central lagoon features are similar to those found in the northern section of the barrier lagoon. Figure 4 shows the extent of coral cover in Belize.

The threats that are expected to have the most significant impact on coral reefs are increased sea surface temperatures, increase in the frequency and severity of severe climate events, and changes in the pH of sea water due to increased volume of greenhouse gases. Additionally there are the anthropogenic threats to the barrier reef system. The results of a recent Conservation Area Planning exercise done for the Mesoamerican region by The Nature Conservancy identified the major anthropogenic threats as over fishing and the use of inadequate methods, inadequate methods for aquatic

tourism, sedimentation, use of agrochemicals and pesticides, discharge of gray water, damage from boats and invasive species. (TNC MAR-CAP, 2007)

Figure 6: Map of Belize showing coral reef areas (pink).

Corals reefs will be minimally affected by sea level rise, and healthy reefs are expected to adapt readily to sea level rise. The projected increases in sea level of less than 1 m over the next 50 years are not expected to be sufficient to negatively impact even those species that occur at the limits of depth.

Coral bleaching is the result of the coral polyp expelling the zooxanthellae symbiont. This is a process that is generally reversible and is believed of occur during periods of stress. Studies have shown that a 1 degree rise in temperature over seasonal maxima was sufficient to trigger bleaching. (Gitay et al, 2002) At 2° above seasonal maxima, most corals died. There have been two major bleaching events in Belize in 1995 and 1998 that affected most of the country. Another region-wide bleaching event occurred in 2005 but did not appear to affect the western Caribbean as severely as it did the remainder of the Caribbean. The bleaching coincided with El Niño events when there was calm weather, and increased sea surface temperatures and solar radiation. McField (1999) reports that 52% of corals in Belize were affected in 1995 and 1998, and in many cases there was full or partial mortality. Both events were believed to be comparable in size.

Coral can and do recover after bleaching events, but are usually weaker and more susceptible to disease and competition. The occurrence of several coral diseases have been correlated with higher average temperatures, particularly black band and coral plague. Studies in the Caribbean region indicated increases in the occurrence of these diseases at a time when the Caribbean has some of the highest sea surface temperatures on record.

There has been an increase in the frequency and severity of storms over the last 20 years. Reports show that between 1980 and 2007 Belize has been hit by five hurricanes and three tropical storms, two of which were at least Category 3 on the Saffir-Simpson scale. In addition, there have been threats for four, two of which were Category 5 storms. This can be compared to the period 1961 to 1991 when there were a total of three hurricanes and two tropical storms to hit the country. The reef system has been impacted severely by these hits and near misses. There was documented damage to reef structure in southern Belize by Mitch (1998) and Iris (2001), and to northern Belize by Keith (1999), Wilma (2006) and Dean (2007) (Azueta 2007). Species of branching coral such as *Porites* and *Acropora*, are prone to breakage while the smaller boulder species are prone to roll over by high energy waves.

There is some debate in the scientific community as to the effect of increasing carbon dioxide concentrations on coral reefs. There is the theory that high levels of carbon dioxide will limit the ability of the polyps to deposit the calcium carbonate skeleton by changing the pH of the water. There is recent evidence that under conditions of low pH in the laboratory corals will stop producing a skeleton but will continue to maintain other life functions, including reproduction, and will start building new skeletons when conditions return to normal (Fine et al 2007). The concern is that such conditions will leave the coral polyps less fit to compete ecologically. There is also a theory that because of the calcification process done by corals, reefs are possible sinks for atmospheric carbon dioxide. However, it has been shown that the precipitation of calcium carbonate is

accompanied by a phase shift that actually releases carbon dioxide. This would mean that healthy reefs are really a source for low levels of atmospheric carbon dioxide.

In 2006 the MBRS reported on the synoptic monitoring that has been done by the project for the last three years. Six indicators were used to determine general reef health, species composition, live tissue cover, colony size, mortality, disease and bleaching. Analysis of monitoring data for 2004 – 2005 showed that for the Belize Barrier Reef:

- Mean live coral cover was 25.75% and varied from a low of 11.11% to a high of 44.58% across the sampling locations. This compares favourably with the mean of 26% for the Wider Caribbean and Brazil as reported by Kramer (2003). The coral species monitored are reef builders and the live coral cover is an indication of the rebuilding capacity of the system. A live coral cover of greater than 20% is considered to be good while less than 10% is considered to be poor.
- Mean species richness was 11, with a high of 22 and a low of 5. Species richness is the number of species present and is a quick and easy parameter to measure.
- Mean colony size had a height of 23.21 cm and a diameter of 37.67 cm. Smaller colonies are a general indicator of slower growth (or frequent re-growth) and greater stress. Colonies with heights above 30 cm and diameters above 35 cm are considered in the best health.
- Mean mortality was 44.65%. Mortalities of 0 – 15% are considered to be optimum while 35 – 55% is considered average and over 80% is considered to be poor.
- Rates of bleaching were very low. On average less than 5% of colonies were observed with bleaching. This value would be lower if not for the high incidents of bleaching (almost 20% of colonies) observed in Glovers Reef. All other locations reported less than 1% of colonies with bleaching.
- Rates of disease were less than 1%. Again colonies in Glovers Reef were observed with the highest percentage of colonies that were diseased.

The conclusion of the report is that the reefs in Belize are good for most categories and would benefit from continued management. In the absence of any other recent definitive work on the reef system, this can be considered to be the state of the Belize Barrier Reef to date. It has been theorized that the relatively high incidents of bleaching observed in Glovers Reef could be as a result reduced water flow within the lagoon. This needs to be verified with additional monitoring.

There is no way that the value of the reef system to Belize can be overstated. The Belize Tourism Board reported that tourism revenues for 2006 were some $506 million BZD. It is estimated that 80% of tourists visit a destination within the coastal zone. Within the Fisheries sector, earnings from capture fisheries were estimated at $25 million BZD for 2006. Shrimp aquaculture added another $60 million BZD for a total of $85 million BZD from the sector. This represents the tangible and direct value that can be calculated in dollars earned. In 2007 World Resources Institute undertook an economic valuation study in an attempt to develop a model that could be used to quantify the total value of coastal resources to the country, including intangibles. Results are not yet available.

4.2 Mangroves

Mangrove is the term used to refer to a diverse group of salt tolerant tree and shrub species. They thrive in nutrient rich, silty water of varying salinity, sometimes dominating wetland areas as well. All four of the mangrove species native to the Caribbean, are found in Belize. In 1993 it was estimated that mangrove forests covered some 760 km^2 of land area in Belize. Distribution is primarily along low-lying sections of coast and river banks, cayes, estuaries and coastal lagoons. The largest percentage of cover is found in the northern portions of the country and in the cayes, particularly the Turneffee Atoll. Figure 5 is a mangrove distribution map for Belize using 2000 information.

The major threats to mangroves from climate change are changes in weather patterns and the increase in frequency and severity of climatic events. Two key factors in the success of mangroves appear to be the salinity and sedimentation levels. Changes in rainfall patterns could affect distribution and species composition because rainfall regulates salt concentrations in soil and plants, as well as providing a source of freshwater for the mangroves. However, if high rainfall occurs over a short period and other months of the year are prone to drought, the conditions could become unfavourable for the growth and distribution of mangroves. (Hong, 2006). The 1999 assessment indicated that mangrove communities along the larger watersheds such as the Belize, Sibun and New River systems will be less vulnerable than those along the smaller catchments in the south such as the Sittee, Moho, Deep River and Golden Stream. One major consideration for mangrove communities on the cayes would be the increased erosion from higher sea levels, leading to die back and wind throws. The increase in the frequency and severity of storms could have a major impact on coastal mangrove communities. Observations have shown that mangroves affected by Hurricane Keith (1999) and Iris (2001) have still not fully recovered and continue to show signs of structural damage, die back and wind burn. Of note is the fact that Hurricanes Keith and Iris were both Category 4 storms. However, it is widely held that healthy mangroves will be able to adapt to sea level rise by sequentially recede as the habitat changes to maintain its position in the ecosystem. This means that most mangroves will continue to occupy its current position and role along the coast even if the coast is not in its present location.

Major anthropogenic threats include mangrove clearance and loss of habitat. The recent surge in tourism has resulted in an attendant surge in coastal development. Large sections of the coast and cayes have been targeted for upscale residential and resort construction. Mangroves are seen as a nuisance and large tracts have been clear cut to make way for construction. With the exception of the Buttonwood (*Conocarpus erectus*), most mangrove cannot survive on ‘dry land’. When large sections of coast and wetlands are filled the mangroves die. Observations made in Turneffee during the evaluation of dredging permits showed that pumping dredge spoil into a stand of live red (*Rhizophora mangle*) and white (*Laguncularia racemosa*) mangroves killed all the trees in the stand. Therefore, mangroves will be impacted by any situation that causes the soil around the roots to go dry. Additionally, mangroves are seen as a carbon sink for atmospheric carbon dioxide.

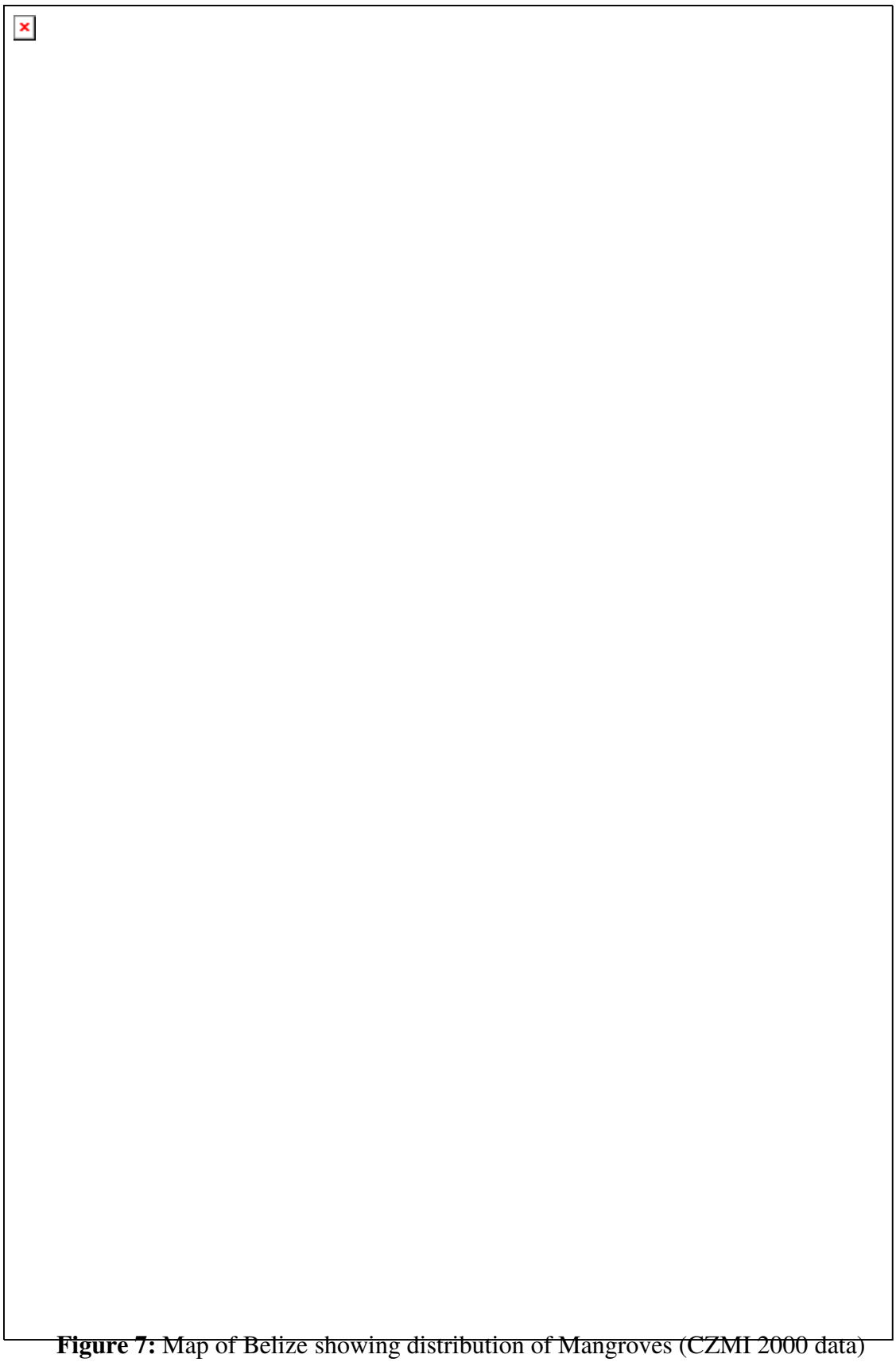

Figure 7: Map of Belize showing distribution of Mangroves (CZMI 2000 data)

There is no information on the current status of mangroves in Belize. Several studies have been done by University of Belize and WWF in Turneffee, Fisheries Department in Bacalar Chico, Smithsonian Institution in South Water Caye, TIDE in Port Honduras and Friends of Nature in Placencia Lagoon. However, none of the initiatives to date have undertaken an assessment of the entire country.

A 2006 UNEP report places the annual economic value of products and services that mangroves provide at between US$200,000 and US$900,000 per hectare. Mangroves play an important role in maintaining healthy tropical marine ecosystems. Most marine species spend a portion of their life cycle in the mangroves. Some terrestrial species, including birds, use the mangroves for feeding and nesting. Human uses include construction material and firewood. Ecosystem services provided include shoreline protection from erosion and storm surge, filtration of sediments and excess nutrients, a carbon dioxide sink and as a buffer from most human activities along the coast. Loss of mangroves could have a devastating effect on the ecosystem and the economy of the country.

4.3 Seagrass

Extensive sea grass beds are found in the northern portion of the barrier lagoon, the central lagoon of Turneffee Islands, some coastal and back reef strips in the southern barrier lagoon and in the coastal lagoons and estuaries. The predominant sea grass species in Belize are the Turtle grass (*Thalassia testudinum*), Eel grass (*Syringodium filiforme*), and three other species with no local names, *Halophila baillonii, Halophila decipiens*, and *Halodule wrightii*. (Short et al, 2005). Figure 6 shows the extent of sea grass beds in Belize.

Sea grass populations are sensitive to light and water quality. With a maximum of 1 m increase projected over the next 100 years, sea level rise is not expected to present a threat to sea grass beds. The major threat is expected to come from changes in weather patterns and the increase in frequency and severity of storms. Increased rainfall and runoff will reduce salinity and increase sedimentation, both of which will have a negative effect on sea grass beds. Storm events result in physical disturbance and increased turbidity. It is expected that most sea grass beds will be able to withstand and recover from these threats. However, increased number and severity of storms will result in increased disturbance and a shorter period between these events which leaves less time for recuperation. The greater concern is the damage from anthropogenic sources. Dredging, land reclamation and pollution (point and non-point source) are the major threats from human activities. The increased coastal development means that there are more sea grass beds susceptible to these influences. Work is currently being done in Placencia Lagoon to monitor and evaluate the nature and effects of such coastal development.

Since 2003 SeagrassNet has done monitoring of sea grass populations in Belize. The MBRS synoptic monitoring programme also includes sea grass monitoring as part of its protocol. Status of sea grass beds is determined by calculating root and shoot density, and total biomass. The MBRS synoptic monitoring report gave biomass estimates at between

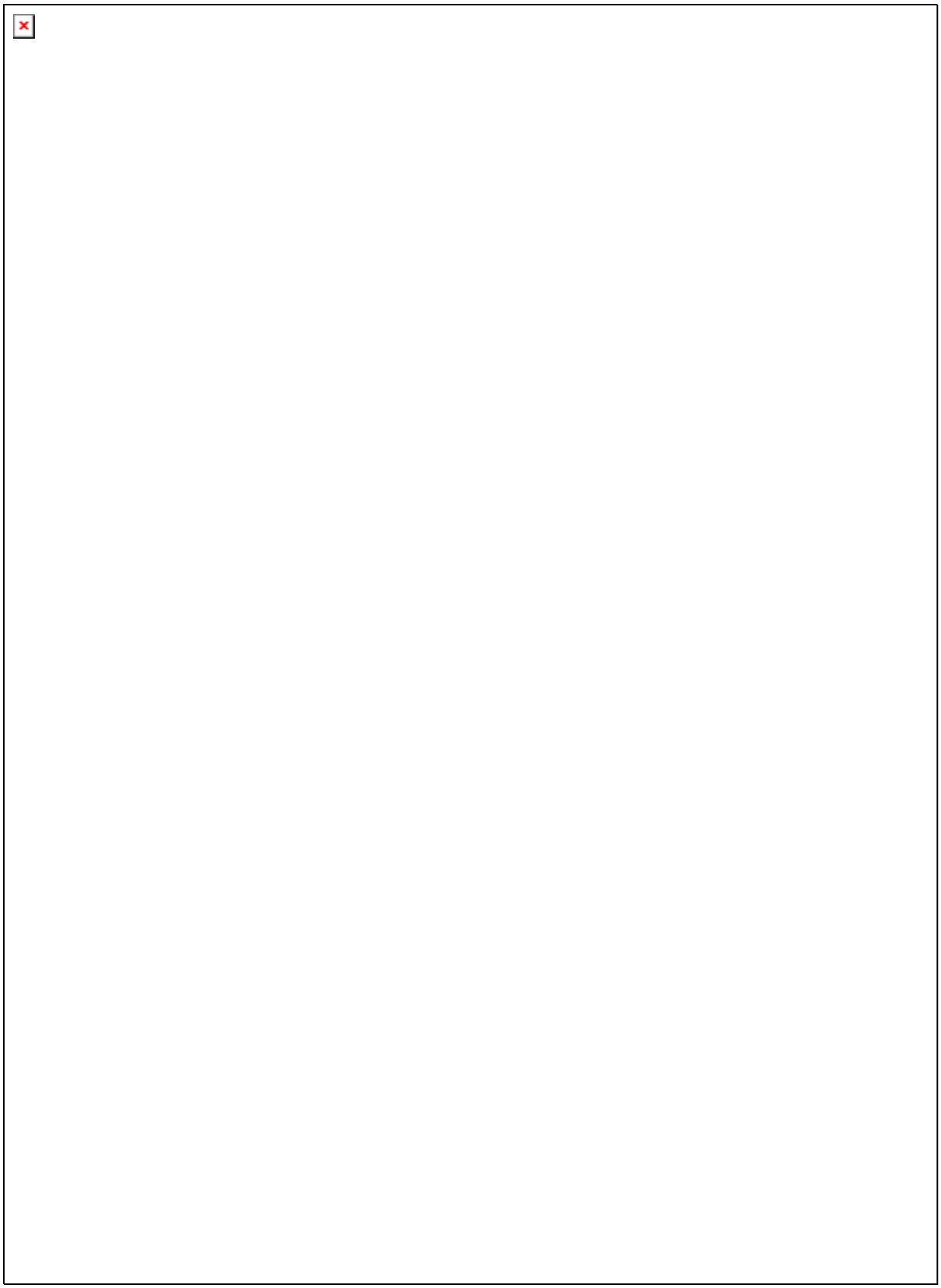

Figure 8: Map of Belize showing distribution of Sea grass beds (CZMAI data)

3 – 1,596 g/m^2. (García-Salgado, 2006). This is a large variation and is probably not indicative of the entire country, as only two locations were monitored, Corozal/Chetumal Bay and Port Honduras. There is currently no available information on the status of sea grass beds in the entire country. As is the case with mangroves, information is available on a few individual sites, notably Placencia Lagoon, Glovers Reef and Port Honduras.

Along with coral reefs, Sea grass beds are considered to be amongst the most productive ecosystems in the world. Sea grass beds are an important nursery for a number of important marine species, some of which are harvested commercially. They are also important as feeding grounds for Marine Turtle, Manatee and dozens of marine bird species. Loss of sea grass beds would result is a related loss of nursery and feeding grounds and the migration of those species from the area. They stabilize coastal sediments, capture and recycle nutrients, and reduce wave energy. In Belize, as much as 50% of the spiny lobster and 40% of conch production are from sea grass beds. This equates to some $10 million BZD annually. With the exception of a limited amount of snorkeling, not much tourism activity take place in sea grass beds.

4.4 Coastal Areas and Cayes

The country of Belize is estimated to have over 220 km of coastline. The section of coast from Rocky Point to the Sibun River bar is predominantly low-lying, and in most cases averaging less than 30 cm above sea level. This area is populated predominantly by mangroves (Ref Figure 5). From the Sibun going south, the coast rises gradually to a mean height 1 – 3 m above sea level. This allows for the creation of narrow beaches, usually 5 – 10 m in width. In some instances the littoral forest is found almost to the water's edge. The beaches are nourished primarily by quartzite sand deposited by the many rivers found along this stretch of coast. This can be seen from Sibun River bar to Sittee River bar and from Monkey River bar to Punta Icacos. In some cases the beaches are the seaward edge of narrow berms that range from 50 – 300m in width, followed by wetlands (mostly mangroves) on the western margins. Some of these berms have been settled as in the case of Hopkins Village. At the mouth of major rivers where the availability of sand is greater, the beaches tend to be larger and better formed. Some settlement has occurred in these locations, notably Mullins River, Dangriga and Monkey River.

There are some 1,062 mangrove and sand cayes within the barrier lagoon and the atolls. Most of the mangrove (drowned) cayes are at or below mean sea level, while the remainder of the cayes are a maximum of 1- 2 m above. (McField et al, 1996). Cayes on the crest of the main barrier reef and on the windward side of the atolls tend to have higher elevation but also experience greater wave action. The major threat to the cayes is increased erosion from a increased sea level and damage from storm surges. Figure 7 shows the location of cayes in Belize.

Threats to beaches, cayes and low-lying areas are primarily from sea level rise, the changes in weather patterns, and the increase in frequency and severity of storms. Low-lying areas such as Belize City are currently prone to partial flooding at high spring tides and will be vulnerable to inundation caused by higher tides. Increased rainfall poses a

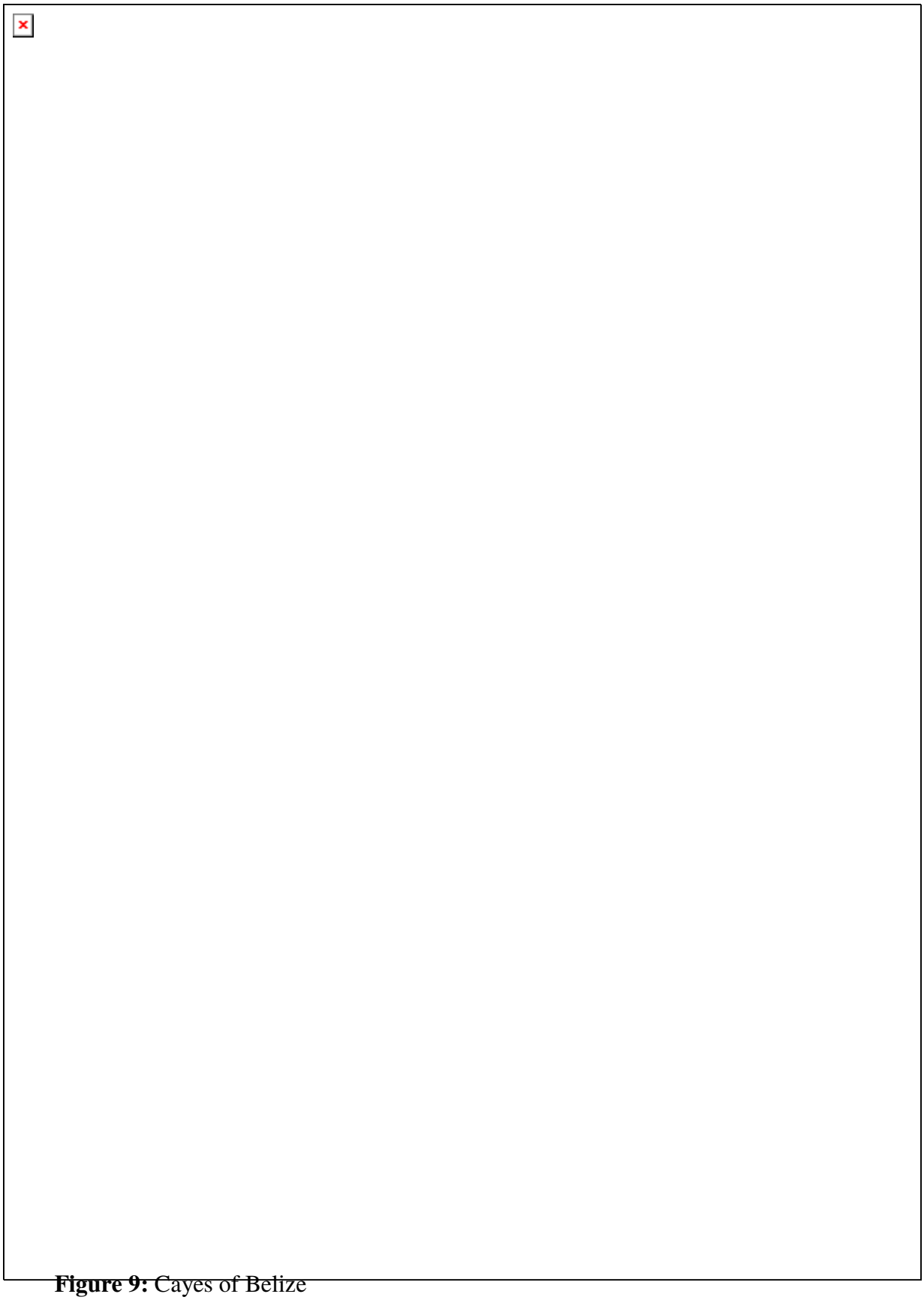

Figure 9: Cayes of Belize

similar threat of flooding for low-lying areas. In 2007 large sections of Belize City were flooded after receiving 50 – 70 mm of rain in a 24-hour period. It is projected that such heavy rainfall will continue to be the norm. From 1991 to 2007 the country of Belize had a mean rainfall level of 2,107 mm. The mean rainfall levels for 2008 to 2025, and for2026 to 2050 are projected to be 2,177 mm and 2,212 mm, or an increase of 70 mm and35 mm respectively. This gives rise to the possibility of increased floods in low-lying coastal areas. The other major threat to coastal areas is damage from storm surge. With an expected increase in the frequency and severity of storms, both the coast and cayes are expected to suffer from increased storm surges. In 2001 Hurricane Iris, a Category 4 hurricane with a storm surge of 3 – 5 m destroyed 90% of Placencia and Monkey River Villages. In 2007 two Category 5 hurricanes made landfall in the western Caribbean, a previously unknown phenomenon. Storm surges from hurricanes of this magnitude are on the order of 5 – 7 m and would destroy a similarly large percentage of any coastal community. Coastal development and land reclamation are the two major anthropogenic threats to the coast and cayes.

The coastal areas and cayes are important economically and socio-culturally. For most people it is the preferred location for recreation and residence. For tourism, the coast and cayes are an integral part of the "sea, sun and sand" concept. A large percentage of the recent development in the tourism industry has been along the coast or in the cayes. The two fastest growing communities in the country at the moment are San Pedro Town and Placencia Village (including the Peninsula). The Garifuna consider living near to the sea to be part of their cultural identity. Many of their traditional beliefs and practices are connected to the sea, so being near to the sea is important to them as a people. Also of importance is the role the beaches and cayes play in the protection and maintenance of biodiversity. Crocodiles, turtles and some seabirds nest on the beaches along the coast and in the cayes. The stretch of beach between Mullins River and Colson Point, as well as some of the cayes in the Sapodilla range, are well known as a nesting beach for Hawks Bill Turtles. Least Terns, Sandpipers, Plovers and Laughing gulls are known to nest on cayes in the south of the country. Loss of these sites through inundation, erosion or destruction from storm surges would have an impact on the economy as well as the local biodiversity.

There is no comprehensive information available on the current status of coastal areas and cayes. The most recent information available was provided in the State of the Coast Report 2000 prepared by the CZMAI and is sketchy at best. Modeling work done by Cayetano *et al* in 1996 using the Brunn Equation indicates that a mean sea level increase of 30 cm in fifty years would result in the loss of approximately 30 m of beach in areas north of Dangriga and 16 m on beaches south of Dangriga. Some information is available on individual areas such as San Pedro, Caye Caulker, Belize City, Dangriga and Monkey River where erosion from a different source has become a concern. Unfortunately the documents are difficult to locate. Incidents such as these are handled on a case by case basis by the Department of Environment (DoE) or the National Environmental Appraisal Committee (NEAC). Since the AVVA by Cayetano *et al* in 1996 no comprehensive work has been done for the entire country. While information is not available in Belize for all the parameters, using figures from Japan, which does not have the same level of

protection from reef structures, for scenarios of 30cm, 65cm, and 1m sea-level rise, it is estimated that 56.6%, 81.7%, and 90.3% of the currently existing sandy beaches would disappear. (Mimura, 2007) While it is not expected that situations in Belize would be as severe under normal conditions, it is expected that the percentages will be relatively close and they would be exceeded in the event of storm surges.

4.5 Socio-economic

Socio-economically Belize relies heavily on resources and activities in the coastal zone. Tourism, commercial, recreational and subsistence fishing, aquaculture and agriculture are the major economic activities in coastal and near shore areas. While these activities can easily be quantified, only recently has there been a concerted effort to determine the intrinsic social, cultural and recreational value of the resource, as well as the value of ecosystem services provided by the reef, sea grass and mangrove ecosystem complex.

4.5.1 Tourism

Tourism and related services are the largest income earners in the economy to date. At an average of $500 million over the last three years, tourism revenues now account for an increasing percentage of annual GDP. Information from the Tourism Board indicates that one out of every four employed person in the country works in tourism and related activities. Loss or decline of the sector would have significant impact on the Belizean economy, as witnessed by the sudden down turn after September 2001. The sector has grown from approximately 90,000 visitors in 1991 to 900,000 in 2006 as the result of an aggressive marketing campaign to highlight Belize's pristine natural environment. The Tourism Board is projecting a major decline in tourism activity with the degradation or loss of marine and coastal habitats.

The nature based tourism that is promoted in Belize is entirely dependent on the integrity of the natural resources. It is estimated that 80% of overnight tourists visit destination within the coastal zone. Activities include scuba diving, snorkeling, kayaking, sports fishing and manatee watching. The health of the marine ecosystem is important to the continued success of the industry. Any loss of corals or associated marine species could result in a reduction in visitation. While there are other areas within the country that can, and do, serve as tourism destinations, it is estimated that approximately 80% of tourist visit a destination within the coastal zone and approximately 60% of income is derived directly from coastal and marine activities.

4.5.2 Fisheries

For many years commercial fishing has been the third largest revenue earner in the country of Belize, accounting for some $25 million BZD annually. There are some 3,500 licensed fishers in the industry. Ninety percent of the industry is based in the barrier lagoon and the atolls. Reef associated demersal species such as lobster and conch account for 98% of the export earnings in the industry. In 2006 spiny lobster and conch exports accounted for approximately $22 million BZD in earnings. There is currently no information on the size of the subsistence, recreational and sports fisheries.

The primary threats to the Fishing industry are increased sea surface temperatures, changes in pH and loss of habitat. Work done by Turner et al in Australia and New Zealand established a relationship between habitat loss and a decline in fish populations. (Turner et al, 1999) Juvenile mortality (or survival) has an effect on adult population sizes and is affected by preferred habitat type, among other things. (Beukers et al, 1998) Increased sea surface temperatures and pH will have an impact on physiological and behavioural processes. Environmental conditions that are outside the optimal range can decrease foraging, growth, fecundity and migratory behavior in aquatic species. (Roessig et al, 2004) This could result in a reduction in the size of the exploited stocks. Additionally, in an attempt to adjust, commercially exploited species could migrate to more optimum conditions, and out of the reach of the existing fishery.

4.5.3 Aquaculture

First introduced in the 1980's, the constant growth of aquaculture over the last 20 years has resulted in an industry that contributes some $60 - $70 million BZD a year in export earnings. The major species grown is the Pacific White shrimp *Paneaus vannemei*, but other species such as the Red Drum (*Sciaenops ocellatus*), Tilapia (*Oreochromis niloticus*) and Red Claw Crawfish (*Cherax quadricarinatus*) have been attempted. At present there are some 2,000 acres under cultivation on land with shrimp and tilapia. Cage culture of Cobia (*Rachycentron canadum*) is currently being done in the Robinson Point area and another 100 acres of cages are planned for locations a few miles east of Placencia. Despite a fall in prices that continue to be weak since 2005, the industry continues to produce an annual average of 22 million pounds of shrimp. The recently introduced cage culture for Cobia is currently producing 8,000 per week and expected to increase to 20,000 per week.

The shrimp industry currently utilizes marginal agricultural land in the central and southern coastal plain. All the shrimp farms are located within the first two miles of the coast in the coastal plain to take advantage of the proximity to a saltwater source, and soil that has a high percentage of clay, making it better suited for pond construction. There has been limited destruction of mangroves associated with the construction of shrimp farms, unlike in some other shrimp farming countries.

Greatest threats to the industry are from rising sea levels and frequency of storm events. A higher mean sea level would result in sea water encroachment and would require relocation or redesign of the facilities. Higher sea levels would also provide a higher base for storm surges. Increased frequency of storms will also mean an increase in storm related damage. One of the greatest concerns of shrimp farmers has been the possible pond damage and escapes from hurricanes. However, information gathered from the passage of Hurricane Iris in 2001 showed that while there was major damage to buildings, the ponds suffered very little damage and no levees were breached. Grow out methods have shown that lower salinities from increased rainfall do not have a detrimental effect on the survival of the shrimp and levee erosion can be combated through maintenance. As a result impact on the industry from climate change is not expected to be severe.

4.5.4 Agriculture

Before tourism became the largest revenue earner agriculture was the main stay of the economy. It still continues to play a dominant role and sugar, citrus and bananas accounted for $260 million BZD in 2006. Papaya and non-traditional crops helped to boost the total to almost $300 million BZD. This represents a 9% contribution to GDP. Approximately 50% of the banana plantations and 10% of citrus orchards are located in the coastal plain. Projected strong prices for citrus coupled with a stable pricing structure for sugar and bananas for the next 5 – 10 years means that these commodities will continue to be important in the Belizean economy.

As was made clear by the passage of Hurricanes Keith, Iris and Dean, the greatest threat to agriculture is from inundation and storm damage. Because of the topography in the sugar producing regions in the north of the country most sugarcane fields are below the 10 m contour and are subject to inundation. Changes in rainfall patterns would impact the sugar industry because of the lowering of sucrose content in cane plants that are inundated for long periods. Increase in the frequency and severity of storms would result in physical damage to plants. Hurricane Dean damaged approximately 800 acres of the papaya and 6,000 acres of sugarcane. This represents some 90% and 60% of the respective productions. In 2001 Hurricane Iris destroyed approximately 80% of the banana plantations. There is no information on the damage sustained to non-traditional and subsistence crops which are important sources of food for the local market. However, it is expected that they would be impacted in a similar fashion.

4.6 Coastal Settlement

In 2000 it was estimated that some 45% of the population lived in the coastal zone. While the 2007 estimates show a decline in the percentage of the population residing in the coastal zone, from 45% to 38%, the actual number of persons has increased from an estimated 112,000 in 2000 to an estimated 120,000 in 2007. With the exception of Punta Gorda Town, elevation in coastal communities is between 0 – 3 m above sea level. Fueled by the continued growth in tourism, development in coastal communities and along the coast continues at an accelerated pace. Discussions with the Lands Department indicated that while several leases were given out in coastal areas and the cayes, it was not possible to determine the state of development of the individual parcels. It was also acknowledged that a major portion of the coast and cayes was held under private title and long term leases that were planned for tourism and residential development. (Lands Dept, 2007) As mentioned under the section on Beaches and Coastal Areas, the greatest threats to coastal areas are from inundation due to sea level rise and changing rainfall patterns, and storm surges.

4.7 Water Resources

The country of Belize has substantial surface and ground water resources. In addition, both sources are regularly replenished on a seasonal basis because of the reliability of the rainfall patterns. In 1996 it was estimated that the total resource stood at 80.8 thousand cubic meters per capita. Recent increases in water use are placing increased demand on these water resources. A Government of Belize Press Office release indicated that in 2003 some 99% of urban and 93% of rural communities had access to potable water.

Three of the larger urban centres in the coastal area, Belize City, Dangriga and Ladyville, are supplied from surface water sources. With the exception of San Pedro, which has a reverse osmosis system, all other coastal communities extract from ground water sources through deep and shallow wells. In the cayes water is supplied from the thin, and often fragile, freshwater lens that sits above the saltwater in the water table. As was observed in the case of Placencia and Caye Caulker, this lens is susceptible to contamination. Placencia has tapped into the aquifer under the southern coastal plain and a reverse osmosis plant is planned for Caye Caulker.

Saltwater intrusion as a result of sea level rise is projected to be the greatest threat to freshwater resources. In the case of shallow wells, particularly in the cayes, increasing sea levels will push the already thin freshwater lenses upwards. This might be offset by increased rainfall as a result of changing weather patterns. However, over abstraction could lead to salinization of water sources and most cayes would lose their existing source of potable water, as was the case in Placencia.

Highly meandering rivers generally have a reduced flow during the dry season and tidal influences become strong for a significant portion of their length. With increased sea levels, permanent saltwater intrusion and tidal effects would extend further up the river basins. Communities such as Belize City, Dangriga and Ladyville that have their water sources in rivers could find these sources threatened. Most other coastal communities are abstracting from deep wells and would not be significantly affected.

4.8 Inundation

The assessment report of 1999 stated that approximately 60% of coastal areas were permanently inundated. Current topography maps of Belize do not have contour lines between 0 and 20 m. With a projected 30 – 50 cm increase in mean sea level over the next 50 years, areas that are presently a few centimeters above sea level will convert to wetland and current wetlands will convert to shallow lagoons. Increased inundation also increases the possibility of water-borne diseases. The Medical Department in Belize suggested that outbreaks of Dengue Fever in 2007 were probably as a result of the increased amount of standing water on the ground after recent floods. (Tropical Vision TV Ch. 7 Newscast). Because of the gross nature of the contour scales on the current maps, it is not possible to estimate the land area that would be converted to permanent wetlands as a result of increased sea levels.

5.0 Assessment of Capacity to Adapt to Climate Change

In the 4th Assessment Report, Working Group II of IPCC cautioned that vulnerability was very dependent on context and scale and that care should be taken to address the uncertainties inherent in vulnerability assessment. It added that frameworks should also be able to integrate the social and biophysical aspects of vulnerability to climate change. The report from the Panel also suggests that poverty alleviation and elimination should be an integral part of any adaptation strategy. Previous adaptation strategies were primarily science and research oriented. Protect, accommodate, and retreat were the three coastal adaptation strategies previously identified. Current vulnerability assessment offers an

opportunity to develop policy frameworks that focus on such things as poverty alleviation, alternative livelihoods, protection of the commons and the strengthening of collective action.

The Government of Belize, as part of its macro development plan, currently has achieving the Millennium Development Goals as one of the major objectives for development in Belize. Goal #1 is to "Eradicate extreme poverty and hunger" and Goal #7 is to "Ensure environmental sustainability". These development objectives provide an opportunity for the integration of adaptation strategies into the overall development plan. Although climate change is a global issue, local efforts can help maintain and enhance resilience and limit some of the longer-term damages from climate change. Because much cannot be done to combat the physical aspects of climate change, there is the need to manage properly and to limit negative human impact on these systems, in an effort to provide the conditions for affected species to develop resilience.

Belize has undertaken two previous coastal vulnerability assessments. In 1996 Cayetano *et al* did an Aerial Video-assisted Vulnerability Assessment. This was followed in 1999 by Gibson *et al* who did a coastal zone adaptation to climate change. Several mitigating measures were proposed in the second assessment which were aimed at reducing the impacts of human activities to a level where natural ecosystem resilience would be enhanced and systems would be able to keep pace with climate change. The following measures were proposed in the First National Communication include:

a) Establish setbacks for undeveloped coastal areas
b) Construct and improve seawalls
c) Undertake Beach nourishment
d) Relocate vulnerable coastal communities
e) Prepare post-disaster reconstruction plans
f) Monitor relative sea level rise and local wave climate
g) Monitor the shoreline
h) Develop an education and public awareness campaign
i) Develop a national water management system
j) Obtain comprehensive knowledge of nation's water resources
k) Prepare a national water resources plan
l) Promote effective and efficient use of water
m) Develop local management and technical expertise
n) Relocate point sources of potable water in the coastal zone to points above influence of saline intrusion
o) Encourage use of cisterns
p) Adopt forest management plans
q) Adopt agricultural practices based on availability of water
r) Relocate agricultural activity away from the coastal zone

In addition Gibson *et al* proposed the following measures:
Biophysical:

a) Make the Integrated Coastal Zone Management an integral part of Belize's action plan for climate change

b) The National Biodiversity Strategy and Action Plan be formally adopted
c) Reef and Mangrove Monitoring and Research
d) A network of Marine Protected Areas
e) Improved land use and agricultural practices
f) EIA requirements for coastal development
g) Adoption of a Marine Dredging Policy
h) Update and implement the national mangrove management plan
i) Initiate a programme for the planting of mangroves in critical areas
j) The protection of specific wetland areas

Socioeconomic:

k) Develop an integrated water management policy, support watershed management and control water abstraction
l) Change the land use policy – formal adoption of the Cayes Development Policy
m) Consider measures for reducing pressure on heavily exploited stocks
n) Encourage the diversification into the exploitation of new stocks and expansion of the EEZ
o) Improve the management of catch levels
p) Adopt policies that promote "green" marine based tourism
q) Maintain and expand the mooring buoy system
r) Conduct site-specific research on the carrying capacity for critical and marine protected areas

5.1 Results of Adaptation Initiatives

As part of the vulnerability assessment, Belize's capacity to adapt to climate change will be evaluated under the following headings: Governance, Economic, Social and Ecosystem

5.1.1 Governance:

Governance looks at the structures that are needed to make the changes in attitude and behaviour, whether they are in place, and to what extent they are functioning. It looks at whether there is an agency to do what has to be done, what legal status it has to do that job, any policies or strategies to guide how the job gets done and the capacity of the persons involve to do the job. At present there are several agencies that have some form of jurisdiction over resources in the coastal zone.

The National Meteorological Service is the Focal Point for the UNFCCC and as such has the responsibility to take the lead in ensuring that Belize meets its commitments under the Convention. However, this has not been legislated. The Coastal Zone Management Authority and Institute is the agency mandated by the Coastal Zone Act to coordinate, develop policy and advise on integrated coastal zone management. The Fisheries Department is responsible for the management of aquatic resources below the surface but above the seabed. The Forest Department's mandate extends to littoral forests, mangroves and marine mammals. The Belize Tourism Board has the responsibility of developing, guiding and supervising tourism activities. The Lands Department's mandate includes land use in the coastal zone and the construction of any structures over the

water. The Agriculture Department has responsibility for all agriculture-related activities including the management and control of agrochemicals and cultivated species. Geology and Petroleum Department has a mandate for all subsurface resources, whether terrestrial or marine. The Department of Environment is responsible for ensuring that the general health of the environment, including air and water quality, is above a prescribed standard. The Belize Port Authority has responsibility for most ports in the country and the control and management of navigation. There are three other agencies that do not have specific mandates within the coastal zone but have an input. These are the Solid Waste Management Authority and the National Emergency Management Organization (NEMO). The Central Housing Authority has a mandate for urban planning but this agency has not been active in recent years. Table 1 below summarizes the current status of the agencies mentioned above.

Several multi-agency bodies are also in place to facilitate collaboration among the major stakeholders. Most of these bodies include private sector participation. Among these are the National Climate Change Committee, the National Environmental Appraisal Committee (NEAC), the National Protected Areas Commission, the Pro-Tem Water Commission and the National Human Development Committee. The purpose of the National Climate Change Committee is to monitor the impact of climatic variability on the socioeconomic and environmental sectors of the country. Its functions are listed in the draft Terms of Reference for the committee. The composition of this committee is provided in Annex 2. NEMO also functions as a multi-agency task force, with several agencies forming the National Emergency Management Committee and the Secretariat being responsible for coordination and implementation. Some of these committees are more active than others and the effectiveness of decisions made by them is generally dependent on the particular lead agency for each committee.

In addition to the legal instruments, there is the need to have in place mechanisms to guide the execution of required actions. This generally takes the form of policy documents and/or strategic and work plans. There is also the need to have some means of monitoring and evaluating the implementation of these policies and plans. Of the eleven agencies identified, Department of Environment, Belize Tourism Board, NEMO and Ministry of Agriculture (Agriculture and Fisheries Departments) had policies or plans that were for the current period (2007 and beyond) which were in various stages of the implementation. The remaining seven agencies had policies or plans that required updating. The Met Department, as UNFCCC Focal Point, has developed a National Climate Change Policy that is before the Cabinet for adoption. The text of the policy was not available for review.

Table 1: Summary of agencies that operate within the coastal zone of Belize and status of activities relevant to climate change				
Agency	Role / Mandate	Legislation	Policy / Strategic Plan	Actions to date
CZMAI	To guide research, recommend policy and coordinate activities that are allowed in the coastal zone	Coastal Zone Act	Coastal Zone Strategic Plan	The CZMAI has gone through a period of contraction and has lost most of its staff, and the capacity to fulfill most of its mandate under the CZMA. There are also some weaknesses in the enabling legislation.
Fisheries Department	Develop policy for, and manage the aquatic resources of the country. Also the co-chair for the NPAC	Fisheries Act	National Food & Agriculture Policy (2002-2020) No Farmer = No Food.	Done a complete review and evaluation of the lobster industry to determine trends and recommend management strategies
Forest Department	Develop policy for, and manage terrestrial fauna and flora. Also the co-chair for the NPAC.	Forest Act, National Parks Act, Wildlife Protection Act	There is a 1956 Forest Policy that is still being used. The department is in the process of developing a new Forest Policy.	The department has recently completed both a communications and a financial sustainability strategy.
Lands Department	Manage the distribution and tenureship of land	National Lands Act, Belize Land Development Authority Act, Land Reform (Security of Tenure) Act, Land Utilization Act, Registered Land Act	No current land use policy	A new Land Management Program was implemented in 2003 which among other things would "…build capacity for land use planning at the local, regional and national levels;"
Ministry of Agriculture	Promote agricultural production and provide support services for the sector	No enabling legislation	National Food & Agriculture Policy (2002-2020) No Farmer = No Food.	Belize Agriculture Health Authority is the arm of the Ministry that regulates the importation and use of agrochemicals
Geology and Petroleum Department	provide management for the non-renewable natural resources. Responsible for dredging and sand mining	Petroleum Act, Mines and Minerals Act	No current policy	The department has guidelines for dredging and sand mining, and are in the process of developing a new set of regulations for offshore exploration and drilling.
Department of Environment	Management of natural	Environmental Protection	National Environmental	Completed the inventory of

	resources, protection of the environment, control of pollution and recommend policy	Act, (Environmental Impact Assessment Regulations)	Policy and Strategy, National Solid Waste Management Plan	GHGs and POPs and is currently developing a country strategy for POPs.
Belize Tourism Board	Recommend policy, coordinate and manage all sectors of the tourism industry	Belize Tourism Board Act, Belize, National Tourism Council Act	Belize Tourism Policy 2005	Recently completed the Tourism Development project that was to improve the infrastructure and level of services provided in the industry.
National Emergency Management Organization	Coordinate preparation and response to national emergencies	Disaster Preparedness and Response Act	Belize National Hazard Mitigation Plan 2005	Has completed training for the public and private sector in disaster preparedness and emergency response
Met Department	To provide the country with up to date and accurate weather forecasts and provide support to other sectors of government through reliable climatology information	No enabling legislation	National Climate Change Policy (draft)	The department is the focal point for UNFCCC but not much has originated with that office because of staffing constraints.
Belize Port Authority	regulate and control navigation within the limits of the ports, and the control, improvement, preservation and maintenance of all ports, harbors, rivers and public wharves of Belize	Belize Port Authority Act, Harbors and Shipping Act	No current Policy	No information available
Solid Waste Management Authority	Recommend policy and coordinate the management of solid waste collection and disposal	Solid Waste Management Authority Act	No current policy	The DoE is has responsibility and is currently implementing the Solid waste management project to improve the collection and disposal of solid waste.
Ministry of Housing	To carry out the functions of the Central Housing and Planning Authority	Housing & Town Planning Act	No current policy	There are planning documents for Belize City, Corozal and Ambergris Caye and one planned for Caye Caulker. No “planning’ has been done recently.

There are several recently developed policies that are not specific to one agency but which have implications for the country's ability to adapt to climate change. These are the National Protected Areas Policy and System Plan (NPAPSP), National Poverty Elimination Action Plan (NPEAP), National Poverty Elimination Strategy, the National Water Policy and the Cayes Development Policy (Draft). Implementation of these policies will be key in determining the country's vulnerability to climate change.

An important aspect of governance is the ability and willingness of a particular agency to adequately fulfill its mandate. Three things were taken into consideration when looking at the ability of an agency to meets its legal and functional obligations; technical capacity, human and financial resources. With the exception of BTB, all other agencies indicated that they were operating under significant finance and personnel constraints, which limited their ability to deliver basic services. It was felt that the required capacity was resident or could be developed in the country but not necessarily within the public sector. Additionally, the University of Belize has developed programmes in Business, Tourism and Natural Resource Management at the Associate and Bachelor level that will help to develop the necessary capacity in country. There was also access to numerous targeted short term courses and workshops within the country and the region through the various projects currently being implemented.

5.1.2 Economic:

At present the economy of Belize relies heavily on resources within the coastal zone. Recent accelerated growth in the tourism and aquaculture industries have resulted in significant impacts on the resources. Concerns have been raised about the level of coastal development and the ability of the ecosystem to cope with such things as modification or loss of habitat as a result of land clearing, land reclamation, dredging, increased effluent loads and increased human activities. Despite these concerns, lead agencies in the tourism, fisheries and aquaculture sectors have been promoting the use of best practices for operators in these industries. The current 'green' revolution is providing incentives for operators to develop eco-friendly ways of doing business.

The BTB recently collaborated with Conservation International to develop a walk through programme for hotels that evaluated the extent to which the individual hotels met certain eco-friendly standards. However, while the policy provides direction on the actions necessary to increase the earnings from tourism, there are no clear statements that indicate the role the BTB intends to play in ensuring the health and integrity of coastal resources that are vital to the existence of the industry. The International Coral Reef Action Network (ICRAN) in collaboration with the Belize Tour Guide Association has developed a set of best practices for the operators, guides and guests. With the guidance and support of Environmental Defense, the aquaculture industry is working with buyers in the US and Europe to develop a certification programme based on eco-friendly production standards. At present participation in these programmes is voluntary but may need to become part of the industries' development policies for them to be effective.

Some work is being done by World Resources Institute (WRI) to develop a model that can be used to do economic evaluation of coastal ecosystems. The project is currently in

the data gathering stage and looks at coral reef associated fisheries, coral reef associated tourism and shoreline protection services. While the value from fisheries and tourism is well known, the evaluation of shoreline protection services will be invaluable in providing policymakers with the value of maintaining coastal habitats intact.

5.1.3 Social:

While most technical professionals within government and the NGO community are familiar with the efforts to adapt to climate change, the average Belizean is either unaware, or for those were aware, uninterested. Global climate change and sea level rise were seen as affecting other people in other countries. Information received during informal discussions suggests that for most Belizeans no relationship is made between such events as the extensive floodings in recent years (Western Highway and Belize City) and the current life style. This disconnect appears to exist because no effort has been made to link cause and effect at the local level. Insufficient information is provided on the level of GHG emissions, the volume of garbage accumulated daily, the amount of water use or the volume of agrochemical use within the country, and how they impact on the health of the resources. Much of this information is already available but is buried in reports that are sitting on shelves. The lack of any enforceable land use or coastal development policy has helped to exacerbate the problem. There is evidence of increased land clearing along the coast or on steep slopes along the Hummingbird Highway, a practice that is expected to increase with the issue of a large number of leases for resorts, residential homes and farmland in those areas. There is a need to reverse this trend as it will escalate as the population increases. While there is the need to provide land for development, it has to be balanced against the benefits realized by keeping those resources in their natural state. Relevant information needs to be made available to ensure that Belizeans living and relying on resources in the coastal zone can be assured a healthy environment.

5.1.4 Ecosystem:

Perhaps the greatest and most consistent strides in the adaptation to climate change have been made in the area of ecosystem management. While not a specific response to climate change, the declaration and management of Protected Areas satisfies one of the more important requirements for adaptation; protection of the physical environment to allow it to develop resilience. Belize has declared an impressive array of coastal and marine protected areas that provide refugia for key species and destinations for tourists. Management of these protected areas is shared between GoB and several NGOs. Annex 3 is map showing the extent of coastal and marine protected areas.

Belize has always sought to provide proper management for its natural resources. To ensure the effective management of the entire protected areas system, a National Protected Areas Policy and System Plan was developed and adopted. Through the MBRS Project a comprehensive synoptic monitoring programme has been put in place, in the MPAs, for most threatened species. This programme currently monitors corals, mangroves, sea grass and water quality. Unfortunately this programme does not extend to all MPAs within the system. Separate monitoring programmes are in place for turtles, manatees and crocodiles. The Pesticides Control Board keeps a register and monitors the

importation and use of agrochemicals. There is currently no monitoring of development and changes in land use along the coast. The Geology and Petroleum Department has developed guidelines for the issue of dredging and quarry permits and does involve the relevant agencies in the approval of such permits. However, unless it is a high profile case, there is little or no monitoring after the permits are approved. There is the need to verify the extent to which these anthropogenic changes are impacting on the ecosystem.

Table 2 summarizes the status of the recommendations made in the first Vuulnerability Assessment Report. Base on the information available, the conclusion is that most of the structures are in place to plan for, implement and manage adaptation to climate change. However, there is the need for streamlining to ensure their effectiveness.

Table 2: Status of Recommendations made in the first Vulnerability Assessment

Recommended Action	**Status**	**Comments**
Establish setbacks for undeveloped coastal areas	This is already in the legislation	There needs to be some clarification of where and when the legislated setbacks come into effect. There also needs to be some policy on what
Construct and improve seawalls	Work is being done by individuals on private property and this process is facilitated by the Geology and Petroleum Department	With exception of the Southern Foreshore in Belize City there is no indication of any initiative by the government to undertake such a project as public works.
Undertake Beach nourishment	Work is done on an individual basis on private property	No coordination or plan at the government level
Relocate vulnerable coastal communities	There has been some migration inland primarily from Belize City	There is no indication that this was done as a result of the recommendation made but rather as a campaign promise to provide addition housing.
Prepare post-disaster reconstruction plans	A Hazard Mitigation Plan has been prepared and adopted.	There is no timeframe for implementation
Monitor relative sea level rise and local wave climate	The Met Department established a series of Tide gauges as part of the CPACC project	The instruments may not be working and the data needs to be analyzed.
Monitor the shoreline	Being done on an ad hoc basis	There is no comprehensive programme in place.
Develop an education and public awareness campaign	Education and public awareness is being done by individual agencies and is specific to their particular programme.	There is no coordination between agencies to ensure that there is a unified approach to the development and presentation of outreach information.
Develop a national water management system	Draft water policy and legislation have been developed	These instruments need to be formalized
Obtain comprehensive knowledge of nation's water resources	Being done by the Hydrology Unit of the Met Department	There is the need to disseminate the information.
Prepare a national water resources plan	This is being done as part of the water policy	
Promote effective and efficient use of water	This is also being done as part of the policy	The Met Department is currently providing information to the general public through "Tips" given during the nightly weather reports. However, these are not limited to water use.

Develop local management and technical expertise	Being addressed in the water policy	
Relocate point sources of potable water in the coastal zone to points above influence of saline intrusion	This is being done through the SIF and BNTF for rural communities. Not being done for systems under the control of BWSL.	
Encourage use of cisterns	No indication that this is being done	There is no information available on
Adopt forest management plans	Plans are currently being developed	
Adopt agricultural practices based on availability of water	Included in the Ministry of Agriculture's policy for 2002 - 2020	No indication that it is currently being implemented
Relocate agricultural activity away from the coastal zone	Not being done	This is not considered a priority at the moment. Such actions will need to be incentive driven.
Make Integrated Coastal Zone Management an integral part of Belize's action plan for climate change	Not done	
The National Biodiversity Strategy and Action Plan be formally adopted	The Strategy and Plan have been adopted	The strategy and action plan are not being implemented.
Reef and Mangrove Monitoring and Research	Currently being done	Being undertaken by a number of entities both local and foreign, and needs to be coordinated.
A network of Marine Protected Areas	Already done	There is the need to streamline management practices to ensure continuity across the network
Improved land use and agricultural practices	Included in the Ministry of Agriculture's policy for 2002 - 2020	Implemented on a limited scale.
EIA requirements for coastal development	Already in place for large developments	Needs to be extended to all coastal developments
Adoption of a Marine Dredging Policy	Not done	The Geology and Petroleum Department has developed its own set of guidelines which include consultation with the appropriate agencies
Update and implement the national mangrove management plan	Not done	This willform part of the NFP
Initiate a programme for the planting of mangroves in critical areas	Not done	The reverse is currently happening with the level of development planned or taking place
The protection of specific wetland areas. (Faber's Lagoon, Straight/Almond Hill Lagoon/Hector Creek complex, and the swamp behind Dangriga)	Partially completed. Hector Creek, Straight and Almond Hill Lagoons have not been declared.	Gra Gra Lagoon National Park (Dangriga) was declared in 2002. Other coastal protected wetlands and lagoons were declared before 1999.
Develop an integrated water management policy, support watershed management and control water abstraction	A draft water policy has been developed that includes abstraction control and some watershed management.	This is currently being done through the Climate Change Centre on behalf of the Met Department
Change the land use policy – formal adoption of the Cayes Development Policy	This is to be addressed through the Land Management Programme	There is no information available to indicate that the Cayes Development Policy will form part of any revised

		land use policy
Consider measures for reducing pressure on heavily exploited (fish) stocks	Currently being done by the Fisheries Department	Introduced quotas for the conch fishery and held a consultation to review the management of the lobster fishery
Encourage the diversification into the exploitation of new stocks and expansion of the EEZ	Currently being done by the Fisheries Department	The Department has done training for fishers and exploratory fishing in areas outside the barrier reef. Implemented a FADs programme for pelagic species.
Improve the management of catch levels	Currently being done	The Department instituted a quota system for conch harvesting and did a complete review of the lobster fishery with technical assistance from Cuba.
Maintain and expand the mooring buoy system	Currently being done	In collaboration with the BTB, BTIA, BTGA and NGO co-management partners the mooring buoy network is being improved and expanded.
Conduct site-specific research on the carrying capacity for critical and marine protected areas	No work done to date	
Adopt policies that promote "green" marine based tourism	Currently being implemented through the MPA system	Current management practices designed the protect the ecosystem

6.0 Recommendations

Given the size of the environmental footprint generated by Belize it is reasonable to assume that, while reduction of emissions should remain the ultimate goal, our contribution to the reduction in the level of greenhouse gases will continue to be negligible when compared to other countries in the region and the world[1] Consequently, Belize needs to focus on those actions that will reduce direct impact and help to build resilience within the natural environment. The recommendations made in previous assessments have met with limited success for a number of reasons, including lack of funding, lack of coordination and unavailability of personnel. Other observations made during this current assessment are the lack of political will that is hidden under the guise of development, and the fear of public officers to make decisions that might be technically sound but politically unpopular. There are no recommendations for these.

Inherent in these recommendations is the need to monitor and evaluate. The recommendations that are made below seek to optimize the available time, human and financial resources. This is not always possible as some recommended actions are inherently time, labour or financially intensive. Based on the evaluation of capacity it is evident that many of the structures required for adaptation to climate change are already in place and that what is needed is consistent implementation. The greater the capacity to adapt, the less vulnerable to climate change the country will be.

6.1 Revitalize and reconstitute the National Climate Change Committee.

This recommendation is made with some reservation. The National Climate Change Committee is to be the body that should monitor and advise on matters of climate change but it has met infrequently in four years. Additionally, in the absence of a formal climate policy there is little functional or legal justification for the existence of the committee. Given the new emphasis on community participation in climate change adaptation decisions, there is the need to have more community and private sector involvement. As is stands the committee is already large, with a membership of 20, but the balance is heavily skewed towards the government agencies. It is recommended that:

- The need for the committee is rationalized in light of the draft climate change policy;
- Belize Audubon Society be replaced by a representative from the Association of Protected Areas Management Organizations (APAMO);
- CARDI and CCCC be removed as full members and placed as observers;
- Replace Economic Development with National Development;
- Include representation from the National Association of Village Councils (NAVCO), the Belize Tourism Industry Association (BTIA) and the Shrimp Farmers Association.

6.2 Revitalize and strengthen the Coastal Zone Management Authority through a revised mandate and with increased staff and financial resources.

The problem with the CZMAI was never its role or responsibility, but rather its authority and sustainability. Turf battles further added to its current reduced role. The need for

[1] 8,000 tonnes for Belize as compared to 13 billion tonnes for the US – 1994 figures (UNFCCC website).

Integrated Coastal Zone Management, and by extension the CZMAI, is greater now given the increasing activities within the coastal zone. A strengthened CZMAI would provide the interagency coordination in climate change that is lacking at the moment. Given the importance of integrated coastal management, improved Coastal Planning and Watershed management would be part of the mandate of the CZMAI

6.3 Bring back the Annual State of the Coastal Zone Symposium or some similar forum for the presentation of technical information on the work that is being done within the coastal zone. This can be coordinated by a revitalized CZMAI or through the University of Belize.

Very important monitoring and research work is being done in the country more so now than in the past. However, large portions of this information are not available to advise management because there is generally no knowledge of the existence of the information. Providing a forum for the presentation and discussion of the information places it in the public domain and makes it accessible to be used for management purposes.

6.4 Conduct a series of country-wide Baseline Assessments within the major habitats. Such assessments would establish baselines for coastal erosion, watersheds management practices, coastal development and ecosystem health for the entire country. With the increase in Cruise Tourism there is the need to establish Limits of Acceptable Change for MPAs and a mechanism for declaring "no take" areas. The MBRS Synoptic Monitoring Report was a step in that direction but is limited in its treatment of mangroves, sea grass and water quality.

6.5 Develop an incentive programme that encourages the private sector to actively participate in adaptation to climate change.

Mainstream best practices such as water usage, reduced gas consumption and garbage reduction through rebates and tax incentives. It is human nature that most people will not participate in programmes that they cannot benefit from in some way. There is really no incentive for people to change their habits if doing so will not make any appreciable difference to them. There is opportunity to provide tax and import duty incentives or points rewards for tourism operators, hotel owners, fishers, etc who use eco-friendly technology. The tourism hotel walk through programme is one that can be expanded with the help of incentives. There is also opportunity for recycling programmes that reduce solid waste.

6.6 Establish a functional Information Clearing House.

There is the need to collect, collate, catalogue and copy all the technical information that is currently scattered across the various government agencies and NGO partners. This will serve the dual purpose of i) making the information readily available and ii) indicating gaps in the information needed for proper management. There are two places where this Clearing House can be located, the new CZMAI or the Forest Department as part of the Clearing House Mechanism (CHM). Both agencies already have similar mechanisms in place for other themes and inclusion of climate change information would simply be an expansion of the existing infrastructure. In addition there is the need to

streamline the management and maintenance of the system in both locations. One possible improvement could be the development of a web-based access system.

6.7 Revise and streamline the current legislations and policies that relate to the management of the coastal zone to eliminate overlaps and close existing gaps.

6.8 Improve the coordination of interagency cooperation and exchange of information on matters related to climate change. This can be achieved by placing the responsibility for coordination with a specific agency such as the Met Department or CZMAI. One reason why the NEAC functions is because it has a single coordination point in the DoE.

6.9 Develop strategies to increase compliance particularly with regard to coastal development.

The general concern within the regulatory agencies is the shortage of resources. In most cases the compliance functions are dropped when resources get scarce. Given the importance of compliance programmes it is vital that new ways be found to keep them going. There are NGOs that currently use stakeholders (tour guides and fishers) to be the eyes and ears of their compliance programmes. As communities become more aware it will be possible to involve them in an expanded compliance monitoring programme.

6.10 Develop a Public Awareness and Education Strategy.

There is the need to develop public awareness and information dissemination strategy that involve all the member organizations and agencies of the BCC, and is targeted to all sectors of the population. Promote the teaching of best practices in the school system. Develop public awareness by keeping the public informed of developments through the media, talk shows, newspaper articles, special events etc, and make them user friendly. Climate Change should not be made to seem a special event in itself but should be presented as an integral part of everything that is happening. The cause and effect link needs to be made.

6.11 Consolidate and Strengthen the MPA system.

This is being done through the NPAPSP. There is the need to identify mechanisms for funding for critical activities such as compliance and monitoring across the entire network possibly through the System Plan.

6.12 Expand and Streamline the Ecosystem Monitoring Programme.

A number of different monitoring methodologies and strategies are being used to monitor ecosystem health, particularly in MPA. There is the need to standardize the current monitoring programme across all MPA to allow for ease of comparison. More importantly, the monitoring programme should be expanded to include the monitoring of development activities and extended to include areas that are not currently protected.

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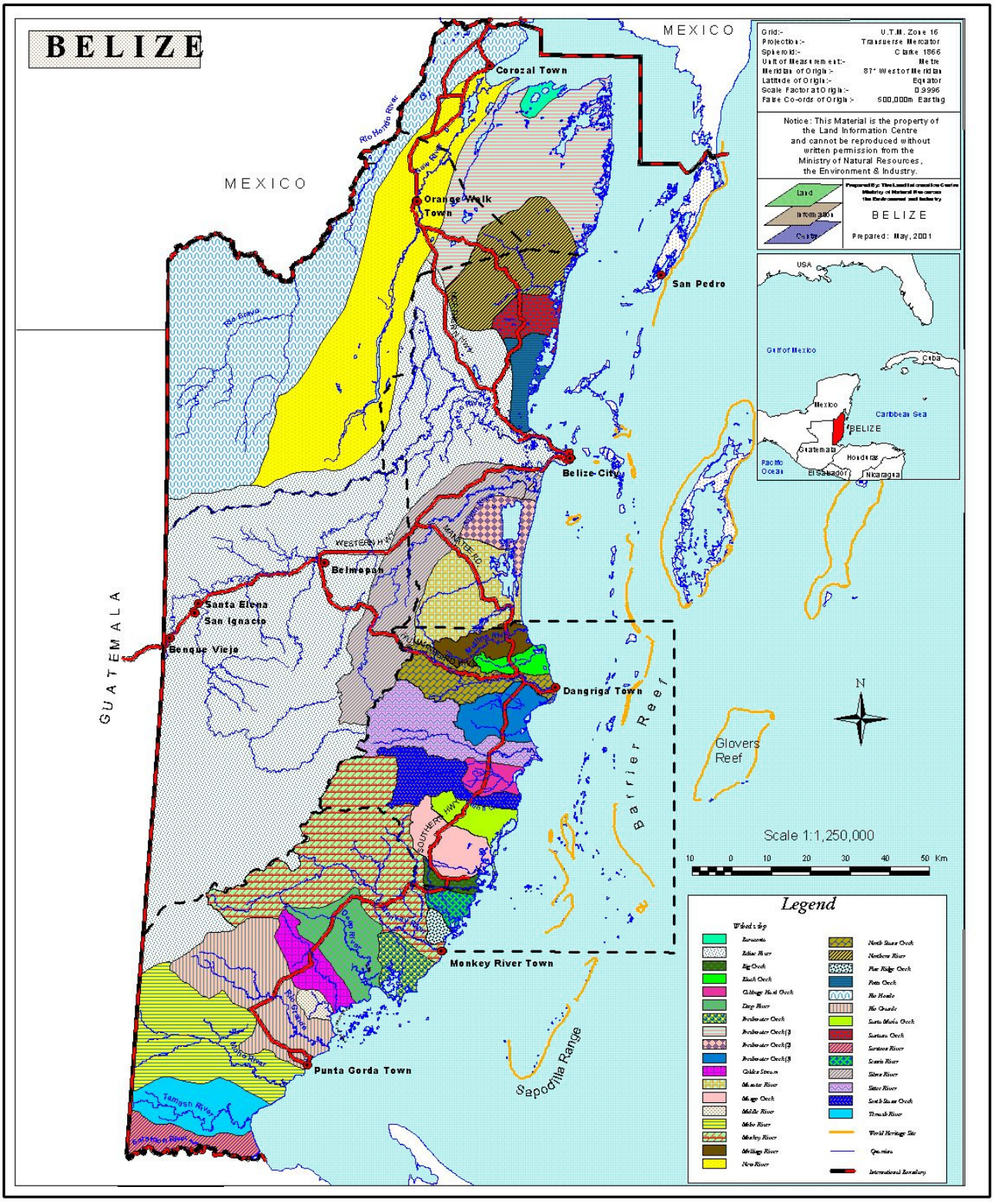
Annexes

Annex 1: Map of the Major Watersheds in Belize



Map courtesy of DoE

Annex 2: Composition of the National Climate Change Committee (by agency or organization)

Government Departments and Agencies:

Meteorology	Forestry
Fisheries	Agriculture
Health	Geology and Petroleum
Environment	Lands
Economic Development	Belize Tourism Board
Housing	University of Belize

Coastal Zone Management Authority and Institute

Private Sector Associations and Boards:

Belize Audubon Society	Citrus Growers Association
Belize Sugar Industries	Cane Farmers Association

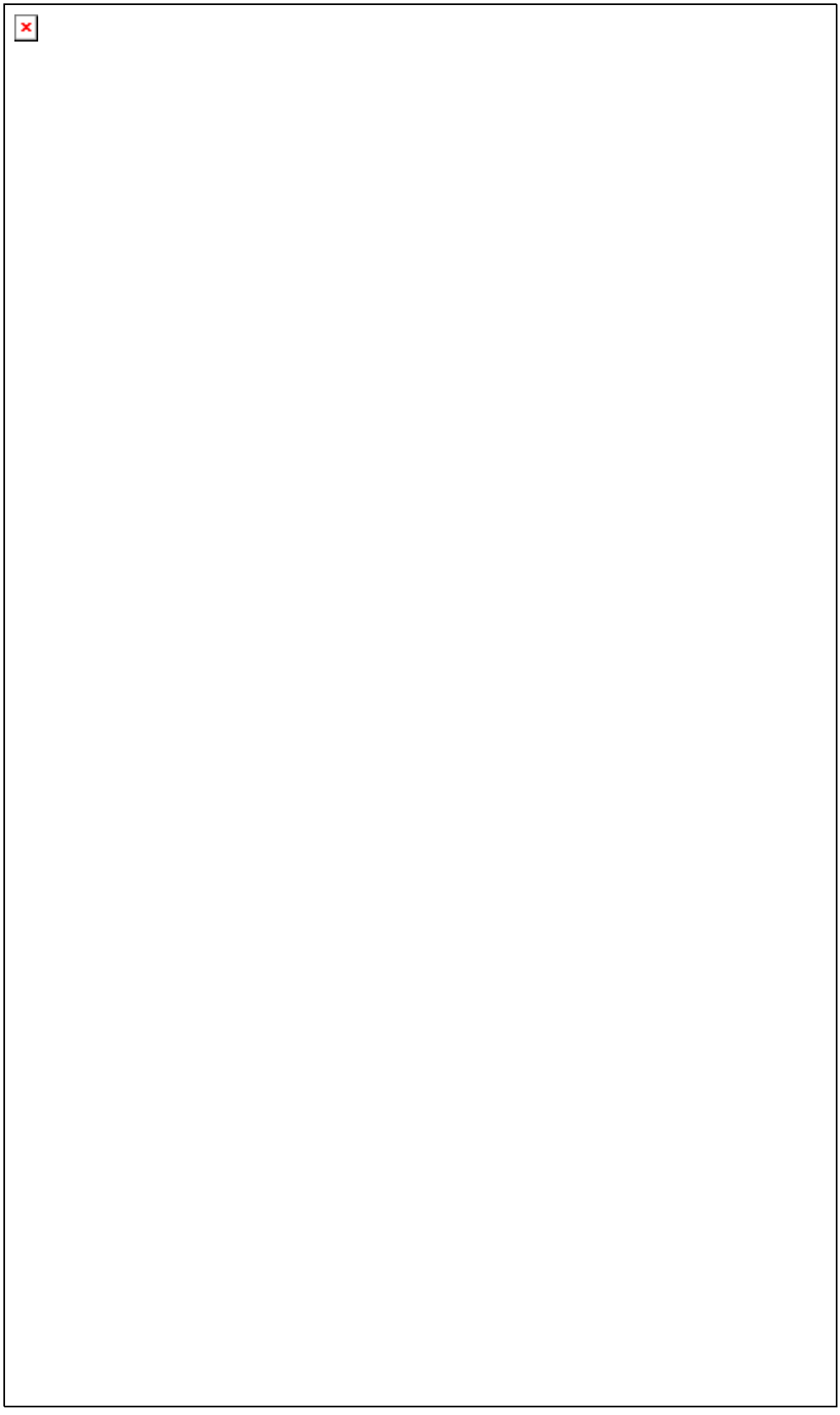
Banana Growers Association

Regional Organizations:

Caribbean Agriculture Research and Development Institute

CARICOM Climate Change Centre

Annex 3: Map of Coastal and Marine Protected areas in Belize



International Conventions and Agreements, which impact the Coastal Zone, to which Belize is a signatory:

- United Nations Law of the Sea Convention (LOSC) (ratified 13 August, 1983).
- World Heritage Convention (ratified in 1990).
- Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES) (ratified 1976).
- Convention on Biological Diversity (CBD) (ratified in December, 1993).
- Central American Biodiversity Convention.
- Convention for the Conservation on Biodiversity and the Protection of Priority Areas in Central America.
- Agreement on Cooperation between Belize and Mexico for the Protection and the Improvement of the Environment and the Conservation of Natural Resources in the Border Zone (signed 20 September, 1991).
- Protocol on Specially Protected Wildlife (SPAW Protocol)
- Land-Based Sources of Pollution Protocol (LBSP).
- United Nations Framework Convention on Climate Change (ratified September, 1994).
- Convention for the Prevention of Pollution from Ships (MARPOL 73/78) (ratified 12 May, 1995).
- International Convention for the Regulation of Whaling (signed 1982).
- Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (signed 1995).
- Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) Toxins and their Destruction (signed 1980).
- Western Central Atlantic Fisheries Commission (WECAFC) (1985).
- Latin American Organization for Fisheries Development (OLDEPESCA) (1997).
- Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (The Cartagena Convention).
- The Convention on Wetlands of International Importance Especially as Waterfowl Habitats (RAMSAR) (Signed 1971).
- The Tulum Declaration (Belize, Guatemala, Honduras and Mexico)
- Stockholm Convention On Persistent Organic Pollutants (Pops)
- Convention for the Protection of World Cultural and Natural Heritage, 1975 - UNESCO
- Inter-American Convention for the Protection and Conservation of Sea Turtles, 1998.
- Declaration for the Establishment of the Sustainable Tourism Zone of the Caribbean and Plan of Action, 17 April 1999.
- Convention Establishing the Sustainable Tourism Zone of the Caribbean, Isla de Margarita, Venezuela, 12 December, 2001.
- International Convention for the Conservation of Atlantic Tuna (2005).