BELIZE

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UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

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BELIZE

Second National Communication
to the
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of the
United Nations Framework Convention
on Climate Change

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Statement from the Minister, Ministry of Natural Resources and the Environment

"Dear Readers,

Global climate change is a major environmental and developmental issue and is an impediment to achieving the Millennium Development Goals.

Although Belize is a minute contributor to global greenhouse gas emissions, it will be among those countries which will be severely impacted by climate change. The serious adverse effects of climate change, particularly those on our corals and forests, and the increased intensity and frequency of severe weather events affecting human lives, are particularly obvious around us. These impacts pose major impediments to Belize's efforts to promote sustainable economic and social development and the reduction of poverty, which are the country's primary and overriding priorities. Our focus is to build a society and economy that is resilient to the impacts of climate change.

Once again, the Government of Belize expressed its gratitude to Global Environmental Facility and United Nations Development Programme for supporting the preparation of our Second National Communication.

While enabling Belize to meet another of its obligations under the Convention, this process also enable us to conduct a periodic assessment of how we are managing climate change. The result of the greenhouse gas inventory indicates sectors in which we can voluntarily reduce emissions. The vulnerability assessments serve to advise how and where we need to adapt to climate change. We have already undertaken mitigation measures within the energy sector with the transition from fossil fuels to the use of renewable energy for electrical power generation.

For the first time we have conducted a technology needs assessment exercise, as part of this process, which will serve to identify technologies required to effectively manage climate change.

The preparation of the Second National Communication therefore provides us with opportunities to mainstream results into our plans and strategies for sustainable development.

We thank all those who participated in the preparation of the Second National Communication".

Honourable Gaspar Vega
Deputy Prime Minister and
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Reports prepared for the Second National Communication can be found on the website of Belize's National Meteorological Service at www.hydromet.gov.bz

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ABBREVIATIONS AND ACRONYMS

AOSIS	Alliance of Small Island Developing States
API	Annual Production Index
AVVA	Aerial Videotape-assisted Vulnerability Survey
ASL	above sea level
BBR	Belize Barrier Reef
BECOL	Belize Electricity Company Limited
BEL	Belize Electricity Limited
BWSL	Belize Water Services Limited
C	Celsius
CARICOM	Caribbean Community
CBD	Convention on Biological Diversity
CCAD	Central American Commission on Environment and Development
CCCCC	Caribbean Community Climate Change Centre
CDM	Clean Development Mechanism
CFE	Comisión Federal de Electricidad (Mexico)
CH_4	methane
CHM	Clearing House Mechanism
CO	carbon monoxide
CO_2	carbon dioxide
CPACC	Caribbean Planning for Adaptation to Global Climate Change
CRRH	Central American Regional Committee for Hydrological Resources
CSO	Central Statistical Office
DSSAT	Decision Support System for Agro-technology Transfer
ECV	Essential Climate Variables
EPA	Environmental Protection Agency
F	Fahrenheit
FAO	Food and Agriculture Organization of the United Nations
Ft	feet
GCM	Global Circulation Model
GCOS	Global Climate Observation System
GCMP	Generated Climate Modeling Products
GDP	Gross Domestic Product
GEF	Global Environmental Facility
Gg	gigagrams

GHG	Greenhouse Gases
GISS	Goddard Institute for Space Studies
GSN	Global Climate Observation System
GUAN	Global Climate Observation System Upper Air Network
GWP	Global Warming Potential
Ha	hectares
HFC	hydrofluorocarbons
IDB	Inter-American Development Bank
ICZM	Integrated Coastal Zone Management
INC	Intergovernmental Negotiating Committee
IPCC	Intergovernmental Panel on Climate Change
KW	Kilowatt
KWh	Kilowatt hours
LIC	Land Information Centre
LST	Local Standard Time
MACC	Mainstreaming Adaptation to Climate Change
MAFC	Ministry of Agriculture, Fisheries and Cooperatives
Mm	millimeters
MW	Megawatt
MWh	Megawatt hours
NCCC	National Climate Change Committee
NCDC	National Climate Data Center (US)
NCEP	National Centres for Environmental Production
NCSA	National Capacity Self Assessment
N_2O	nitrous oxide
N/A	Not available
NGO	Non Government Organization
NICU	National Implementation Coordination Unit
NMS	National Meteorological Service
NMVOC	non-methane volatile organic compounds
NO_x	nitrogen oxides
NRI	Natural Resources Institute
pa	per annum
PEG	Project Execution Group
PFB	Programme for Belize

PSC	Project Steering Committee
PSWGIA	Philip Stanley Wilberforce Goldson International Airport
R.K. Beans	Red Kidney Beans
RPIU	Regional Project Implementation Unit
SO_2	Sulphur dioxide
SPACC	Special Project for Adaptation to Climate Change
Sq. km.	square kilometers
tC	tons of carbon
tC/ha	tons of carbon per hectare
UKMO	United Kingdom Meteorological Office
UNCED	United Nations Conference on Environment and Development
UNCCD	United Nations Convention to Combat Desertification (Land Degradation and Drought)
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
USAID	United States for International Development
UTC	Coordinated Universal Time (French Acronym)
UWICED	University of the West Indies Center for Environment and Development
WASA	Water and Sewage Authority
WMO	World Meteorological Organization

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EXECUTIVE SUMMARY

NATIONAL CIRCUMSTANCES

Population

The Belizean population displayed a growth rate estimated at about 3.3% per year that could cause the population to be doubled in 21 years. Despite this, Belize still enjoys the lowest population density in Central America (~12.3 persons/km^2), with large areas of the country essentially uninhabited. Belize has a good health care network, high levels of child immunization, and clean water, but is also experiencing a rise in infectious diseases.

Education

All children between the ages of six and fourteen years receive compulsory basic education in Belize. Students under the age of 6 may attend one of 118 pre-schools distributed throughout the country. In 2004-2005, 9% of the under-6 population attended pre-school... Net primary school enrollment reflects the mandatory education law, with 86% of children between 6 and 14 attending one of the 288 primary schools. Primary school completion rates have hovered around 70% for the last 5 years.

Economic Profile

Agriculture remains a mainstay of the economy, but tourism has become the largest contributor to GDP and the largest source of foreign exchange for Belize. Belize has slowly diversified its economy over time, with substantial aquaculture and manufacturing industries, and more recently, a small but lucrative petroleum industry.

The extraction of petroleum from an estimated 10 million barrel reserve in western Belize commenced in December 2005. In 2006, approximately 811,199 barrels of crude oil were extracted from this location, 80% of which was exported to the US.

Belize imports one and a half times more goods than it exports. In 2006, goods valued at US $660 mn were imported, while US $427 mn were exported. The top imports were machine and transportation equipment (17%), fuels and lubricants (16%), manufactured goods (12%), and food (9%).

INVENTORY OF SOURCES AND SINKS OF GREENHOUSE GASES

The Greenhouse Gas Inventory was conducted for Reference years 1997 and 2000 in the following sectors: Energy, Industrial Processes & Solvents, Agriculture, Land use, Land-Use Change & Forestry and Waste. The emissions of Greenhouse Gas for the 1994 reference year were re-calculated, using the revised UNFCCC software.

Belize's two main sources of **Energy** at the study period were from imported fossil fuels, and biomass. Biomass includes the burning of bagasse in the sugar industry, consumption of fuel wood for domestic use, and the production of white lime. In 1997 and 2000, emissions from fuel combustion showed a steady decline when compared to the 1994 emissions; this being attributed to the reduction in consumption and combustion diesel by Belize Electricity Limited.

Activities within the **Industrial Processes and Solvents** Sectors occurred in only two areas: the Mineral Products, and the Food Production and Drink subsectors. Lime production and road paving with asphalt are the principal activities in the Mineral Products sub-sector. .Beer, wine, and spirits; meat, fish, poultry, bread, and animal feed are the products of the Food and Drink production sub-sector.

This second inventory revealed that emissions within the Industrial Processes sector remained unchanged compared to those of the first. However emissions have increased from 1.73 Gg in 1994 to 1.81 and 2.20 Gg for the Reference years 1997 and 2000 respectively.

Emissions within the **Agriculture** sector were from the same sources as those for the first inventory. Emissions increased from 54.8876 Gg in 1994 to **66.9793** and **100.44** Gg for reference years 1997 and 2000 respectively. Agricultural soils and prescribed savannah burning were the two main sources of GHG emissions. The agriculture sector was a net emitter of GHGs but accounted for less than 2 % of the total national emissions.

Recalculation of the results for 1994 showed that the total emission of CO_2 from the **Land Use Land Use Change and Forestry** sector of 7,483 gigagrams was mainly from deforestation and soil carbon from agriculturally impacted soils. Carbon sequestration from forest growth following logging and the regrowth of abandoned lands reduced this quantity by 2,891 Gg to a net emission value of 4,592 Gg. For Reference year 1997, carbon dioxide emissions from this sector amounted to 9,803 gigagrams, similarly from deforestation and from soil carbon in agriculturally impacted soils, with carbon sequestration reducing this quantity by 3,225 Gg to yield a net emission value of 6,578 Gg. The Reference year 2000 displayed the same trends yielding emissions of 11,950 Gg from deforestation and from soil carbon in agriculturally impacted soils. Carbon sequestration from forest growth following logging and natural reforestation on abandoned lands reduced the volume of the emissions by 3,862 Gg to a net emission value of 8,088 Gg.

The emissions for the 1994 reference year were re-calculated, resulting in lower than previously reported GHG emissions from the **Waste** sector. The main sources of emissions were from domestic and commercial wastewater handling. Net emissions (without emissions from industrial waste water handling) amounted to 0.51 Gg for 1994, 0.69 in 1997 and 1.02 in 2000. There was an increasing trend over the three years. When factored in, the industrial component was the major source of emissions in the waste sector, and the trend was for a reduction in emissions from this sector. The data showed that the primary factors influencing change in the emissions from the waste sector were decreases in waste water production resulting in emissions of 225 Gg in 1994, and about the same levels of 169 Gg in 1997 and 2000.

VULNERABILITY ASSESSMENTS AND ADAPTATION STRATEGIES

For the preparation of the Second National Communication, it was decided that vulnerability assessments would be conducted in different but very relevant and important sectors in the Belizean development. For the Second National Communication these included:-

Vulnerability and Adaptation Assessments in the Agriculture Sector

Belize's economic growth and food security is highly dependent on Agricultural activity. There is moderate diversification in cultivation of crops, and food security may be at risk from the impending impacts of climate change. The assessment conducted for the Initial National Communication (INC) focused on three staple crops - rice, beans and corn. This second study expanded the range of crops, but concentrated on two of the major trade commodities, sugar cane and citrus. The assessment concluded that with appropriate response measures adopted in a timely manner, the overall sustainability of the sugar and citrus subsector and the overall agricultural sector would probably not be at a significant risk

Vulnerability Assessment of the Coastal Zone

The vulnerability assessment conducted for the coastal zone of Belize for the INC utilized the Intergovernmental Panel on Climate Change (IPCC) Aerial Videotape Assisted Vulnerability Analysis (AVVR) methodology to map the coastline. This methodology was used to determine those areas most likely to be affected by sea level rise. A more comprehensive assessment was conducted for the Second National Communication that took into consideration the social, economic, and environmental impacts that would result from a rise in sea level and other climate change related phenomena.

Conclusions emerging from the vulnerability assessment indicated that Belize needs to focus on those actions that will reduce direct impact and help to build resilience within the natural environment. Since recommendations made in previous assessments have met with limited success due to lack of funding, lack of coordination and unavailability of personnel among other reasons. New recommendations seek to optimize the available time, human and financial resources. 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 what is needed is consistent implementation.

Vulnerability and Adaptation Assessment of the Fisheries and Aquaculture Industries

This sector of agriculture is very important for food security and revenue generation. A significant proportion of the population is employed in this industry. The assessment focused on both capture fisheries and the aquaculture industry. The assessment concluded that proper adaptation included building capacities which will help to better inform decisions and enable use of information that will lead to enhanced ability to cope with climate change. One important strategy that would help to build capacity is to take immediate action which would minimize stress to those ecosystems that support fisheries and aquaculture. Preserving the physical integrity of critical marine and fresh water environments is an essential first step towards the minimization of stress.

Stepping up the monitoring of selected environmental factors such as sea surface temperatures, inland temperature, rainfall or precipitation will, in the long term, improve our understanding of the dynamics of fisheries/aquaculture climate change issues and lead to a more efficient, effective planned strategy for sustainable development.

Vulnerability and Adaptation Assessment of the Health Sector

The risks to human life and well-being resulting from climate change needed to be determined. In collaboration with the Ministry of Health, this initial study focused on Dengue and Dengue Haemorrhagic Fever and the conditions that would favour outbreaks or increases in incidents.

All three elements required for the transmission of dengue are present in Belize on a permanent basis and for that reason; the disease has become endemic showing periodic epidemics when characteristics of these elements are such that transmission is enhanced. Since the environmental conditions as it relates to temperature, humidity, rainfall and altitude are within the ideal ranges in all districts, the entire country is considered to be at risk of dengue transmission. The level of risk is determined more by life style and socio-economic conditions of communities, than by geographical location. Further studies would have to be conducted in other to quantify vector density in the urban setting.

Vulnerability and Adaptation Assessment of the Tourism Sector

The Tourism Industry has become the largest revenue generator for Belize, directly and indirectly involving the greatest proportion of the labour force, and affecting all other sectors. The study examined the impact of a changing climate on the economy.

The assessment of the tourism sector of Belize highlighted several areas of supply- and demand-based economic vulnerability to climate change, including the risks to coastal land and infrastructure, exposure to resource damages such as coral bleaching, and an associated reduction in demand because of resource changes or risks to personal health and safety. A preliminary assessment of Belize's tourism sector suggests that it is highly vulnerable to the effects of climate change through both its exposure to climate impacts and its weak capacity for adaptation. Adaptation measures that reflect these specific sources of vulnerability should be considered in light of the country's limited capacity to moderate the harmful effects of climate change. Such measures include diversifying the portfolio of tourism offerings to emphasize inland attractions, planning for coastal development with greater caution, and considering the feasibility of artificial reefs as underwater attractions to alleviate some of the existing pressures on Marine Protected Areas.

Vulnerability and Adaptation Assessment of Water Resources

This study was undertaken under the Mainstreaming Adaptation to Climate Change (MACC) Project to address climate change in Belize's water sector. The study incorporated activities such as a technical review that addresses climate change issues and threats related to freshwater resources of Belize. Other products of this study included a National Adaptation Strategy and a Water Resources Management Policy.

Recommendations emerging as a result of the assessment of this sector suggested that measures to improve efficiency should be applied by the commercial water suppliers, in extraction from the sources, storage, and delivery to customers. This will be important in the context of reduced water availability occasioned by climate change. Another recommendation is to conserve the country's water resources. The study estimated that the agriculture sector was the country's single largest user accounting for marginally in excess of 43% of the over 15 B gallons used in 2007. A sizeable portion of the water used in this sector is used in low efficiency surface irrigation systems that cause high water losses. In virtually all instances, agricultural companies that source their water for irrigation from rivers have no incentive to be efficient in water usage since the water is "free". The recommendation is to provide incentives to encourage the use of more efficient irrigation equipment to minimize water losses and encourage conservation of the resource.

PROGRAMMES CONTAINING MEASURES TO MITIGATE (ABATE) CLIMATE CHANGE

All Parties are required taking into account their common but differentiated responsibilities and their national priorities to formulate and implement national programmes to mitigate climate change by addressing GHG emissions. As a non-Annex I Party, Belize, however, is not obliged to limit its emissions of greenhouse gases. This issue was not addressed in the INC.

The SNC identified two programmes undertaken by the Government of Belize to alleviate poverty while at the same time assist with mitigation of greenhouse gases. However, the second greenhouse gas inventory provided relevant data needed to calculate the impact of the introduction and utilization of renewable energy on national emissions. To the extent possible further studies were conducted to calculate the greenhouse gas emissions that were averted by the introduction of hydropower into the national grid in 1995, and the impacts of further expansion of the system by 2005 with the introduction of a reservoir and additional generating capacity. Projections for future energy needs also indicated continued increases in demand, so the exercise included assessment based on the completed facility. These exercises also took the opportunity to determine the impact of the avoided GHG emissions resulting from the application of solar panels at an entire village level for electrical power generation, and the impact of replacing thousands of incandescent bulbs with compact fluorescent tubes.

STEPS TAKEN TO IMPLEMENT THE CONVENTION

Reactivation of the National Climate Change Committee has resulted in this group moving closer to being institutionalized. The Committee is responsible to assist government with managing climate change in Belize. Follow-up tasks for the Committee include among other things, guidance on completing the review and adoption of the National Policy on Adaptation to Climate Change.

Belize has continued to participate in regional and international sessions related to the Convention and capacity has been enhanced since a greater number of persons have been involved in the various meetings and workshops. A manual for guidance with processing CDM project applications is in nearing completion.

OTHER INFORMATION

This section of the report described various projects and activities underway or completed that may have or have had indirect positive environmental impacts.

CONSTRAINTS AND GAPS

The National Capacity Self Assessment conducted in 2004/2005 had identified some gaps and constraints that affected Belize's ability to properly implement the Convention. That exercise helped to identify certain needs and priorities such as:-

- Formulation and implementation of a national climate change programme which would be developed with national stakeholder participation;
- Reduction of information gaps through research and systematic observation, and increased availability and accessibility to reliable data and information; and
- Establishment of a National System for the management of green house gas inventories.

Some advances made include strategic alliances among government and non-state stakeholders o facilitate research in sectors including climate change (eg.WWF research in climate change impacts on the Belize barrier reef, rehabilitation of mangrove ecosystems, etc). The establishment of the Caribbean Community Climate Change Centre, headquartered in Belize, is a regional initiative to conduct research, formulate strategies and plans, and generally address climate change issues for the CARICOM member states. Some of the constraints previously identified would also be mitigated through the measures applied and mentioned elsewhere under capacity building.

TECHNOLOGY NEEDS ASSESSMENT

The Technology Needs Assessment undertaken as part of the SNC preparation should allow Belize to capitalize on one of the more important recommendations of the convention, "the development and transfer of technology". This is particularly important in helping Belize to cope with an ever evolving climate system. TNA preparation was undertaken through a three step approach including Preliminary sector overviews to identify major emitting sectors as well as vulnerable sectors, establishment of national criteria for identification, assessment and selection of appropriate technologies/ best practices, prioritization of sectors and selection of key technologies, and the identification of national barriers and policy needs as they relate to implementation of selected criteria. The process was highly consultative in nature involving a broad cross section of governmental and private sector entities. The TNA synthesis report was complemented by a report on the implementation mechanism that identified actions and opportunities for implementation.

It should be noted that the recommendations for technology needs made were only an assessment based on issues related to climate change mitigation and adaptation as identified in various reports, stakeholder consultations and possible applicability and adaptability of technologies as well as a consideration of proposed developmental plans and policies in the various sectors, where they exist. Policy recommendations are made only in so far as they may have relevant technology implications. This report does not constitute an endorsement of one type of technology over another nor does it base its recommendations on any technology that has been tried and tested in Belize. Any choice of a particular technology would require further analysis based on cost-benefit and policy considerations as well as environmental impact of the technology, which are outside the scope of this study. Although some general assessments of impacts were presented, detailed environmental impact assessment would need to be done based on the peculiarities of the receiving environment.

CHAPTER 1 NATIONAL CIRCUMSTANCES

1.1 GEOGRAPHIC SITUATION AND COUNTRY PROFILE

Belize is a small independent country on the Caribbean coast of Central America, bordered on the north by Mexico and on the west and south by Guatemala (15° 53' to 18° 30'N Latitude; 87° 15' to 89° 15' W Longitude; Figure 1). The former British colony until 1981 (British Honduras) has a land area of 22,960 km^2 of which 95% is located on the mainland and 5% is distributed over more than 1,060 islands. Total national territory (including territorial sea) is 46,620 km^2. The country is well known as the home of the longest barrier reef in the Western Hemisphere. This 220 km reef stretches the entire coastline and is recognized by the United Nations as a World Heritage Site. The Government of Belize has also recognized the reef's uniqueness, protecting substantial portions in marine reserves.

Belize is physiographically very diverse because it lies at the boundary between two sharply contrasting geologies. Northern Belize is an extension of the Yucatan Platform, while southern Belize shares the mountainous geology of eastern Guatemala[1]. The Yucatan Platform consists of hard, dense limestone over red shale[2] that results in a topography consisting of low (approximately 250 masl), rolling limestone hills and escarpments. The escarpments are the result of north-northeast trending faults caused by the subsidence of the continental shelf toward the Yucatan Trough in the Caribbean Sea[3]. The dominant physiographic feature of the country is the Maya Mountains, which rise steeply from the coastal lowlands to a maximum elevation of 1124 masl. The Maya Mountains are a tectonically uplifted block of ancient meta-sedimentary, granite, and volcanic rocks[4] that occupy the south-central portion of the country, stretching west into Guatemala's Peten district. Surrounding the mountains are low karstic limestone hills that grade into an abbreviated coastal plain that meets with the Caribbean Sea.

Over 1060 mangrove cayes (small islands) and three atolls dot Belize's marine territory. Many of these are located along the barrier reef shelf, while the three atolls—the Turneffe Islands, Lighthouse Reef, and Glover's Reef—rest beyond the protective shelter of the barrier reef. Many of the cayes are uninhabitable, but those that are have often been settled or used by fishermen, or are developed for tourism. Many cayes and large sections of Belize's coastline stand at less than one meter above sea level, making these areas very vulnerable to storm surge from cyclones and rising sea levels.

1.1.1 CLIMATE

Belize lies in the subtropical geographic belt and has a climate governed strongly seasonal variations in rainfall. Mean monthly temperatures range from 16° - 28° C in the winter months to 24° - 33° C in the summer[3] and humidity ranges between 40 and 99% throughout the year (mean = 80%; King et al. 1986). Distinct wet (June – Dec.) and dry (Jan. – May) seasons exist throughout the country and are most pronounced in the north. More than 80% of annual precipitation in southern Belize occurs during the wet season[5], and a strong precipitation gradient exists from north to south. Annual precipitation ranges from approximately 1100 mm in northern Belize to 4000 mm in the deep south[6].

1 Fairbridge 1975

2 Viniegra 1971

3 Hartshorn et al. 1984

4 Bateson and Hall 1976

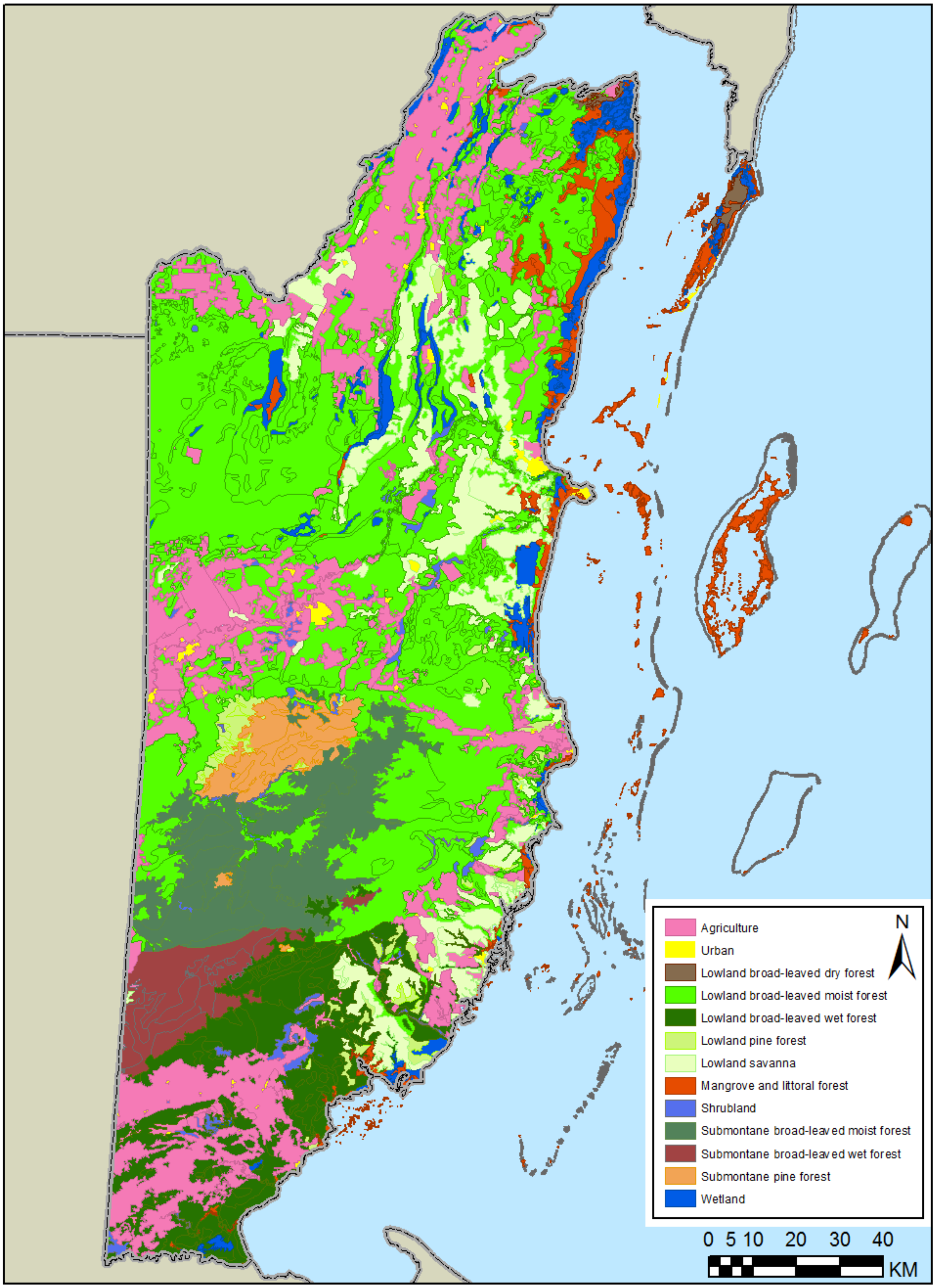
5 Heyman and Kjerve 1999

6 Walker 1973

During the winter months (Nov. – Feb.) cold, wet air masses, locally called "Northers", occasionally descend from the north to cause heavy rains and choppy seas.

Figure 1 Locator map for Belize showing location in Central America upper right

Figure 2 Major terrestrial ecosystem types of Belize (Meerman and Sabido 2004)



Belize has a long history of devastating encounters with cyclones (tropical depressions, tropical storms, or hurricanes), with major events recorded in 1931, 1955, 1961, 1971, 1974, 1978, 2000, 2001, and 2007. Historically, tropical storms and hurricanes have affected the country once every three years, and, according to hurricane tracks available from the US National Weather Service, are more likely to hit in the north than in the south[7]. Belize City, the former capital, was destroyed twice by hurricanes in the 20th century prompting the relocation of the capital to Belmopan City.

1.1.2 HYDROGRAPHY

The abundance of rain in Belize and the low coastal topography has favored the formation of an important network of waterways and water bodies. These provide the national population with drinking water, building aggregate, destinations for recreation and tourism, fish and wildlife, and a place for daily domestic activities. There are 16 major watersheds and numerous smaller ones that deliver freshwater, sediment, and nutrients to the Caribbean Sea. Four of the 16 watersheds are shared with Guatemala, and one (Rio Hondo) has major portions draining both Guatemala and Mexico. Although the Rio Hondo watershed dwarfs the rest of Belize's rivers in terms of catchment area (15,075.5 km^2), only 18% of this occurs in Belize. The Belize River (total area 9,434 km^2; 69% in Belize) occupies substantially more of Belize's land mass and dominates the central portion of the country[7].

Northern Belize is characterized by wetlands that tend to occur in crustal slumps within the north-northeast trending fault zones that occur there, or within karstic depressions[8]. Topography of the northern coastal plain is relatively flat and most of the freshwater wetlands occur at or below five meters above sea level. Most of these systems are spring-fed and many are perennially waterlogged, with water fluctuations of about 1 m in conjunction with the seasons[9]. Many of the wetlands of northern Belize occur as expansive lagoon systems containing multiple habitat types (e.g., swamp forests, herbaceous marshes, and open water areas). The most notable among these is Crooked Tree Lagoon, a 165 km^2 wetland complex connected to the Belize River via two streams[10]. Other substantial wetlands include New River Lagoon, Progresso Lagoon, Cox Lagoon, and Pulltrouser Swamp. Several freshwater wetlands also occur in southern Belize. There, recent tectonic movement along fault lines has back-tilted the continental crust to form a number of swamps[11]—most notably the Sarstoon-Temash delta, and Aguacaliente Swamp, a 35 km^2 wetland surrounded by tropical wet broadleaf forest.

1.1.3 ECOSYSTEMS AND LAND COVER

Belize occurs in the Mesoamerican biodiversity hotspot, a region characterized by exceptional levels of endemism and high levels of habitat loss[12]. A great variety of terrestrial, marine, and freshwater ecosystems are represented in Belize (Figure 1; Table 1). Eighty-five terrestrial ecosystems[13], 15 marine ecosystems[14], and 43 different riverine ecosystems[15] have been classified in the country. Lakes and lagoons are not yet classified. When the most recent nationwide ecosystem classification was done (2004), approximately 15,867 km^2 or 69% of Belize's land area was under some form of forest cover[16], though this number is certainly lower today. In the coastal zone, seagrass habitats are the most prevalent ecosystem, followed by deep water systems, sand- and silt-bottom habitats, and coral reefs[17] (Table 1). Despite the fact that coral reefs and their associated habitats only comprise about 6% of the coastal zone, they are disproportionately important for

7 Lee et al. 1995
8 Pope and Dahlin 1989
9 Seimens 1978
10 Zisman 1996
11 King et al. 1986
12 CI 2007
13 Meerman and Sabido 2001, 2004
14 CZMI 1997
15 Esselman et al. 2005
16 CZMI 1997
17 Esselman et al 2005

their high levels of biodiversity[18], and the tourism and fisheries economies that they support. Coral reef systems are also highly vulnerable to the consequences of global change from increased temperatures, damage from severe storm events, and ocean acidification from increased levels of dissolved CO_2[19]. Several severe coral bleaching events have been documented from Belize waters in the past decade as a result of temperature stresses to these ecosystems.[20].

Table 1 Broad ecosystem classes for terrestrial[21] and marine[22] habitat types.
Note that the marine figures do not take into account deep water pelagic figures beyond the Mesoamerican Barrier Reef.

Ecosystem class	%	km²
Terrestrial		
Lowland broadleaf forest and shrubland	51.4	11,803
Agriculture, all subclasses	16.7	3,835
Sub-montane and montane broadleaf forest	10.0	2,296
Lowland savanna including pine savanna	8.8	2,021
Mangrove and littoral forest	4.2	964
Sub-montane pine forest	2.1	482
Water	2.1	482
Wetland	1.9	436
Lowland pine forest	1.4	321
Coastal savanna (marine salt marsh)	1.1	253
Urban	0.5	115
Marine		
Seagrass habitats	44.2	4152
Deep water	35.1	3294
Sand/silt with sparse algae	11.8	1105
Coral reefs and associated habitats	6.2	586
Unclassified	2.4	227
Shallow gorgonian beds	0.4	33

1.2 POPULATION PROFILE

1.2.1 DISTRIBUTION OF THE POPULATION

In 2007, the population of Belize was estimated to be 311,480 persons[23] (Figure 3), up from 240,204 persons at the time of the last full census (2000)[24]. The population is growing at about 3.3% per year, a rate that, if sustained, would cause Belize to double its population in 21 years. However, population models predict slower growth to approximately 499,835 persons in 2050[25]. High growth rates can be attributed to elevated fertility rates (3.6 children/woman) and high levels of immigration. From 2000 to 2004, 8,829 individuals were granted citizenship or permanent residency in Belize, a number that accounts for approximately 27% of total growth during this period. The birth countries of the new citizens were mainly Guatemala (30%), El Salvador (19%), and China (16%)[26]. Despite the small but rapidly growing population, Belize still enjoys the lowest population density in Central America (~12.3 persons/km²), with large areas of the country essentially uninhabited and existing in a wilderness state.

18 Hughes et al. 2003
19 McField 2001
20 McField 2001
21 CZMI 1997
22 Esselman et al 2005
23 SIB 2007a
24 CSO 2005
25 SIB 2007b
26 SIB 2007b

Figure 3 Belize Population Growth Scenarios

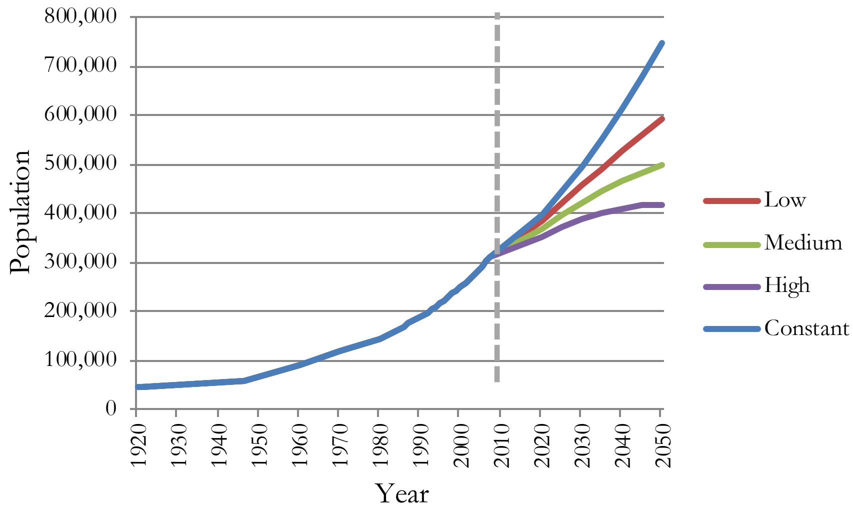


Figure 3 above describes the Belize population from 1920 to 2007 (vertical gray line), with predicted population from 2008-2050 under four different growth scenarios. Constant growth holds all demographic factors equal to today, and low, medium, and high scenarios, represent increasing deviation of crude birth and death rates from current values. The High scenario assumes that both crude birth and death rates decline relatively strongly in the future[27, 28].

Belize is demographically young, with 39% of the population below the age of 15 years, and 4 % over 65. Fertility rates are high but falling—from 7 children/woman in the 1960s to 5 children/women in the mid-1980s to 3 children/woman in 2006. The infant mortality rate is still unacceptably high (19.6 per 1000 births in 2006) and varies across the country, reflecting disparities in living conditions and services. In 1992, infant mortality in the Toledo District was more than twice that of the nation. By 2006, the ratio had improved but still remained high (1.4 to 1)[29]. Belize has a falling death rate (7.8/1000 in 1969 to 4.7/1000 in 2005) and falling infant mortality rate (51.2/1000 in 1960 to 16.3/1000 in 2005). In 2005, life expectancy for males was 69 years and for females, 74 years[30].

For its size, the population of Belize is ethnically diverse, with the majority group being Mestizo (50.7% in 2006), followed by Creole (26.9%), Maya (8.9%), Garifuna (6.1%), East Indian (3.1%), Mennonite (1.9%), and small but growing percentages of Chinese, North American, and British immigrants (CSO 2005). The Mestizo majority is a relatively recent occurrence. During colonial days through 1991, Creoles were the ethnic majority, a shift driven by the recent influx of Central American immigrants.

Though English is the official language of Belize, the primary language of its citizens varies geographically by ethnic group. In the north (Corozal and Orange Walk Districts) and west (Cayo District), it is predominantly Mestizo and Spanish speaking, with some Yucatec Maya. In the Belize District, it is English-speaking Creole. All four of these districts have Mennonite communities, which form a distinct German-speaking cultural element. In the south, the population in the Stann Creek District is split evenly between Garifuna, who speak their own language, and Spanish-speaking Mestizo, while 65% of the inhabitants of the Toledo District are Maya and speak either Kekchi or Mopan Mayan[31].

The Belize population is statistically split almost equally between urban and rural dwellers, with more urban dwellers in the two most populous districts (Belize and Cayo), and an abundance of rural dwellers in all of the

27 CSO 2005

28 MoH 2007

29 MoH 2007

30 World Bank 2008

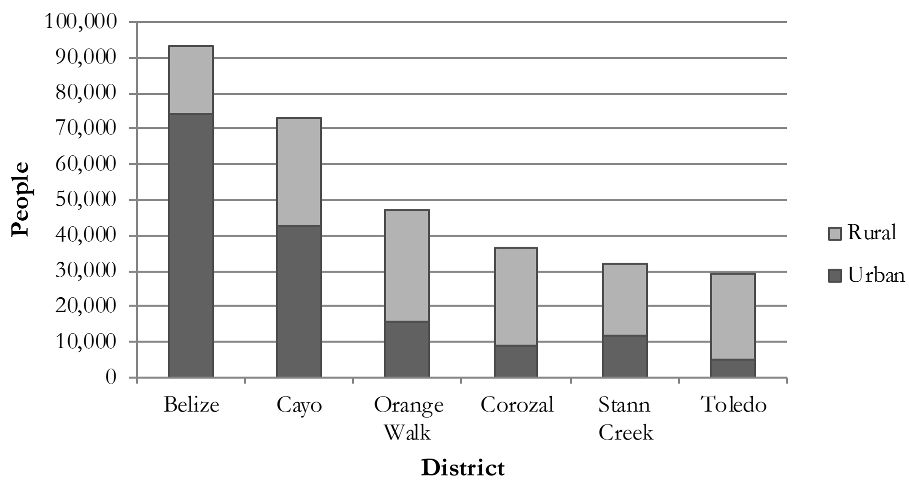
31 SIB 2007b

remaining districts (Figure 4). The largest urban center is Belize City, a low lying coastal city with a population of about 60,000 people. A number of other large population centers (San Pedro, Corozal, Dangriga, and Punta Gorda) and many villages are also located on the coast, making approximately 40% of the population highly vulnerable to hurricanes and rises in sea level[32].

The Belize District, where Belize City is located, is by far the most urban, whereas the Toledo District in deep southern Belize has the most rural population[33].

In 2007, the labor force (i.e. those in, available for, or seeking employment) stood at 122,439 people or 39% of the population—64% of them male[34]. The total unemployment rate was 12%, and mean income (in 2005) was US$385 per month[35]. On a national basis, 33.5% of the population is poor and 10.8% is extremely poor or indigent (i.e. their level of income was not high enough to enable them to satisfy their basic food requirements). Poverty rates are highest in the Toledo district, where 79% of the population is poor and lowest in the Belize District (24.8%). The rate of poverty in Orange Walk and Stann Creek are slightly above the national rate, and the Corozal and Cayo districts join Belize as the districts with the lowest poverty levels[36].

Figure 4 Total population of rural and urban dwellers in the six districts of Belize in 2007



Belize has a good health care network, high levels of child immunization, and clean water, but is also experiencing a rise in infectious diseases. The Belizean population is served by seven government hospitals, four private hospitals, and a network of 40 health centers and 44 rural health posts. In addition, mobile clinics move from village to village and account for about 40% of primary health care. In 2004, there was 98.8% coverage of adequate and safe potable water supplies in urban areas, falling to 95.4% in the countryside[37], but only 50% of the population had improved sanitation facilities (23% of rural homes were on septic systems), and 44% were using pit latrines[38] (2000 statistics).

Infectious diseases are a public health concern in Belize. Malaria had been thought to be controlled but increased dramatically during the 1990s, peaking at 10,311 cases in 1994. Since this time malaria control measures have reduced the incidence of the disease to just over 1,000 cases per year from 2000-2004[39] and

32 SIB 2007b
33 CSO 2005
34 SIB 2007d
35 SIB 2007b
36 NHDAC 2004
37 World Bank 2008
38 SIB 2007b
39 SIB 2007b

down to 844 in 2006[40]. There have been no cases of Cholera reported in the 21st century, but dengue is considered a threat during the rainy season, and sporadic outbreaks of diarrhea are also a problem. Belize has one of the highest HIV rates in the Caribbean and Latin America at 3.3%[41]. The highest prevalence is found in Belize City, followed by Dangriga. Belize has reported almost 4,000 HIV and AIDS cases since the first case was detected in 1986, and the epidemic continues to rise with around 450 new cases of HIV/AIDS reported every year[42]. Recent information from the Ministry of Health indicates that a large number of women are contracting HIV, and national authorities believe that the epidemic may be understated because of social stigma against getting tested[43].

1.3 INSTITUTIONAL STRUCTURE

1.3.1 STATE STRUCTURE

Belize is a sovereign state governed under the principles of parliamentary democracy based on the Westminster model. The 1981 constitution provides for a Governor-General who must be a citizen of Belize, but who is appointed by the Queen of England to be her representative. Joining the Governor-General, the executive branch of the government is formed by the Prime Minister and Cabinet, which is drawn from the National Assembly. The National Assembly forms a bicameral legislature comprising a 31-member elected House of Representatives and a 12-member appointed Senate. The judiciary is comprised of a Supreme Court and Court of Appeals, both located in Belize, and a Privy Council which consists of members of the British House of Lords[44]. As a signatory to the Treaty of Chaguaramas, which established the Caribbean Community Single Market and Economy (CSME), Belize also recognizes the authority of the Caribbean Court of Justice to interpret and apply the treaty relevant to trade relations[45].

There are six administrative districts (Corozal, Orange Walk, Belize, Cayo, Stann Creek, and Toledo, Figure 1), and a number of towns and villages. The administrative affairs of these communities are conducted by a combination of city, town and village councils. Belize City has a nine-member elected council, whereas Belmopan City and the town and village councils have seven-member elected councils.

The country is a member of the United Nations, the Commonwealth of Nations, the Organization of American States, the Non-Aligned Movement, the Caribbean Community, the Association of Caribbean States, and the Central American Integration System.

1.3.2 CLIMATE RELATED INSTITUTIONS

The National Meteorological Service is the principal advisor and negotiator for the government on climate change matters. The Chief Meteorologist is the Focal Point for the United Nations Framework Convention on Climate Change (UNFCCC), which was ratified by Belize in 1994. Belize became a signatory to the Kyoto Protocol in 2003, and since this time has established a designated national authority to certify Clean Development Mechanism (CDM) projects, and is in the process of creating national regulations. Toward this end, a National CDM Committee has been assembled with technical experts from six Ministries, civil society, and the Belize Trade and Investment Development Organization (Beltraide)[46]. A delegation from Belize attended the December 2007 UN Climate Change Conference in Bali.

The Belize Forest Department is the agency responsible for management and protection of areas designated as Forest Reserves and Protected Areas. This agency is an essential partner to any implementation of forestry projects related to Clean Development Mechanisms, or their equivalent in the 'post-Kyoto' era.

40 UNAIDS/WHO 2006

41 SIB 2007b

42 UNAIDS/WHO 2006

43 GoB 2006

44 GoB 2006

45 CCJ 2003

46 NMS 2008

The Caribbean Community Climate Change Centre (CCCCC) coordinates the Caribbean region's response to climate change from its headquarters in Belmopan City. The CCCCC officially opened in August 2005 as a node for information on climate change issues and on the region's response to managing and adapting to climate change. In this role, the Centre is recognized by the UNFCCC, the United Nations Environment Programme (UNEP), and other international agencies as the focal point for climate change issues in the Caribbean[47].

1.4 EDUCATION AND RESEARCH

All children between the ages of six and fourteen years receive compulsory basic education in Belize[48]. Students under the age of 6 may attend one of 118 pre-schools distributed throughout the country, as did about 9% of the under-6 population in 2004-2005[49]. Net primary school enrollment reflects the mandatory education law, with a large majority (86%) of children between 6 and 14 attending one of the 288 primary schools. Primary school completion rates have hovered around 70% for the last 5 years[50]. Education beyond the age of 14 is voluntary, and approximately 40% of children attend one of 50 secondary schools throughout the country[51]. An additional 2% attend one of several vocational schools[52]. The male-to-female ratio for secondary school is approximately 0.92:1, and greater than 3:1 for vocational school. In the last five years, slightly more than 4,000 Belizeans per year (about 3% of the population over 20 years old) have been enrolled in some form of tertiary education[53].

Several institutions of higher education are found in Belize, which offer Associates, Bachelors, Masters, and Doctor of Medicine degrees. The state-sponsored University of Belize (UB) is the largest university in Belize with campuses in Belize City, Belmopan, Central Farm, and Punta Gorda. UB endeavors to prepare its students to contribute to sustainable development of the nation and offers degrees in a wide range of subjects including natural sciences, language, mathematics, information technology, business, and nursing. Galen University is one of few schools in Belize that offer graduate and professional degrees in business, arts and sciences, and education in addition to their undergraduate programs. The Central America Health Sciences University (CAHSU) Belize Medical College in Belmopan was founded in 1996 and confers Doctor of Medicine degrees to its students.

1.5 CLIMATE MONITORING AND RESEARCH

The National Meteorological Service (NMS) is responsible for management of long-term hydrological and meteorological data, daily forecasting for agricultural, tourism and forestry management, and for issuing warnings to safeguard life and property. To fulfill these goals, it maintains a network of 41 hydrological and 34 meteorological observing stations, an upper air observing station and a Synoptic Forecasting Office equipped with telecommunication equipment and workstations, WEFAX satellite receiving equipment and a 10 cm weather radar. The Chief Meteorologist is responsible for coordinating research activities for preparation of National Communications to the UNFCCC including research on greenhouse gas emissions and risk assessments. In this capacity, the NMS has facilitated vulnerability assessments on staple crop yields, coastal vulnerability to sea level rise, and water resources[54].

Belize has participated in research and capacity building activities to assist with adaptation to climate change. In the Caribbean Planning for Adaptation to Climate Change (CPACC) project, Belize installed a tide gage, assessed coastal zone resources, designed a coral reef monitoring program to detect climate change impacts,

47 CCCCC 2007
48 MoES 2001
49 SIB 2007b
50 SIB 2007c
51 CPACC 2005
52 SIB 2007b
53 SIB 2007b
54 CCCCC 2007

and drafted an adaptation policy for Belize response to climate change[55]. CPACC, which ended in 2000, was followed by the Mainstream Adaptation to Climate Change (MACC) project which focused on the water resource management in an agricultural watershed, installed an additional tide gage, and set up a station to separate the effects of land movement from sea level rise. MACC ended in 2008.

Other climate change research has been conducted by independent researchers from universities and NGOs. This research spans a range of topics including carbon sequestration by tropical forests, sea level rise, responses of mangroves to climate change, seagrass sensitivity to environmental variation, and coral bleaching. In the mid-1990s, a Belize NGO, Programme for Belize, implemented the Rio Bravo Carbon Sequestration Pilot Project with funding from six North American energy companies. This pilot project has since been complemented by remote sensing analyses designed to estimate above ground carbon stocks. This research has estimated that mean carbon stocks in northwestern Belize forests equal 13.1 Mg/ha[56].

Toscano and Macintyre (2003) used C14 dating of corals and mangrove peat from sites in Belize and elsewhere to estimate sea level rise in the Western Atlantic. They found average rates of rise of 0.93 mm per year for the past 2,000 years.

Several authors have investigated the role and response of mangroves to climate change. These studies have shown that mangroves are sensitive to several variables predicted to change as climate changes (insolation, sedimentation, and water depth), and that these crucial coastal forests may not persist in the face of rapid climate change[57]. Another study of mangroves showed that reduced growth with increasing water depth will offset or balance the increases in growth predicted as a result of elevated atmospheric CO_2 concentrations[58]. The protective capacity of mangroves for coastlines during catastrophic storms has been convincingly demonstrated in Belize[59], and mangrove destruction has been implicated degradation of seagrass habitats[60].

A number of studies have investigated coral bleaching and recovery. Several of these documented an extensive coral bleaching event that occurred in 1998 in which 70 - 90% of the corals along the Mesoamerican Barrier Reef bleached as a result of elevated water temperatures[61,62,63,64]. Aronson et al. (2005) showed that the decline of coral reefs since 1980 is the result of disease outbreaks, bleaching episodes, and hurricanes, and ruled out the alternative hypothesis that corals have been declining for more than a century. Castillo and Helmuth (2005) have detailed the physiological responses of corals to thermal stress, finding that acclimation to warm temperatures prior to temperature spikes reduces stress in corals, and Rotjan et al. (2006) found that chronic grazing of corals by parrot fishes can exacerbate the influence of environmental stressors like heat.

1.6 HOUSING STOCK

During the last national census (2000), fifty one thousand nine hundred and forty-five houses were enumerated throughout the country. Just over half of these were located in rural areas. A large majority of households (44%) were home to five or more persons. Most houses had two (36%) or three (25%) bedrooms, and were relatively new—42% built since 1990. On a national basis (urban and rural combined), the statistically most common house is a cement-floored structure, with wood outer walls (44% of homes), and a sheet metal roof (80% of homes). Almost 80% of households are powered with electricity from a public generator, though kerosene lamps are still common in some rural areas. It is also still common to find

55 CPACC 2002

56 Brown et al. 2005

57 Ellison and Farnsworth 1996

58 Ellison and Farnsworth 1997

59 Granek and Ruttenberg 2007

60 Short et al. 2006

61 Mumby 1999

62 Kramer and Kramer 2000

63 McField 2001

64 Aronson et al. 2002

dirt floors and thatched roofs in rural areas[65]. The general tendency historically is for families to upgrade their thatch or wooden homes to more permanent cement structures, a progression that requires greater investment but improves hurricane preparedness.

There is a sharp division between urban and rural homes in their drinking water source and sanitation facilities. In urban areas, 38% of homes receive their water from a public source piped into their dwelling, and an additional 28% use purified (bottled) water. This contrasts with rural areas where most drinking water (37%) comes from a private rainwater catchment vat or a well. Five percent, or about 1300 rural households still rely on rivers, streams, ponds, or springs for their drinking water[66]. These statistics suggest that a large number of Belizean rural households that depend on rainwater or runoff may be vulnerable to drought and changes in the quality of surface and ground waters, which would reduce water security.

The differences in toilet facilities perhaps reveal the strongest difference between houses in rural and urban areas. In urban areas, most households (47%) have toilets that run to a septic tank in their yard, and many households (30%) are also connected to a sewer system. By contrast, in rural areas, about 70% of households use some type of latrine, 22% have septic systems, and 6% have no toilet facilities at all[67].

1.7 ECONOMIC PROFILE

1.7.1 GENERALITIES

From the early colonial history of Belize until the mid-20th century, the Belize economy was dominated by forestry activities. However depletion of mahogany stocks and diversification of economic development led to a shift toward export agriculture. Cane sugar has been a strong segment of the economy since the decline of the mahogany industry, and subsequent expansion of citrus and banana industries also took place. Today these crops remain a mainstay of the economy, but service industry related to tourism has become one of the strongest sectors of the economy. Belize has slowly diversified its economy over time, with substantial aquaculture and manufacturing industries, and more recently, a small but lucrative petroleum industry.

Belize's currency (Belize dollars, BZD) has been pegged to the US dollar since 1976 at a ratio of 2-to-1 (BZD-to-US$). As a result Belize has achieved generally satisfactory macroeconomic outcomes—inflation has been relatively low and stable, growth has been above the regional average, and exports have performed well[68].

1.7.2 RECENT GROWTH

As of 2006, the GDP at current market prices was US$1,213.65 million (mn), with a per capita GDP of approximately US$3,896 mn[69]. GDP growth during the nineties averaged 4.6%, and notwithstanding three natural disasters and the September 9/11 attack, growth between 2000 and 2006 averaged 6.5%. The service and wholesale/retail trade sectors contribute most significantly to GDP (20% and 14.5% respectively in 2006), followed by manufacturing (10.6%), transport and communication (10.4%), government services (9.8%), and agriculture and forestry (9.1%)[70] (Figure 5). Tourism is a large contributor to both the service and wholesale/retail trade sectors. In 2006, tourist arrivals totaled 903,000 and tourist receipts amounted to US$199 mn, or about 16% of the GDP[71].

Belize imports one and a half times more goods than it exports. In 2006, goods valued at US$660 mn were imported, while US$427 mn were exported. The top imports were machine and transportation equipment

65 SIB 2007b

66 SIB 2007b

67 SIB 2007b

68 IMF 2006

69 CBB 2006

70 El-Masry 2007

71 CPACC 2002

(17%), fuels and lubricants (16%), manufactured goods (12%), and food (9%). The United States is the source of 39% of goods entering the country, and another 20% come from Central America. Agricultural products comprise the majority of export earnings in Belize (Table 2). Citrus concentrate was the most valuable export commodity for Belize in 2006 (US$54.5 mn), followed by cane sugar (US$50.5 mn), and bananas (US$25.3 mn). Petroleum (US$44.3 mn) and marine products (US$43.0 mn) also contributed substantially to export earnings[72]. The United States was the main recipient of Belizean exports (42%) in 2006, followed by the United Kingdom (17%). Between 2003 and 2006 the balance of trade deficit ranged from US$173 mn to US$231 mn with an average of US$199 mn[73].

Figure 5 GDP by industry and total GDP for the period 1992 to 2006[74]

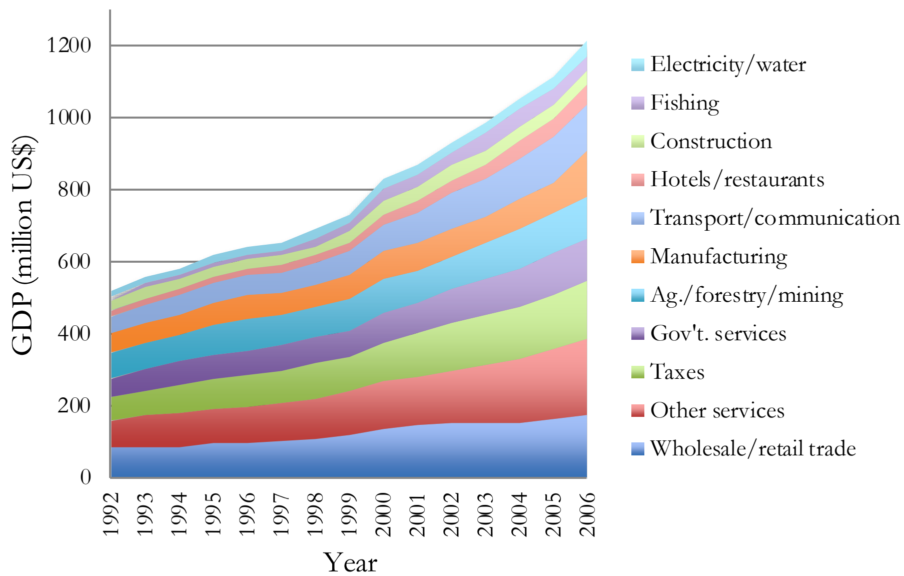


Table 2 Gross domestic product (million US$) of different agriculture crops, marine products (including aquaculture), petroleum, and timber[75, 76]

Product (mn US$)	2003	2004	2005	2006
Citrus Concentrate	39.05	40.30	53.60	54.50
Oranges	1.20	1.40	1.75	1.45
Citrus Juice	0.95	1.65	0.40	0.05
Sugar	35.60	40.75	34.95	50.05
Molasses	1.25	0.90	1.40	2.10
Banana	26.30	26.20	24.95	25.30
Livestock production	19.55	20.90	N/A	N/A
Papayas	8.40	11.40	13.45	15.50
Black Eye Peas	1.70	1.20	1.85	1.70
Red Kidney Beans	0.85	1.20	2.60	0.95
Petroleum	0	0	0	44.25
Timber	1.80	1.50	1.30	0.65
Garments	15.45	18.40	17.30	18.30
Marine Products	55.10	53.80	49.05	43.0

72 CPACC 2002
73 CPACC 2002
74 El-Masry 2007
75 SIB 2007b
76 CPACC 2002

Belize's sugar and banana industries have long benefited from preferential market access, but this access is being weakened by deepening global trade liberalization. Preferential access to the EU market has afforded Belize growers significantly higher export prices. However, ongoing reforms in the EU trade regimes for bananas and sugar are eroding these prices, thus having economic and social consequences for Belize. An IMF assessment of the economic implications of the expected decline in trade preferences predicted negative effects on the trade balance, economic growth and, to a lesser extent, the fiscal balance of Belize. Medium term scenarios predict that loss of preferential agreements will lead to a lower GDP growth of ¼% through 2010 and moderate declines in export receipts for bananas and sugar[77].

1.7.3 RECENT DEVELOPMENTS

In 1998, the then newly elected government enacted aggressive policies to stimulate economic activity, which led to large fiscal and current account deficits fueled by foreign borrowing. As debt service costs rose, access to voluntary financing fell and borrowing costs increased sharply. As a result, Belize's sovereign credit ratings, which help determine the country's access to international capital markets, dropped in early years of the new millennium. At this time the IMF cautioned that the macroeconomic policies were overly expansionary and could threaten the country's currency peg[78]. In response, the government began to implement a stabilization program in the 2005/06 budget by raising taxes, cutting expenditures, and tightening monetary conditions. These moves helped reduce the central government deficit from 8½% of GDP in FY2004/05 to 3 percent in FY2005/06. In 2006, the government made a debt exchange offer to its creditors which would convert eligible debt instruments into new bonds that would start to amortize in 2019. A majority of Belize's creditors accepted the debt exchange in February 2007, which led to a decrease in the debt service burden and an upgrade of sovereign debt ratings[79].

The extraction of petroleum from an estimated 10 mn barrel reserve in western Belize commenced in December 2005. In 2006, approximately 811,199 barrels of crude oil were extracted from this location, 80% of which was exported to the US. The geology of Belize suggests a high probability for the existence of more oil deposits, which if located and exploited, could lead to a shift in the economic base of Belize over a relatively short time span[80]. There are currently 6 companies with production sharing agreements with the Belize government exploring the country for oil[81].

1.8 ENERGY PROFILE

1.8.1 REGULATORY STRUCTURE

The Public Utilities Commission (PUC) is the government body, whose role is "to regulate the electricity, water, and telecommunications sectors in Belize to efficiently provide the highest quality services at affordable rates, ensuring the viability and sustainability of each sector"[82]. In this capacity, the PUC is instrumental in regulating the energy industry in Belize, and for formulating and implementing energy policies.

It is an important time for Belize with regard to energy sector development. With a burgeoning population, growing service and industrial sectors and a rapidly increasing demand for electricity—9% per annum[83]—Belize must develop the energy sector wisely to facilitate sustainable national development and a clean environment. Recognizing this, the PUC undertook a one year project entitled Formulation of a National

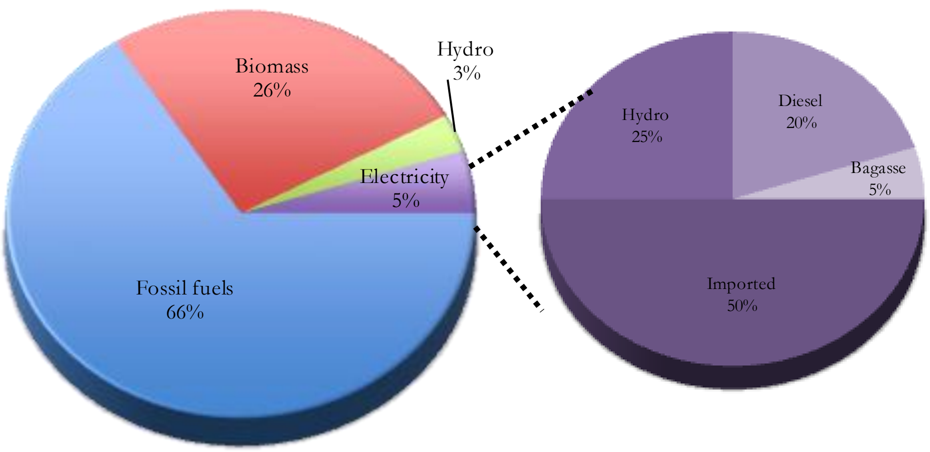
77 CBB 2006
78 El-Masry 2007
79 CDB 2007
80 CDB 2007
81 MNREI 2002
82 PUC 2001
83 LC 2003

Energy Plan for Belize in 2003, which recommended that Belize develop a comprehensive National Energy Policy and Implementation Plan. In 2004, the Government of Belize endorsed the PUC to lead the formulation of a National Energy Plan for Belize, an effort that is currently in the planning stages.

1.8.2 ENERGY SUPPLY AND DEMAND

Belize acquires its energy from four main sources: imported fossil fuels (66%), biomass (26%), hydro (3%), and imported electricity (5%) (Figure 6). Belize currently imports nearly 100% of fossil fuels used, although the further development of the oil industry may lead this to change. The main petroleum based sub-products—gasoline, kerosene and diesel—are supplied by three retailers. Gasoline is used mostly in the transport sub-sector, diesel in both the transport and electricity sub-sectors and kerosene is used in the aviation industry and for lighting. The liquid propane gas (LPG; butane/propane) market has four main importers. Retail (pump) prices in both the petroleum and LPG industries are regulated by Government of Belize[84].

Figure 6 Total energy (left) and electricity (right) supply for Belize (LC 2003).



In the electricity sub-sector, about 50% of the electricity produced is imported from Mexico. Hydropower (25%), diesel (20%), and combustion of sugar cane waste biomass (5%) fill the other half of electricity supply (Figure 6). Belize's demand for electricity is growing very quickly. In 2002, aggregate peak demand was 54MW and 273 Gwh were sold to consumers that year. In 2010 peak demand is expected to reach 96MW and 523 Gwh are expected to be sold (Table 3; LC 2003). Of electricity sold by BEL, 56% is for residential application, 31% for commercial application, 8% for street lights, and 5% for industrial application[85].

Belize Electricity Limited (BEL) is the main commercial provider. This company dominates the distribution/transmission market and is required by law to provide transmission facilities to any generator capable of paying its fees.

84 BEL 2001

85 BEL 2001

Table 3 Energy sales and forecasts for demand (2008-2010)[86]

Year	Total Sales (GWhs)	Total System Growth (%)	Grid Sales (GWhs)	Grid Generation (GWhs)	Grid Peak (MW)
2000	229.4	14.96	214.4	245.4	40.9
2001	256.6	11.88	242.5	277.3	46.2
2002	273.4	6.56	263.0	293.1	47.8
2003	298.0	9.00	295.2	329.0	54.3
2004	321.3	7.81	318.1	354.5	58.5
2005	349.4	8.73	349.4	389.4	64.2
2006	379.6	8.65	379.6	423.1	69.8
2007	411.9	8.52	411.9	459.1	75.7
2008	446.6	8.43	446.6	497.8	82.1
2009	483.8	8.33	483.8	539.3	89.0
2010	523.6	8.22	523.6	583.6	96.3

1.8.3 THE FUTURE

A PUC-sponsored energy sector diagnostic report[87] emphasized the importance of energy security for Belize, citing the heavy reliance of imported fossil fuels as a factor that creates vulnerability. The report states that "the best Belize can aspire to, in order to improve energy security is to reduce the dependency on imports in the electricity sub-sector, practice energy conservation and review the possibility of bio fuels to ameliorate the extreme dependence in the transport sub-sector"[88]. The report also urged Belize to take part in the Plan Puebla-Panama Initiative for Energy Integration, a project aimed at unifying Central American countries' electricity grids to reduce costs and the frequency of power disruptions. The first stage of the project is the Sistema de Interconexion Electrica Para America Central (SIEPAC), which includes installation of a 195 km, 230kV power transmission line between Guatemala and Belize City[89].

To date, Belize has made significant progress in reducing its dependency on imports in the electricity sub-sector through addition of hydro power and biomass-to-energy capacity. In 2005, the Belize Electricity Company Limited (BECOL) completed the construction of the Chalillo Dam, which has a generating capacity of 7 MW, but also serves as a water storage facility that increases the annual generation of the Mollejon hydroelectric dam downstream from 80 GW to more than 160 GW[90]. The Vaca Hydroelectric dam (under construction) will have an installed capacity of 18 MW[91]. In 2004, BEL signed an agreement with Belize Cogeneration Energy Limited (BELCOGEN), a subsidiary of Belize Sugar Industries Ltd., to buy electricity from a 31.5 MW bagasse-fired plant that is now under construction and due to come online in 2009. In a final recent step toward energy independence, BEL signed an agreement with Belize Aquaculture Ltd. to supply up to 15 MW of power generated from high efficiency engines that run on heavy fuel oil or diesel at prices competitive to those of electricity from Mexico. This plant will also come online in 2009[92].

Renewable energy technologies have historically been used both in small, isolated applications and power plants in Belize. Currently, hydroelectricity, stand alone solar photovoltaics (PV), small wind electricity generation, solar thermal, hybrid systems (diesel/PV or diesel/wind), biomass cogeneration and biogas are all being used at some scale in Belize. It has been estimated that Belize can add 20 MW of electricity from wind, and expand solar in off-grid applications. Aside from the dams mentioned above, thirteen additional

86 BEL 2001
87 BEL 2001
88 BEL 2001
89 PUC 2003
90 BEL 2001
91 PUC 2007a
92 BEL 2008

hydropower development locations have been identified in Belize in a recent national assessment, opening the door for further development of hydropower[93].

1.9 TRANSPORT AND TELECOMMUNICATIONS

1.9.1 TRANSPORT

Belize's transportation infrastructure includes approximately 3,909 km of unimproved dirt roads, 2,542 km of paved or improved dirt side roads, and 541 km of paved 2-lane highways[94]. There are also two international airports, ten local airports that serve the domestic airline industry, and a number of private airstrips. Three commercial ports in Belize can accommodate large ocean freighters (Belize City, Commerce Bight, and Big Creek), and smaller water craft are commonly used to carry people to the islands in the coastal zone.

Five large commercial airlines, one regional airline, and two domestic airlines operate flights to, from, and within Belize. This number is likely to grow, as direct flights from Europe begin as a result of recent upgrades to Phillip Goldson International Airport in Belize City. The number of arrivals in Belize has risen steadily through time, except for a brief lull following the 2001 terrorist attacks on the World Trade Center. Total passenger traffic on airplanes in and out of Belize in 2004 was 464,001. Total aircraft movements in Belize equaled 47,354, of which civilian services (both international and domestic) accounted for 92%, military flights for 5%, and private aircraft for 3%[95].

The number of licensed motor vehicles in Belize has increased by about 9% per year between 2000 and 2004, with a total of 48,300 vehicles registered in 2004. The majority of these (84%) were private passenger vehicles, mostly pick-up trucks and cars (29% and 25% respectively), followed by freight vehicles (9%), and public service vehicles (7%)[20]. No statistics are available about the breakdown of fuel types used by vehicles, though diesel is the cheapest fuel source and thus a very common engine choice for private and freight vehicles. Belize depends heavily on ship transport for many of its imported and exported goods. A total of 261 ships (217 foreign owned, with about half from China) fly under the Belizean flag[96]. In 2006, Port of Belize Ltd. reported 243 ship calls at its Belize City and Commerce Bight ports[97]. Between 1995 and 2000 the number of registered passenger boats (running gas or diesel outboard engines) grew 27% annually, from 278 in 1995 to 727 in 2000[98].

1.9.2 TELECOMMUNICATIONS

Two companies provide telecommunications services to Belize: Belize Telemedia Limited (BTL) and SMART/SPEEDNET. BTL enjoyed a monopoly until 2004, and still dominates the telecommunications market as the main service provider of stationary and mobile telephones and internet. SMART/SPEEDNET began operations in 2004 and offers mobile phone service, fixed cellular service, and wireless internet.

Like many places in the world, telephone usage in Belize has seen a shift in recent years away from stationary land lines to mobile cellular telephones (Figure 7). In 2005, mobile phones outnumbered landlines by about 3 to 1, even though landlines had outnumbered cellular phones as recently as 2001[99]. Internet usage has also risen quickly, with the majority of customers still operating with dial-up connections, but with high speed DSL drawing more and more customers since first being offered by BTL in 2004[100].

93 Soubrier 2006

94 TNC 2006

95 SIB 2007b

96 CIA 2007

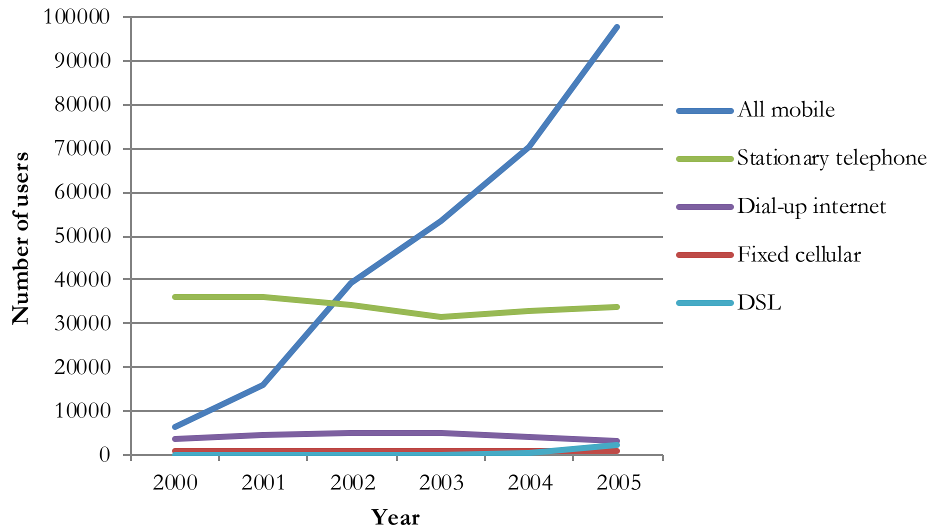
97 Port of Belize 2005

98 BEL 2001

99 PUC 2007b

100 Stantec 1999

Figure 7 Number of users of different telecommunications services; 2000 and 2005[101]



1.10 WASTE

The Solid Waste Management Authority (SWMA) was established by the Solid Waste Management Authority Act of 1991. The SWMA is the organization responsible for waste collection and disposal services in Belize. The SWMA coordinator works closely with the Department of the Environment (DOE)–the agency responsible for prevention and control of pollution by coordinating all activities related to the discharge of wastes into the environment.

In the most recent technical assessment of Belize's waste stream[102], it was estimated that Belize generated 112,000 tons of domestic solid waste, or about 1.32 kg/person/day. About half of this is domestic waste from the major urban centers of the country (Table 3). About 60% of this consisted of organic material and the remaining 40% was comprised of equal percentages of metals, glass, plastic, paper and other waste[103]. The majority of Belizean households (51%) dispose of their waste through municipal collection services which exist in all major urban centers in Belize. An additional 33% of households burn their waste, and the rest carry it themselves to a public dumping area (8%), dump it in their own yard (4%), or bury it (2%)[104]. Burning of waste is a preferred disposal technique in rural areas.

During the period 1995-2000, industrial waste generated was estimated to be between 400 and 650 thousand metric tons, primarily from agricultural activities[105]. Solid waste from these industries is mostly organics (60%) and consists of rejected fruits from the banana industry, citrus rinds from the production of juice concentrate, and bagasse, the fiber left from sugar cane processing. Bananas are disposed of in approved sites near the farms, citrus rinds are composted, and about half of all bagasse is burnt for the production of energy, a figure that will increase as the new biomass-to-energy plants becomes operational in 2009. Another waste product is shrimp heads that are usually buried for decomposition[106].

There are no sanitary landfills with adequate environmental protection measures operating in Belize. Disposal sites for waste collected in all cities and towns consist of open dumps that lack technical and

101 Stantec 1999

102 Stantec 1999

103 Stantec 2000

104 SIB 2007b

105 Stantec 2000

106 PAHO 2003

environmental controls, adequate equipment, and sufficient cover material[107]. The largest disposal site is located at the edge of Belize City in what is a low lying mangrove area with a high water table, which receives the majority of Belize City's solid waste stream, which equaled over 81 tons per day in 2000[108]. Other, sometimes impromptu, waste disposal sites are dispersed throughout the mainland and on the offshore islands near centers of population. Fires are common at most disposal sites and leachates are assumed to escape into the local water table.

Belize developed a Solid Waste Management Plan in 2001. The plan proposes:

- A regional sanitary landfill in a central location with a 25-year capacity
- Modified landfills at existing sites in Orange Walk and Corozal
- New modified landfills in Placencia, Dangriga and Punta Gorda
- Transfer stations along the Western corridor
- Closure of the landfills on Caye Caulker and San Pedro and movement of their waste to the central sanitary landfill
- Development of a collection system to provide service to small villages and rural residents along the three main highways corridors.

This plan remains in a pre-implementation state.

Table 4 Solid waste generated in different municipalities in 2000[109]

Municipality	Tons per day	Tons per annum	Kg/capita/ day
Corozal	12.82	4,680	1.50
Orange Walk	17.44	6,365	1.27
Belize City	81.56	29,770	1.54
San Ignacio	19.46	7,104	1.32
Benque Viejo	5.70	2,080	1.13
Belmopan City	9.62	3,510	1.18
Dangriga	8.55	3,120	0.95
Punta Gorda	4.27	1,560	0.99
San Pedro	10.68	3,900	2.18
Total	170.11	62,089	1.32

Information on liquid waste and sludge is very limited. In terms of human liquid waste, about 15% of all households are connected to a sewer system, and an additional 35% use septic systems. The households connected to sewer systems are located in Belmopan, Belize City and San Pedro. Volumes of sewage generated are unavailable. The waste stream from a septic leach field may enrich groundwater with nutrients. In densely settled areas on porous soil, this may cause groundwater contamination, but is as yet unmeasured in Belize.

1.11 AGRICULTURE

The conditions for agriculture vary widely in Belize from swampy lowlands in the north to very wet alluvial floodplains in the south. All areas exhibit strong dry-wet seasonality. Cultivated land amounts to about 3,835 km^2 or 17% of the national land area[110]. The majority of land used for agriculture (37%) has been classified as shifting cultivation and unimproved pasture, followed closely by mechanized agriculture of corn, beans, and

107 SIB 2007e

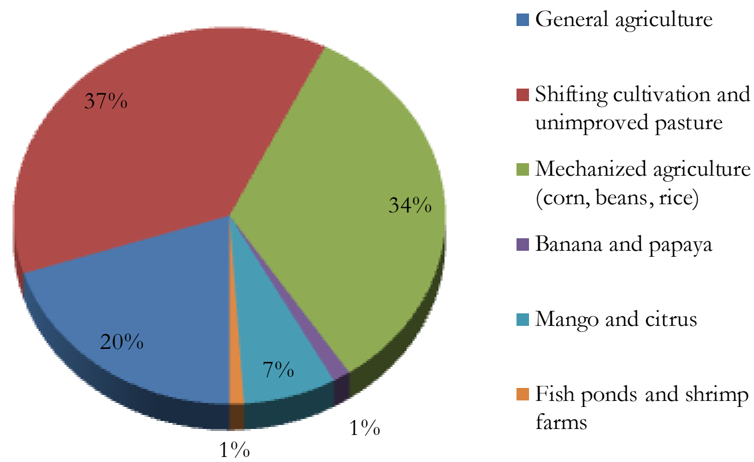
108 SIB 2007b

109 SIB 2007b

110 CZMI 1997

rice (34%) practiced primarily by Mennonites[111] (Figure 8). The remaining 29% is comprised of general agriculture, mango and citrus plantations, banana and papaya farms, and fish or shrimp ponds.

Figure 8 Percentages of agricultural land in different agricultural cover types[112].
The general agriculture category is a catch-all grouping for agricultural types that could not be classified effectively from the satellite imagery used.



The most economically important crops are citrus products, which combined earned US$56 mn in 2006, sugar/molasses (US$52.15 mn), and bananas (US$25.3 mn). Individually, these all compare favorably with other high value non-agricultural exports (Table 2), but erosion of preferential trade agreements may deter future growth. Livestock production is valued at about US$20 mn per year, predominantly from production of poultry/eggs, beef, and pork[113].

Commercial agricultural crop production through time reveals that sugar cane is the most productive crop by biomass. Sugar production increased through the late 1980's then leveled off in the mid-1990s. Oranges and bananas are also productive crops that have increased in level over time, as has chicken and shrimp production[114], though the latter has leveled and decreased in recent years in response to the closure of a major producer[115].

Livestock production is a relatively modest industry in Belize with the exception of chicken, a major staple for the population. No estimates are available for the number of cattle, pigs, and chickens that exist in the country, but statistics on animals brought to market are kept. The number of cattle brought to market each year has increased steadily from 7,459 animals in 1988 to 13,020 in 2004. Pig production grew only modestly in this period from 8,160 to 14,325 and chickens from 2,831 to 8,039. These numbers only reflect animals killed commercially. Production of livestock on small farms is not included[116].

111 CZMI 1997

112 CZMI 1997

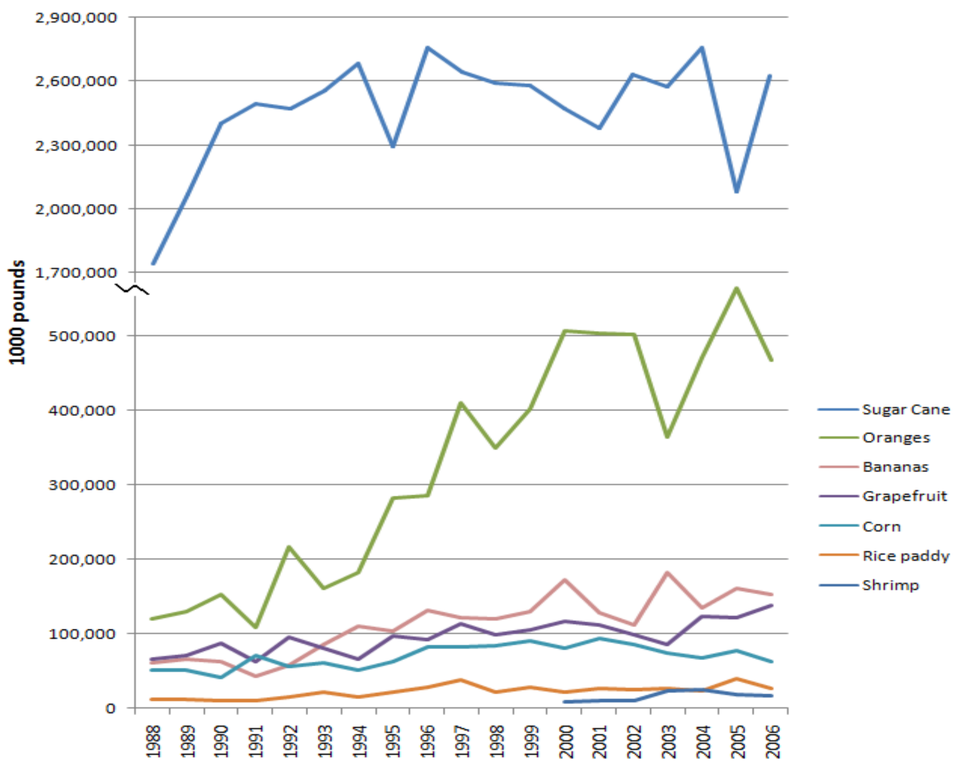
113 CPACC 2002

114 SIB 2007b

115 SIB 2007e

116 SIB 2007b

Figure 9 Agricultural production from 1988 to 2006 measured in standardized units of 1000 lbs. [117], [118]



Milpa, or slash and burn agriculture is an important form of agriculture that utilizes a large proportion of the 37% of land area used for shifting cultivation and unimproved pasture. This form of agriculture is practiced widely among Maya and Mestizo families in rural areas for subsistence production of corn, and some commercial production of beans or vegetables.

1.12 FORESTRY

1.12.1 FORESTED AREA AND PRODUCTION FORESTRY

The colony British Honduras was founded on forestry—logwood, mahogany, cedar, and chicle (a natural chewing gum base)—but the sector declined by the mid-1900s because of unsustainable stock management, and because a synthetic gum base replaced chicle. While a small industry around timber still exists, it contributes very little to GDP (Table 2). The Forest Department within the Ministry of Natural Resources and Environment is the agency responsible for management of all forest reserves and most terrestrial protected areas (except archeological reserves), with more limited authority over private forested lands.

At the time of the last inventory, total forest area in Belize was 15,867 km^2, which is equivalent to 69% of the country[119], though it is likely that the current percentage of forested land is closer to 61% (Percival Cho, Forest Officer, personal communication). Forest cover is changing due to extensive export agricultural development as well as small areas of slash and burn agriculture[120]. While 1990-2000 deforestation rates for

117 SIB 2007b

118 White et al 1996

119 CZMI 1997

120 White et al. 1996

Central America were 1.2% per year, the deforestation rate in Belize during this period (2.3% per year) exhibited much higher rates of loss[121]. Approximately 80% of the lost area was broadleaf forest (620 km^2). The remaining 20% were secondary forest (100 km^2), coniferous forest (34 km^2), riverine vegetation and bamboo (16 km^2) and mangroves (11 km^2). Deforestation is very common along river courses where agricultural conditions (soils and access to water in the dry season) are best. DiFiore (2001) recorded a 22% (72 km^2) loss of forest cover from 1989 to 2001 in the riparian corridor along the Belize River—a forest conversion rate of 2% per year. This trend is likely to hold for other floodplain forests in Belize.

A number of mills currently operate throughout the country, mostly focusing on production of pine lumber and secondary hardwood lumber (Table 5). The Forest Department grants logging concessions within Forest Reserves to local and international logging companies. Recently, in an effort to promote sustainable management of timber resources, the Forest Department began granting long-term (40-year) management concessions. These concessions are managed by stricter standards that regulate rotation periods, utilizing area control, and improved harvesting practices.

Teak and mahogany are the significant species currently used in Belize. It is estimated that there are over 5,000 acres of plantations present in Belize, in small scattered plots of a few acres to a couple of hundred acres. No known mahogany plantations exist, but mahogany line planting for forest enrichment has occurred in several places around the country, though in quantities far less than teak (Percival Cho, Forest Officer, personal communication).

Table 5 Cubic feet of timber harvested from the four most popular species – 1999 to 2004 [122]

Species	1999	2000	2001	2002	2003	2004
Pine	833.0	710.2	1,404.4	1,410.6	21.9	1,689.6
Mahogany	140.3	81.3	126.8	134.2	137.8	868.1
Santa Maria	160.2	86.8	218.6	93.4	133.1	904.9
Yemeri	191.6	109.7	110.3	142.8	20.5	418.3

Approximately 80 km^2 of Belize's economically important Caribbean pine (*Pinus caribaea*) forests were decimated by an infestation of the southern pine bark beetle (*Dendroctonus frontalis*) between 1999 and 2001. Only 4 km^2 of Caribbean pine have been replanted since that time as part of restoration efforts (Percival Cho, Forest Officer, personal communication).

1.12.2 PROTECTED AREAS

Belize has an impressive national protected area system that protects about 36% of its terrestrial and 13% of its marine area[123]. The protected areas system is comprised of a number of different types of conservation reserves, multi-use forest reserves, marine reserves, and archaeological sites (Figure 10). Coordinating management of these areas involves a complex regulatory structure with multiple agencies and many stakeholders, including the Forest Department, Fisheries Department, and Department of Archaeology (each within a different Ministry of government), in combination with non-governmental organization partners.

In 2005, a comprehensive National Protected Areas Policy and Systems Plan was completed with high level representation from relevant agencies to "ensure that the potential contribution of the protected areas system to national development and poverty alleviation is maximized, thereby putting it on a sound and rational footing"[65]. Major results of this process include:

1. *Formulation of a comprehensive protective area policy* that creates a policy framework in which the plan will be implemented.

121 FAO 2001

122 SIB 2007b

123 Meerman and Wilson 2005

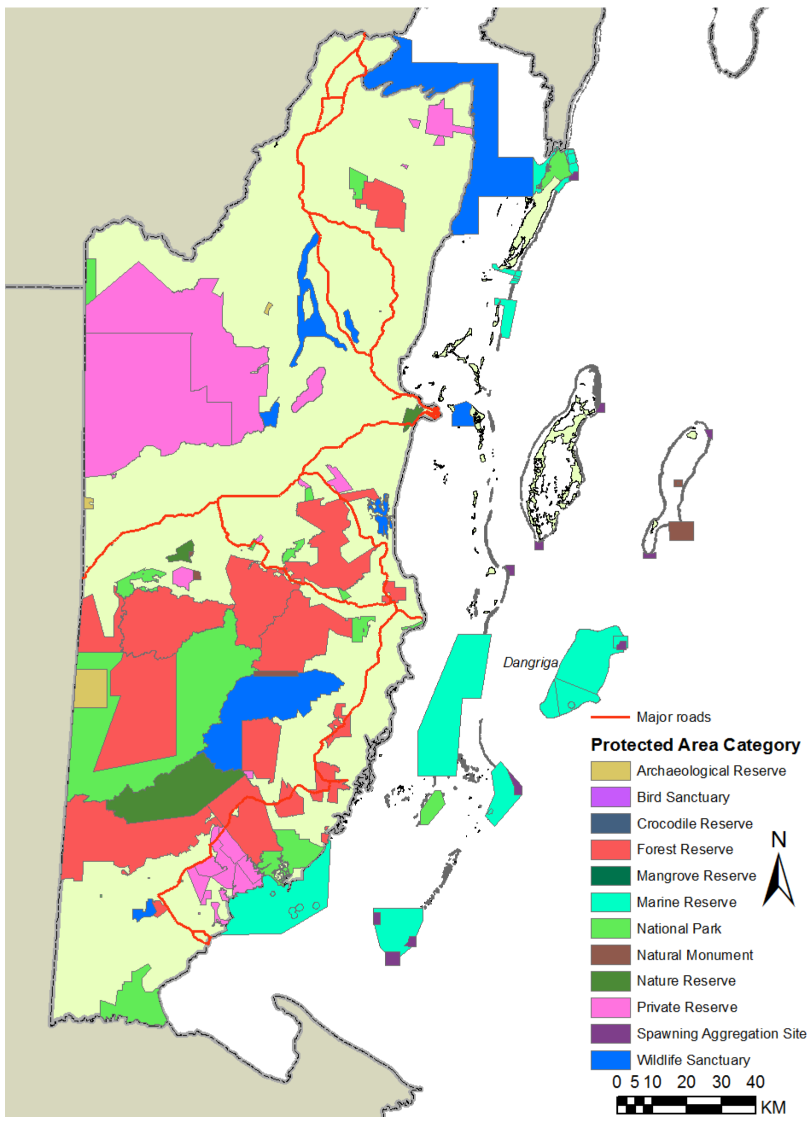
2. *A protected area system assessment and analysis* that evaluates the adequacy and coherency of the network and makes recommendations for maximizing these.

3. *Management procedures and sustainable use* recommendations that address shared governance of the network and supporting legal instruments.

4. *Strengthened management and monitoring* procedures for building capacity, information driven decision making, and financing.

Both the Policy and Plan were endorsed by the Government of Belize to set the stage for implementation. Recommendations of the National Protected Area Plan are currently being implemented over a 6-year time period[124]. It is anticipated that at the end of the process the protected area system will be consolidated and managed in a streamlined manner to better meet the economic needs of the nation while maintaining its functionality as a place where biological diversity and ecosystem services can continue to function unhindered.

Figure 10 Protected Areas.
Belize has an extensive system of many protected areas that is currently being consolidated from the many reserve types shown here to larger reserves with multiple zones in each.



124 NPSAP 2005

1.12.3 FOREST MANAGEMENT AND CLIMATE CHANGE

The Bali Action Plan is one of the tangible results of the 3-14 December 2007 UN Climate Change Conference in Bali. The action plan calls for consideration of "policy approaches and positive incentives on issues relating to reducing emissions from deforestation and forest degradation in developing countries; and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries"[125]. The emerging financial mechanism called 'reducing emissions from deforestation and degradation (REDD)' hold much promise for Belize, because of the significant carbon sinks present. Belize, via its representatives to the COP, plans to actively pursue benefits from receipt of payments for averting forest loss and managing forests for carbon fixation. Application of sustainable forest management practices, in particular, can enhance Belize's potential as a carbon sink. Belize is also well-positioned as a non-Annex I signatory to the Kyoto Protocol to participate in activities under the Clean Development Mechanism.

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CHAPTER 2 SECOND NATIONAL INVENTORY OF EMISSIONS AND SINKS OF GREENHOUSE GASES

2.1 INTRODUCTION / BACKGROUND

The Greenhouse Gases Inventories were conducted as part of the process to prepare Belize's Second National Communication. It is in fulfillment of the commitment under Article 4:1(a) of the Convention which requires Non-Annex 1 (NA 1) countries to *"Develop, periodically update, publish, and make available to the Conference of the Parties, in accordance with Article 12, national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal protocol, using comparable methodologies agreed upon by the Conference of the Parties"*. Decision 17/ CP 8 provided the Guidelines for the preparation of the national communications. The Reference Year for Green House Gas Inventories of emissions and removals for NA1 countries was selected as the year 2000.

Belize's main economic growth continues to be in agriculture and tourism. However there are a number of industries that may be potential sources of GHG's. These industries may need to be monitored in order to determine their potential or actual contribution to the emissions. These industrial processes may also act as sinks, for example, asphalt used in road paving essentially ties up the carbon in the form of pavement, but there might also be opportunities for mitigation during the early stage of the industry's growth.

The purpose of the greenhouse gases inventory is to assess the sources and quantities (masses) of emissions and removals for the particular reference years selected by the Conference of the Parties. The results of such inventories are to be reported in the National Communications. Country parties can utilize such information to guide or monitor ongoing development in order to determine what impact their activities are having on global warming. Non-Annex 1 countries like Belize are not yet expected to set or meet emissions targets, but may engage in voluntary mitigation of greenhouse gases emissions.

The first reference year surveyed for Belize was 1994, so the National Focal Point decided to utilize the SNC project to conduct GHG inventories for 1997 as well, thus enabling analysis of inventories of GHGs that covered a nine-year period.

The collection of data for the additional period could be accomplished with little additional input of time and effort. This would enable analysis to be conducted over a nine-year period since statistical data and supplementary information would be collected for two more three-year periods with those reference years as the median. Utilizing the baseline data collected and analyzed for the 1994 reference year, trends in emissions and removals would be more easily discerned.

2.2 INSTITUTIONAL ARRANGEMENTS FOR INVENTORY PREPARATION

The National Climate Change Committee that had been established prior to the preparation of the First National Communication was still in place, although mostly inactive since some of the original members had moved on. However, the NCCC was reactivated, during the preparation of the national communication, with meetings scheduled on a biennial basis. The National Climate Change Committee is a multidisciplinary group serving as a consultative group to the National Focal Point (NFP). This committee has the potential to lobby government and other stakeholders to adopt measures and strategies to respond to climate change, however institutional arrangements have to be adopted.

The National Meteorological Service (NMS) has served as the government agency with responsibility to advise the GOB on matters pertaining to climate change, since Belize became a Party to the Convention. On the occasion of the First National Communication, the project was implemented by the NMS, at that time one of the departments in the Ministry of Energy and Communication. The Meteorological Service's offices were located near the PSWG International Airport in Ladyville about 14 kilometres out of Belize City. The preparation of the INC and the GHG inventory was managed out of the offices of the Chief Meteorologist. The Infrastructural System utilized for the INC was a small team comprised of the Chief Meteorologist, an International Consultant, a National Consultant, and an Office Assistant assembled to manage that project. For the purpose of the GHG Inventory, a team of national consultants were contracted to estimate the emissions, with one or two consultants working in each sector. Details of that team can be found in the Initial National Communication, posted on the Convention's website.

The institutional arrangement for the SNC remained the same. However, with plans for renovation of the offices of the NMS well advanced, and the actual work due to start at anytime, an office was located in the capital city Belmopan, in order to centralize activities, and to bring contracted consultants, sources of data and information, and resources persons/agencies closer together. This arrangement would also enable better opportunities for consultations and review of outputs of the various exercises. The NMS remained as the office with the responsibility for the implementation of the SNC project, but the NMS had been relocated to the Ministry of Natural Resources and the Environment since 2000. The Ministry of Natural Resources and the Environment (MNRE) therefore became the Executing Agency for the second project. The Chief Meteorologist functioned as the Project Director on behalf of the Ministry. He had also been seconded to serve as part of the staff of the Caribbean Community Climate Change Centre (CCCCC) located in Belmopan. The SNC project was able to rent space in the headquarters of the CCCCC which facilitated direct supervision of the project by the Project Director. An additional benefit of this arrangement was the oversight of financial management afforded by the UNDP office due to presence of this office, also being located in Belmopan. With the hiring of a Project Manager, the basic elements of the institutional arrangements for the GHG inventory were in place.

An early activity conducted during the preparation of Belize's Second National Communication was the appointment of a Project Steering Committee, later called the Project Execution Group (PEG). This PEG was considered a sub-group of the National Climate Change Committee, and was comprised of senior staff members of government departments, statutory bodies, representatives of industry, and the non-government community. This committee had the responsibility to provide active and technical support in the management of the project. This decision-making body, in collaboration with the UNDP representative, was expected to provide guidance to the Project Manager (PM), and monitor the implementation of the project.

The National Communication requires the inclusion of a report of the country's emissions and removals of greenhouse gases. The Second National GHG Inventory was therefore an activity programmed for implementation early in the project period. Belize chose to capitalize on the fact that most of the Initial GHG Inventory team (assembled for the First National Communication) was intact, still accessible, and available. There was an additional benefit to using this experienced group because of knowledge and skills that could be shared as a result of some of their participation in the ongoing United States Agency for International Development Environmental Protection Agency GHG Inventory Improvement Project in which Belize was participating at the time. These consultants already had contacts within the relevant agencies where they would need to access data and information.

The Stakeholder holder participation would be achieved through a series of public presentations from consultations on the draft reports, to complement the individual and company interviews and surveys.

2.3 THE PROCESS FOR INVENTORY PREPARATION

After sector Consultants were contracted, the group comprising Consultants, Project Director, and Project Manager held a number of briefing and organizational meetings. These enabled a common strategy to be applied to acquire, store and manage data, while allowing sharing of information. The UNFCCC Greenhouse Gas Inventory Software, version 1.3.2 was downloaded from the website, and installed on the consultants' computers. All had previously indicated familiarity and some level of proficiency with EXCEL software, but the use of this particular tool was demonstrated by the NFP. They were also provided with backup copies of the software.

The tools including the updated UNFCCC EXCEL software, along with the Reporting Manual, Reference Manual, and the Workbook were provided to the consultants. Although they were independently contracted, they were advised and encouraged to collaborate in the exercise, to make use of the project office, and its collection of reference documents as much as needed.

Consultants were provided with introductory letters to improve access to the data owners.

The first meeting focused on discussion of the first GHG Inventory report, primarily on the past experiences, and difficulties encountered. This also served to identify potentially new or better sources of data and information, and helped to streamline the approach of the consultants in acquiring data. The wish was for efficiency, and avoidance of duplication in visiting the same sources, and meanwhile ensuring that there were no gaps in coverage or access to sources.

All raw data collected during the exercise was stored on the SNC project computer for backup. The original spreadsheets of the first GHG inventory were located; copies were provided to consultants. Efforts were made to scan the originals in order to ensure that handling would not damage them, but also to ensure that digital copies were maintained. Earlier digital copies remaining from the INC were recorded on 3.5 inch diskettes, some of which were no longer readable.

Consultants also worked together as much as possible, with additional meetings providing opportunities for sharing of data, or resolving difficulties when data was proving to be difficult to obtain or interpret.

2.4 METHODOLOGIES AND DATA SOURCES USED

Data was obtained through personal interviews with resources persons, literature review of government departments' monthly and annual reports, company reports, documents maintained on file in the National Archives, the library collection of the National Meteorological Service, as well as collections maintained by other government agencies and non-government organizations. Some information was derived through interviews with persons who were or had served in the particular field and was therefore considered as a provider of Expert Opinion. The Central Statistical Office had been privatized as the Statistical Institute of Belize, but remained a valuable source of data, although it continued to be constrained by the data provided by the department, institutions, and organizations who contributed to it.

The GHG Inventory was conducted according to the United Nations Framework Convention on Climate Change Guidelines for the preparation of the national communications (Decision 17/CP.8) from non-Annex 1 Parties. The 2000 Good Practice Guidance was also utilized for the LULUCF sector. The result of the second national GHG inventory is reported in the Second National Communication, and is also produced as a separate report for national use. The report describes the estimates of direct greenhouse gases such as Carbon dioxide (CO_2), Methane (CH_4), and Nitrous oxide (N_2O); and of indirect greenhouse gases such as

Carbon monoxide (CO), other Oxides of Nitrogen (NO_x), Sulphur dioxide (SO_2), and the Non-methane volatile organic compounds (NMVOC).

Tier 1 level of calculations was used throughout due to the state and quality (completeness and coverage) of the data that was available.

Energy sector statistical data on fuel was collected directly from the *main sources*, namely ESSO Standard Oil S.A. Ltd (the only importer of bulk fuel for retail sales) and Belize Electricity Limited, who are the principal importers of petroleum products into the country. Belize Sugar Industries Ltd. was also a source of data as the only producer and consumer of bagasse. However, other data were collected from other importers in order to capture sources such as Bunker C fuels and data on lubricants. One major assumption was that inventory levels (year-end) were constant. This assumption enabled the conclusion that all imports were consumed. The data sources indicated that this was a valid assumption. The three major local oil retailing companies, private sector bulk consumers, and service station operators were all interviewed to verify data, and to reduce the occurrences of gaps in the data/information.

Data pertaining to sources of GHG emissions in the *Industrial Processes* and *Solvents* sectors were obtained from sources including government agencies, producer organizations and private companies. A list of these sources is provided in the Appendices. Data collection included making site visits to these manufacturing sites to corroborate the data provided. The site visits also provided evidence to determine whether any changes had been made since the last inventory was done.

Data for the *Agriculture* sector GHG inventory was gathered from the following sources: Statistics Unit in the Ministry of Agriculture and Fisheries in Belmopan City; Belize Livestock and Poultry Producers' Associations; Central Statistical Office (now known as the Statistical Institute of Belize); two major fertilizer importers, formulators and distributors; wetland rice farmers/producers; buffalo farm ex-managers; ground white lime and dolomite producers, and personal communication with specialists in the various sub-sectors. When the official repositories of data did not have the required data sets, the Consultant was able to revert to the original producers of the production data, such as the fertilizer companies and poultry or livestock associations.

Statistical data for the *LULUCF* sector was obtained for the most part from previous Forest Department reports and from private forest plantation owners. Statistical data is sometimes inconsistent. For example The TFAP (1989) report for Belize reports that estimates forest cover by Lanly (1981) and those of Hartshorn (1984) both based on the 1978 terminal report of the FAO project BZE/75/008 presented significant (5,650 kms^2) differences.

The Stantec report of 1999 and the 2006 Abstract of Statistics were the main sources of statistical data for the *WASTE* sector GHG inventory. Both documents recorded that the average rate of solid waste production in urban Belize was estimated at 0.97 kg/person/day. Individual rates of production were determined for each urban centre in 1999 (Table 1). However, in the 1998 Inventory, the Consultant conducting this sector of the first national greenhouse gases inventory decided to use 1.18 kg/person/day for the 1994 base year since this rate included other municipalities served by the disposal system.

2.5 ENERGY SECTOR

Two main energy sources were identified; fossil fuels, which are imported, and biomass which includes the burning of bagasse in the sugar industry and consumption of fuel wood for domestic use as well as for the production of white lime.

The results of this study show that there was a small increase in emissions within the energy sector between 1997 levels at 1,026.7511.53 Gg and 1,127.2995Gg in 2000. Considering emissions for 1994 of 579.07 Gg (617.53 Gg recalculated), the trend shows a steady increase in emissions, but the study also revealed that these emissions were from the same sources. No new sources were identified in any of the two reference years considered in this study.

Emissions classified as International Bunkers stood at 41.27 Gg for 1994, 276.02 Gg for 1997 and 94.35 Gg for 2000. Data indicated that this was primarily due to trade within the Commercial Free Zone (CFZ) in the Corozal district, which peaked in 1998.

Activities that resulted in GHG emissions within the energy sector included electrical energy generation, manufacturing, road transportation, marine transportation (National Navigation) and local flights (Domestic Aviation). Residential outputs and the fishing industry also contributed to those emissions. Consumption of gasoline and the resulting emissions increased considerably from 1994 to 1997, but dropped to a lower level by 2000.

The combination of gasoline and diesel showed similar behavior, this probably being attributed to more vehicles being on the roads. The expansion of new-vehicle dealerships may also be a factor in this sub-sector. Consumption of jet fuel increased steadily, while kerosene use declined over the study period.

The principal contributor to CO_2 emissions within the energy sector comes from road transportation. Emissions from this activity were 263.58, 275.94 and 330.55 Gg CO_2 for 1994, 1997 and 2000 respectively, accounting for 44.2%, 44.6% and 51.4% of all energy-related activities countrywide.

In considering the reference year 2000, the third largest CO_2-producing activity would be national navigation. This sub-sector has seen significant activity and growth primarily due to the growth of the tourism industry. As in the case of road transportation, emissions from navigation show a growing trend: 35.51, 57.03 and 74.54 Gg CO_2 for 1994, 1997 and 2000 respectively, and accounting for 5.9%, 9.2% and 12.1% of all energy-related activities countrywide

In the case of emissions due to biomass, the two main contributors are fuel wood and bagasse. For fuel wood, the bulk of the consumption is for domestic use (a CSO estimate shows that 13% of the population use fuel wood as the energy source for cooking). Bagasse is produced and consumed by Belize Sugar Industries Limited (BSI), which is the only sugar factory currently in operation the country. This production / consumption is projected to increase when the BSI co-generation project comes on stream.

Other emissions were insignificant, and include CH_4, N_2O, NO_x, CO, NMVOC's and SO_2. Sulfur dioxide was determined to be most significant.

2.6 Industrial Processes (and Solvents) Sector

Belize is not a highly industrialized country; therefore activities within the Industrial Processes and Solvents Sectors occur within a narrow range. Only two of the sub-sectors displayed any activities. Lime production and road paving with asphalt were two active Mineral Products sub-sector; while production of beer, wine, and spirits, and meat, fish, poultry, bread, and animal feed were activities in the Food and Drink production sub-sector.

The second greenhouse gases inventory indicated that emissions within Industrial Processes sector remain the same as for the first inventory. In 1994 total GHG emissions amounted to 1.73 Gg. This has increased to 1.81 and 2.20 Gg for the years 1997 and 2000 respectively. Indications are that industrial activity continued to increase as Belize's economic development progressed.

Activities contributing to GHG emissions included mineral production and food and drink manufacture. Mineral production includes lime production, and use of asphalt for paving. Food and drink manufacture include production of liquor, bread, processed meats, sugar and animal feeds.

Activities in the industrial sector are localized and tend to function as point sources of pollution. For example rum production is limited to only four plants, two in the Orange Walk District, one in Belize City and one in Belmopan City. Likewise lime production is concentrated in only one area of the country on the Humming Bird Highway.

The inventory determined that the primary emissions from the sector were non-methane volatile organic compounds, mostly form road paving with asphalt, while the GHG emissions were derived from lime production.

Figure 11 The Belize Sugar Industry factory (Orange Walk) in operation

There were three distilleries and one brewery, for **alcohol and beverage production,** in operation during the study period. The different brands of liquors produced are all based on sugarcane rum with different ingredients being added after the fermentations stage.

There was an increase from the reported 1994 estimates of 0.0058 Gg and 0.0064 Gg for the years 1997 and 2000 respectively.

Bread production in Belize is divided into production by bakeries and home production. Numerous bakeries have closed down and new ones opened since 1994 so that data were unavailable for those bakeries, and those in operation did not retain good quality data. It was assumed that bakeries relied on baker's flour only for use in making bread, even though most reported that only a small amount of all purpose flour is used in the production of bread. It was estimated that 1.2 loaves of bread was produced for every pound of flour. The data analyzed was based on baker's flour sold rather than data from individual bakeries which appeared to be less reliable.

Other **food production** was limited to processed meats. These include bacon, hams, picnics, and sausages which have undergone some form of cooking or smoking. Other "processed meats" which have not undergone any form of cooking, example beef patties, are not included. Foods such as fish and shrimp which are only cleaned and packaged are also not included. For this sector the Annual Production Index (API) was used to obtain final default values.

2.7 AGRICULTURE SECTOR

The second inventory of green house gases showed that emissions within the agriculture sector were from the same sources as those for the first inventory. In 1994 the recalculated total GHG emission amounted to 54.8876 Gg. This increased to **66.9793** and **100.44** Gg for reference years 1997 and 2000 respectively. The results showed that agricultural soils and prescribed savannah burning were the two main sources of GHGs in the agriculture sector in Belize; the other sub-sectors produced minimum quantities of GHGs.

The agriculture sector is a net emitter of GHGs but accounts for less than 2 % of the total emissions from all six sectors. As the acreage of mechanized wetland rice cultivation increased, this sub-sector will increased its share of methane emissions. Most of the expansion is expected to continue in the Orange Walk District in northern Belize. Methane from enteric fermentation remained somewhat constant, and the national herd of cattle and swine were not expected to increase dramatically in the near future.

While the total methane emissions (from enteric fermentation and cultivation of flooded rice) reported for 1994 was relatively high for Belize, recalculations reduced the total value was reduced to less than 3 Gg. Burning of savannah and the field-burning of crop residues are the main contributors of CO emissions, these two activities are also large contributors to the non-CO_2 trace gases. The slightly higher estimates of CO emissions recorded in 1997 were due mainly to a higher tonnage of sugar being processed for the export market. It is also worthwhile to note that the emissions of CO over the three periods are practically constant once the local conversion factors (from a BSI study in December 2006) for sugar residue burning were used.

Figure 12 Irrigated rice cultivation in Blue Creek, Orange Walk District

The 1994 submitted data shows that total methane emissions from domestic livestock was well above the average figure for developing countries at a reported 2.837 Gg. However, when the data were recalculated, the estimated methane emissions fell below 1 Gg as is the expected value for developing countries like Belize. The Net Total Emissions for the period ranged between 46.41 Gg in Revised 1994, 48.44 Gg for 1997 and 46.09 Gg for 2000.

2.8 LAND USE, LAND USE CHANGE AND FORESTRY SECTOR

Recalculation of the results for 1994 showed that the total emission of CO_2 from the LULUCF sector of 7,483 gigagrams was mainly from deforestation and soil carbon from agriculturally impacted soils. Carbon sequestration from forest growth following logging and the regrowth of abandoned lands reduced this quantity by 2,891 Gg to a net emission value of 4,592 Gg.

Belize is not unique in that within our region one of the major sources of greenhouse gas emissions is deforestation. The continued reduction in forest areas that are being logged and /or actively managed will also diminish our capacity to offset emissions from deforestation. Increases in land degradation and increased utilization of land with less productive potential coupled with the present rate of population increase may very well contribute to greater forest conversion. Therefore the continuous monitoring of deforestation incorporating existing data gathering mechanisms and institutions is important to provide baseline information for developing strategies to ameliorate the impacts of these development activities on the climate change process and create adequate adaptation mechanisms. It is also very clear that the compilation of data and its retrieval in an efficiently utilizable format is a major weakness in many, if not most of the public institutions (and to a lesser extent private) that are mandated to maintain a database of information relevant to the particular sector they are charged to administer or manage. It also becomes evident that there is a wide overlap in the type of data that these institutions should be compiling and maintaining and the data necessary to carry out a GHGI for the LULUCF sector. A strategy therefore needs to be developed where the importance of GHG inventories and other climate change related activities can serve to assist these institutions in leveraging the attention and resources sorely needed to fulfill their sectoral data management responsibilities. At the same time this would provide timely and consistent data required to fulfill our national climate change related responsibilities, hopefully at an acceptable economic rate. The Forest Department plays and will continue to play a key role in providing data related to changes in forest biomass stocks.

Figure 13 Stages in land use change

1997 Reference Year: Carbon dioxide emissions from the LULUCF sector amounted to 9,803 gigagrams, mainly as a result of deforestation and to a lesser extent from soil carbon in agriculturally impacted soils. Carbon sequestration also resulted from forest growth following logging and forest regrowth on abandoned lands reduced this quantity by 3,225 Gg to a net emission value of 6,578 Gg.

2000 Reference Year: The same trends as for the earlier two reference years was observed for 2000; there was a total emission of CO_2 from the LULUCF sector of 11,950 Gg primarily from deforestation and from soil carbon in agriculturally impacted soils. The pattern for Carbon sequestration from forest growth following logging and natural reforestation on abandoned lands reduced the volume of the GHG emissions by 3,862 Gg to a net emission value of 8,088 Gg.

2.9 WASTE SECTOR

Some of the default values for GHG emissions have been revised and certain changes made in the calculations. The default values presented in the 1996 Revised IPCC Guidelines were applied since Belize has not developed any country-specific values for this sector. The emissions for the 1994 reference year were re-calculated, resulting in lower than previously reported GHG emissions from the waste sector.

Municipal waste produced in Belize is primarily domestic, and includes waste generated by the commercial and business sector located within or near municipalities. Very little industrial waste in included. There is no available data on municipal versus domestic waste as there is no separation at source.

The IPCC Guidelines detail two basic types of wastewater handling for which emissions should be calculated separately:

- Domestic and commercial wastewater; and,
- Industrial wastewater.

The primary source of emissions was from domestic and commercial wastewater handling. In addition to the determination of methane generation from wastewater, the IPCC guidelines now include the estimation from emissions from sludge. Belize has very little or no sludge handling, and therefore, this was not estimated. Sludge handling in Belize is done ad hoc, and there is no consistency in the frequency of handling.

Net emissions (without emissions from industrial waste water handling) amounted to 0.51 Gg for 1994, 0.69 in 1997 and 1.02 in 2000. There was an increasing trend over the three years.

When factored in, the industrial component was the major source of emissions in the waste sector, and the trend was for a reduction in emissions from this sector. The data showed that the primary factors influencing change in the emissions from the waste sector was decrease in the waste water produced 225 Gg in 1994 to 169 Gg in 1997 and 2000.

2.10 Brief description of Key Source categories

After the completion of the first national greenhouse gases inventory, those estimates were examined to determine the major sources of emissions. The key source analysis of the estimates derived from the original inventory (reference year 1994) is presented in table form below.

Table 6 Key Source – 1994 Emissions

IPCC source categories	Greenhouse gas	Reference year Estimate Gg	Level estimate %	Cumulative Total %
Agriculture: Emissions from agriculture residue burning	**N_2O**	4092.00	**0.23**	23.28 %
Agriculture: Emissions from Savannah burning	**N_2O**	4092.00	**0.23**	46.55 %
Energy: Mobile combustion – road vehicles	**CO_2**	2168.16	**0.12**	58.89 %
Agriculture: Emissions from enteric fermentation in domestic livestock	**CH_4**	1761.96	**0.10**	68.91 %
Energy: Manufacturing industries and combustion	**CO_2**	1398.14	**0.08**	76.86 %
Energy: Emissions from stationary combustion	**CO_2**	1111.43	**0.06**	83.18 %
Agriculture: Emissions from rice production	**CH_4**	958.02	**0.05**	88.63 %
Agriculture: Emissions from manure management	**CH_4**	715.93	**0.04**	92.70 %
Energy: other sectors – residential	**CO_2**	351.99	**0.02**	94.71 %
Energy: other sectors - residential	**CH_4**	328.85	**0.02**	96.58 %

Approximately 95 % of Belize's GHG emissions were produced within two of the categories, these being the agriculture and the energy sectors, for the study period 1994. Indications are that the agriculture sector accounted for about 47 % of the total emissions for that period. The emissions from this sector were equally divided between two of the sub-sectors within this category, namely nitrous oxides from the *burning of agriculture residue*, and nitrous oxides from *burning of savannahs*.

1997 Emissions: Although usually done for the emissions amounting to 95 % of the total, the list presented here includes a wider range in order to provide a better picture of the categories and sub-categories contributing in Belize. In this case, the two most significant sources of emissions were identified as sub-sectors in the Land Use, Land Use Change and Forestry sector, namely carbon dioxide emissions from forests and grassland conversions and carbon dioxide emissions from soils. Both sources are associated with land use change or land management activities and together account for almost 90 % of the emissions for the 1997 reference year. Carbon dioxide emissions from the transportation sub-sector (within the Energy Sector) accounted for the third highest level of GHG emissions.

The key sources of emissions are listed in the table below.

Table 7 Key Source – 1997

IPCC Source Category	Sector	Source Category	Applicable GHG	Estimated Emissions Gg	% Of Total
5.B	LULUCF	CO_2 Forest and Grassland Conversion - Tropical Forests	CO_2	5,906.4	76.04%
5.D	LULUCF	CO_2 Emissions from Soil	CO_2	1,000.2	12.88%
1.A.3	Energy	CO_2 Mobile Combustion: Road Vehicles	CO_2	275.9	3.55%
5.B	LULUCF	CO Forests and Grassland Conversion - Tropical Forests	CO	185.0	2.38%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CO_2	CO_2	107.6	1.39%
1.A.3	Energy	CO_2 Mobile Combustion Water Borne Navigation	CO_2	57.0	0.73%
1.A.2	Energy	CO_2 Emissions from Manufacturing Industries and Construction	CO_2	44.7	0.58%
4.D	Agriculture	N_2O (Direct and Indirect) Emissions from Agricultural Soils	N_2O	44.2	0.57%
1.A.4	Energy	Other Sectors: Residential CO_2	CO_2	21.6	0.28%
5.B	LULUCF	CH_4 Forest and Grassland Conversion- Tropical Forests	CH_4	21.1	0.27%
1.A.4	Energy	Other Sectors: Residential CH_4	CH_4	19.1	0.25%
6.B	Waste	CH_4 Emissions from Wastewater Handling	CH_4	16.9	0.22%
1.A.3	Energy	CO_2 Mobile Combustion: Aircraft	CO_2	15.7	0.20%
1.A.4	Energy	Other Sectors: Commercial CO_2	CO_2	15.3	0.20%
6.A	Waste	CH_4 Emissions from Solid Waste Disposal Sites	CH_4	14.9	0.19%
4.C	Agriculture	CH_4 Emissions from Rice Production	CH_4	6.0	0.08%
5.B	LULUCF	N_2O Forests and Grassland Conversion - Tropical Forests	N_2O	5.3	0.07%
1.A.4	Energy	Other Sectors: Residential N_2O	N_2O	3.8	0.05%
4.B	Agriculture	N_2O Emissions from Manure Management	N_2O	2.6	0.03%
4.F	Agriculture	CH_4 Emissions from Agricultural Residue Burning	CH_4	1.0	0.01%
1.A.3	Energy	CH_4 Mobile Combustion: Road Vehicles	CH_4	0.7	0.01%
4.F	Agriculture	N_2O Emissions from Agricultural Residue Burning	N_2O	0.5	0.01%

2000 Emissions: The results of the inventory for the 2000 reference year showed a switch in the positions of the two primary 1997 sources. This time around the carbon dioxides from soils was the highest level, with forest and grassland conversion being the second most significant source. The forest and grassland conversion sub-sector had increased considerably, but the increase in land management activities was enough to exacerbate the emissions from this sub-sector. These results correspond to anecdotal observations about reduction in the trend in land use change, but increased levels in land utilization activities. The transportation sub-sector and emissions from the sub-sector dealing with agricultural land use activities were reported among the top five sources of emissions for this reference year.

The table below provides additional details about the sources of GHG emissions for the 2000 reference year.

Table 8 Key Source Analysis 2000

IPCC Source Category	Sector	Source Category	Applicable GHG	Estimated Emissions Gg	% of Total
5.D	LULUCF	CO_2 Emissions from Soils	CO_2	24,008.9	66.15%
5.B	LULUCF	CO_2 Forest & Grassland Conversion - Tropical Forests	CO_2	11,077.5	30.52%
5.B	LULUCF	CO Forest & Grassland Conversion - Tropical Forests	CO	348.8	0.96%
1.A.3	Energy	CO_2 Mobile Combustion: Road Vehicles	CO_2	330.6	0.91%
4.D	Agriculture	N_2O (Direct and Indirect) Emissions from Agricultural Soils	N_2O	175.2	0.48%
1.A.3	Energy	CO_2 Mobile Combustion Water Borne Navigation	CO_2	77.5	0.21%
1.A.2	Energy	CO_2 Emissions from Manufacturing Industries and Construction	CO_2	46.7	0.13%
5.B	LULUCF	CH_4 Forest & Grassland Conversion - Tropical Forests	CH_4	39.9	0.11%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CO_2	CO_2	34.9	0.10%
1.A.4	Energy	Other Sectors: Residential CO_2	CO_2	23.0	0.06%
6.A	Waste	CH_4 Emissions from Solid Waste Disposal Sites	CH_4	22.7	0.06%
1.A.3	Energy	CO_2 Mobile Combustion: Aircraft	CO_2	20.9	0.06%
1.A.4	Energy	Other Sectors: Residential CH_4	CH_4	19.5	0.06%
6.B	Waste	CH_4 Emissions from Wastewater Handling	CH_4	17.6	0.05%
1.A.4	Energy	Other Sectors: Commercial CO_2	CO_2	16.9	0.05%
5.B	LULUCF	NOx Forest & Grassland Conversion - Tropical Forests	NOx	9.9	0.03%
4.C	Agriculture	CH_4 Emissions from Rice Production	CH_4	6.2	0.02%
4.B	Agriculture	N_2O Emissions from Manure Management	N_2O	4.6	0.01%

The Key Source Analyses for both 1997 and 2000 Reference Years were completed manually since the available software did not allow for automatic estimation of the LULUCF Sector.

2.11 QUALITY ASSURANCE/QUALITY CONTROL PLAN

Three technical sessions were held with the Project Manager and National Focal Point, during the process of resolving the issues around data collection, in order to assist with the resolution of issues and to work on reduction of uncertainties prior to the production of the first draft report. The sessions served to achieve some degree of Quality Control as consultants shared experiences, lessons learnt, and sources of data. A first draft report was produced and submitted to the members of the Project Execution Group for technical evaluation. Subsequently, a final national validation workshop was convened in April 2007 to present the results of the inventory and to obtain additional inputs from the participating stakeholders. These concerns were then incorporated into the final report.

2.12 UNCERTAINTY EVALUATION

All sectors were treated to Uncertainty evaluation. Tier 1 methodology had to be applied since gaps in data and information were found within all the sectors. Even within the Energy sector, data was not disaggregated. For example, data within the transportation sub-sector were grouped instead of being recorded by type and/or size of vehicle. Neither were there specific default values for small single and twin engine airplanes or power boats when these methods of transportation represented a significant portion of the transport sub-sector in relation to fuel combustion within the borders of the country.

2.13 GENERAL ASSESSMENT OF COMPLETENESS

The inventory covered all of the IPCC Sectors where there was activity in Belize. As already indicated, the Solvent sector is not treated since there were no activities in the sub-sectors for the reporting period.

2.14 DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS FOR AGGREGATED GREENHOUSE GAS EMISSIONS

As expected the results of the 1997 and 2000 GHG Inventories displayed steady increases in almost all study areas. Only emissions from fuel combustion for energy production showed a decline in emissions for the 2000 period. This was attributed to the reduction in consumption and combustion diesel by Belize Electricity Limited. The Mollejon Hydro dam had been put into service by this time, so many of the large diesel generators had been removed from service.

Table 9 GHG emissions (total and proportion)

Total Volume of GHG Emissions by Sector (Gg) for Reference years 1994, 1997 & 2000			
Sector	**1994 r**	**1997**	**2000**
Energy	617.5280	1,026.7511	1,127.2995
Industrial Processes & Solvents	1.7350	1.8001	2.1972
Agriculture	46.4146	1.5846	2.0825
Land-Use Change & Forestry	2,056.3650	7,117.1762	12,349.2819
Waste	104.7000	1.5141	1.9158
Total	**2,826.7426**	**8,148.8261**	**13,482.7769**
Proportions of GHG Emissions by Sectors for the reference years			
Sector	**% of Total**	**% of Total**	**% of Total**
Energy	22	13	8
Industrial Processes & Solvents	0	0	< 1
Agriculture	2	0	< 1
Land-Use Change & Forestry	73	87	91
Waste	4	0	< 1
Total	100	100	100

2.15 Description and Interpretation Of Emission Trends By Gas

Carbon dioxide was the gas emitted in the greatest volumes over the three study periods, ranging from 92 % in 1994, the approximately the same in 1997, but increasing to 98% of the total in 2000. Although the total volumes of most of the other GHG actually increased, their proportions in relation to the amount of carbon dioxide produced decreased.

Figure 14 Graphical illustrations of 1994 GHG emissions (recalculated)

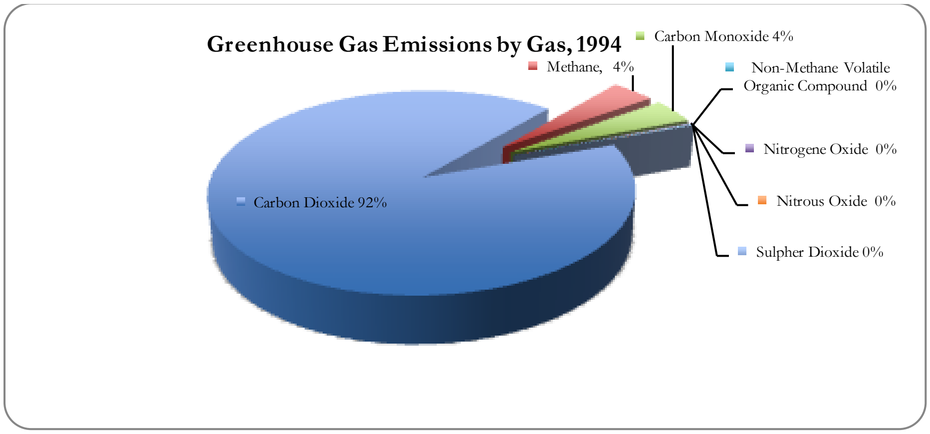


Figure 15 Graphical illustration of 1997 GHG emissions

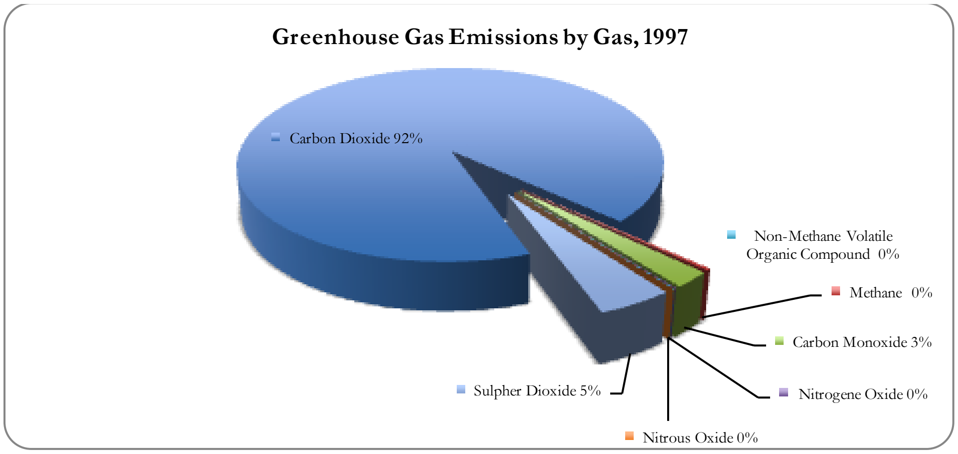
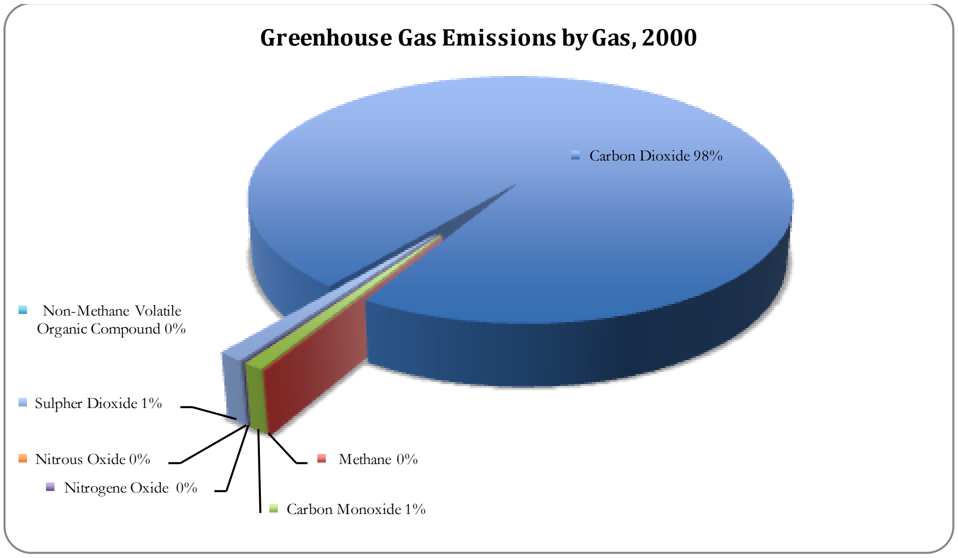


Figure 16 Graphical illustration of 2000 GHG emisssions



2.16 DESCRIPTION AND INTERPRETATION OF EMISSIONS BY CATEGORY

The table below enables a comparison of the GHG emissions across the sector according to the reference years of the inventories.

Table 10 Summary of Emissions by Sources

Total Estimates GHG Emissions by Sector (Gg) for Reference years: 1994, 1997 & 2000						
Sector	**1994 r**	**% of Total**	**1997**	**% of Total**	**2000**	**% of Total**
Energy	617.5280	21.846	1,026.7511	12.600	1,127.2995	8.361
Industrial Processes & Solvents	1.7350	0.061	1.8001	0.022	2.1972	0.016
Agriculture	46.414 6	1.642	1.5846	0.019	2.0825	0.016
Land-Use Change & Forestry	2,056.3650	72.747	7,117.1762	87.340	12,349.2819	91.593
Waste	104.7000	3.704	1.5141	0.019	1.9158	0.014
Total	**2,826.7426**	100	**8,148.8261**	100	**13,482.7769**	100

Figure 17 1994 Emissions by Sector

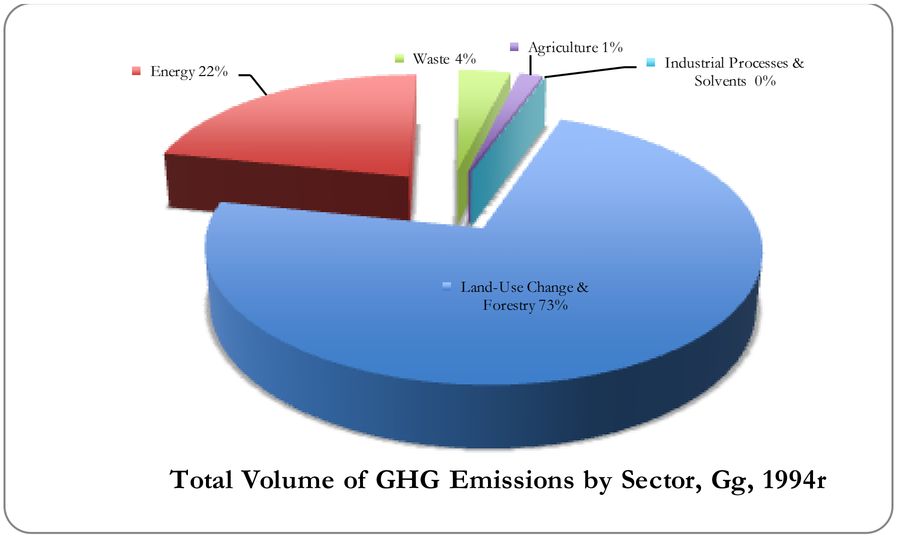


Figure 18 1997 Emissions by Sector

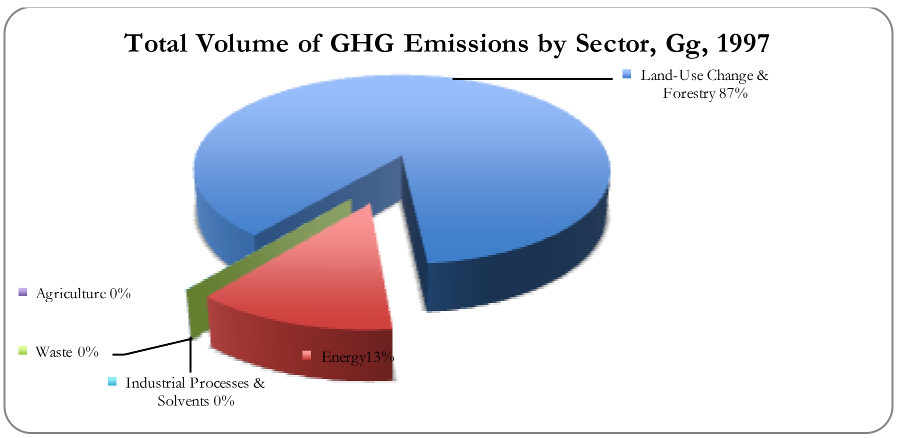
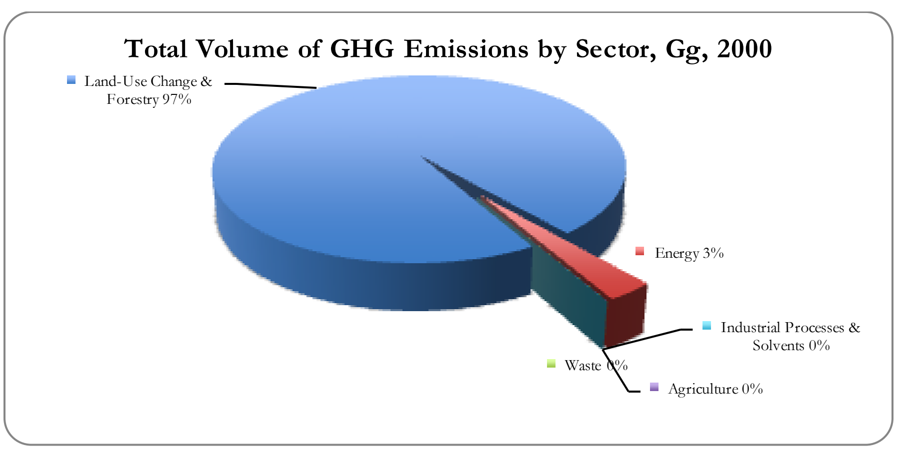


Figure 19 2000 Emissions by Sector



2.17 Description and Interpretation of Emission Trends for Indirect Greenhouse Gases

Nitrous oxides emissions were released from soils during the processes of preparing areas for cultivation. The trend should continue to increase as land is used more intensively, and agricultural expansion continues. Plowing and tilling disturb soils, but application of fertilizers and other chemicals also contribute to the release of the nitrogen oxides.

Figure 20 Trend in indirect GHG emissions - NOx

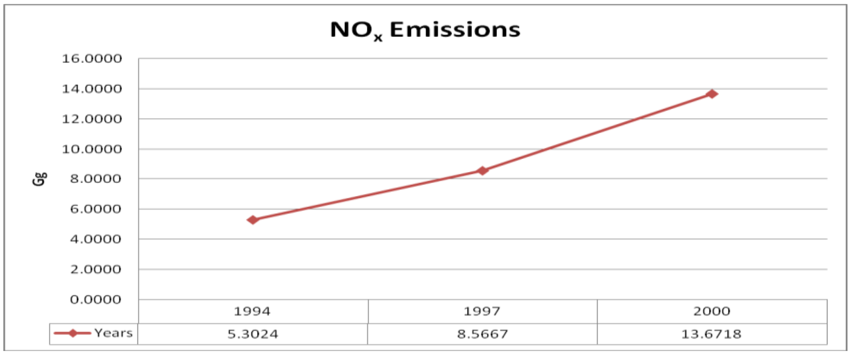


Figure 21 Trends in Indirect GHG Emissions – CO & SO_2

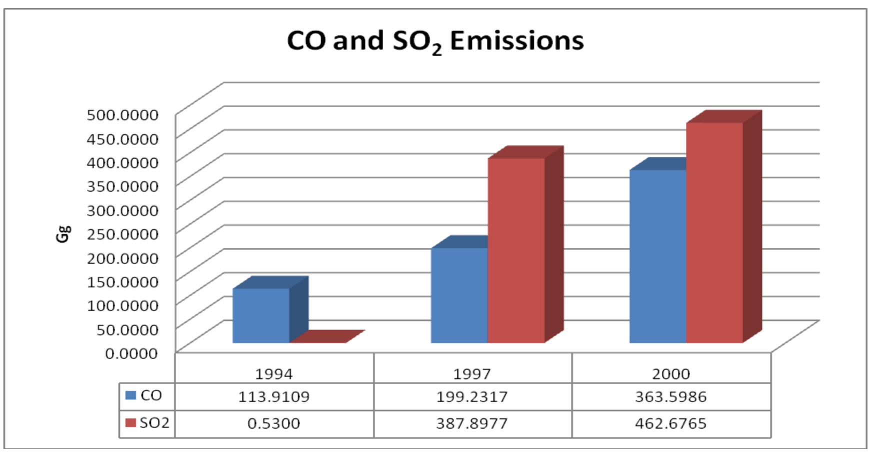
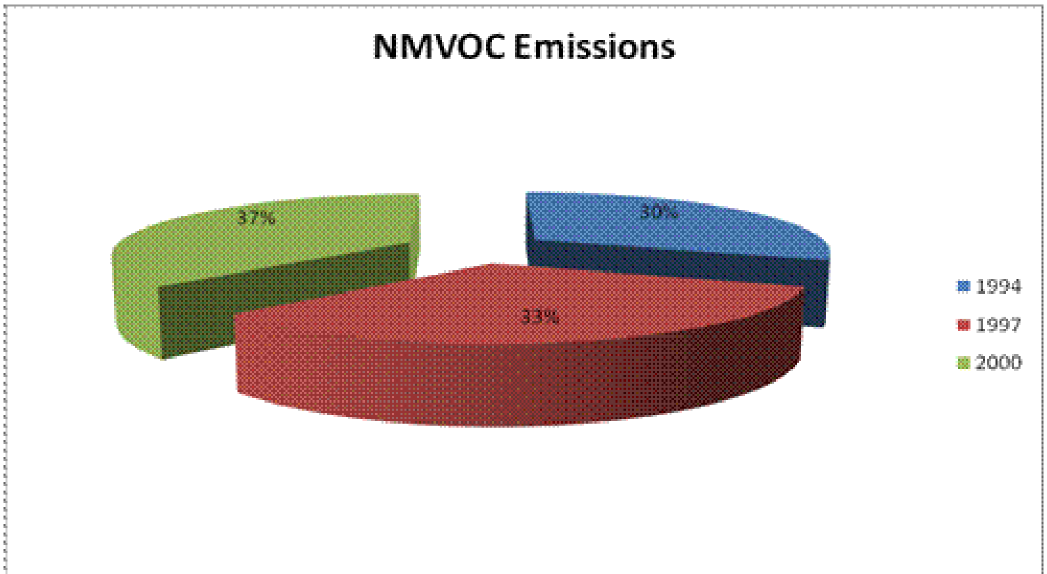


Figure 21 above depicts the trends in emissions of *carbon monoxide* and *sulphur dioxide*. Carbon monoxide displayed a steady increase in volumes from sectors/sub-sectors such as forests and grassland conversion sub-sector of LULUCF, as well as savannah burning and burning agricultural residue in the Agriculture Sector. Sulphur oxide emissions increased rapidly between 1994 and 1997 then the rate of increase declined somewhat between 1997 and 2000, these from the Energy Sector.

NMVOC emissions were derived from activities primarily within the Industrial Processes and Solvents sector, although a small amount emerged from the biomass sub-sector under the Energy sector. Road paving with asphalt accounted for the highest proportion of this gas, with alcoholic beverage, processed meat, bread and other food production, animal feed and sugar production all resulting in an almost constant level of emissions across the three study periods.

Figure 22 NMVOC Emissions



CHAPTER 3 SECOND NATIONAL PROGRAMMES FOR VULNERABILITY ASSESSMENTS AND ADAPTATION MEASURES FOR CLIMATE CHANGE

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"

3.1 INTRODUCTION

The first assessment of Belize's vulnerability to climate change was a study conducted to determine the vulnerability of the coastline to sea-level rise done by the Belize Centre for Environmental Studies (BCES) in 1994. This area had been prioritized because of its low-lying state, the concentrations of populations in this zone, the level of infrastructural development, and the range of economic activities occurring there. Preliminary vulnerability assessments were also conducted in the agriculture sector and reported in the INC.

For the preparation of the Second National Communication, it was decided that vulnerability assessments would be conducted in different but very relevant and important sectors in the Belizean development. These included:-

Vulnerability and Adaptation Assessments in the Agriculture Sector

Belize's economic growth and food security is highly dependent on Agricultural activity. There is moderate diversification of crops, and both food security and economic growth are at risk from the impending impacts of climate change. The initial assessment of this sector focused on the staple crops grown in Belize, rice, beans and corn. The Second National Communication study expanded the range of crops, but concentrated on two of the major trade commodities, sugar cane and citrus.

Vulnerability and Adaptation Assessment of the Coastal Zone

An initial vulnerability assessment was conducted on the coastal zone of mainland Belize using the IPCC's Aerial Videotape Assisted Vulnerability Analysis (AVVA) methodology to determine those areas of the coast most likely to be affected by sea level rise. The process conducted for the SNC was a more comprehensive assessment taking into consideration the social, economic, and environmental impacts resulting from sea-level rise and other phenomena related to climate change.

Vulnerability and Adaptation Assessment of the Fisheries and Aquaculture Industries

This sector of agriculture is very important for food security and revenue generation. A significant proportion of the population is employed in this industry. The assessment focused on both capture fisheries and the aquaculture industry.

Vulnerability and Adaptation Assessment of the Health Sector

The risks to human life and well-being resulting from climate change were identified as another area of study. In collaboration with the Ministry of Health, this initial study focused on Dengue and Dengue Haemorrhagic Fever and the conditions that would favour outbreaks or increases in incidents.

Vulnerability and Adaptation Assessment of the Tourism Sector

The Tourism industry has become the largest revenue generator for Belize, directly and indirectly involving the greatest proportion of the labour force, and affecting all other sectors.

Vulnerability and Adaptation Assessment of Water Resources

The vulnerability of coastal water resources to changes in the hydrological cycle and rising sea levels was conducted under the MACC Project with the intent of reporting in the SNC. The drought experienced in 2007/2008 revealed instances where the coastal wells was showing signs of salt water intrusion. The national measurements also indicated an advancing of the salt water wedge up certain river systems, reaching the point of extraction for Belize's largest urban area. Sites representing coastal aquifers and inland catchment areas were evaluated using scenarios selected to determine the potential future of the surface and subsurface water characteristics. The study was supervised by the National Pro-Tem Water Commission and the Hydrological Section of the National Meteorological Service.

3.2 PREDICTION SCENARIOS SELECTED FOR BELIZE

Guided by the IPCC's definition of "Scenario - A plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships. Scenarios may be derived from projections, but are often based on additional information from other sources, sometimes combined with a 'narrative storyline', the Belize Focal Point for Climate Change; the NMS has selected the A2 Scenario.

Belize promotes the preservation of its 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 is moving primarily towards the regional common markets, such as the Caribbean Common Market (CARICOM) and Central American Common Market (CACM); however, regionally per capita growth is fragmented and technological changes are slow.

Belize will have to become more reliant on its resources and place 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. 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.

Under this scenario 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.

Results from the three members of the A2 ensemble are generally consistent. Differences are most pronounced during the 2020s where multi-decadal variability predominates over the climate change signal. As a result, all A2 ensemble members are discussed collectively. The responses of the major crops and cultivars to climate change in an A2 future world follow that of the A1FI world up until the 2080s. The 2020s are dominated by multi-decadal variability and 2050s are comparable to those of A1FI—both experience similar absolute changes in temperature and precipitation (See Box 1). The 2080s under the A2 world, however, are significantly different, at least in the northern hemisphere where temperatures are on average 2 C cooler in an A2 world than an A1FI world. The result is that aggregated cereal yields are, assuming no CO_2 effects, depressed by no more than 10% anywhere in the world. Re-running the models to include the positive effect of elevated CO_2 levels again reduces the negative impacts across all regions; however, beneficial effects are particularly evident in the mid- and high-latitude areas where temperate cereals tend to be grown.

Box 1 Projected Climate Change Effects in the Caribbean for 2050 (IPCC)

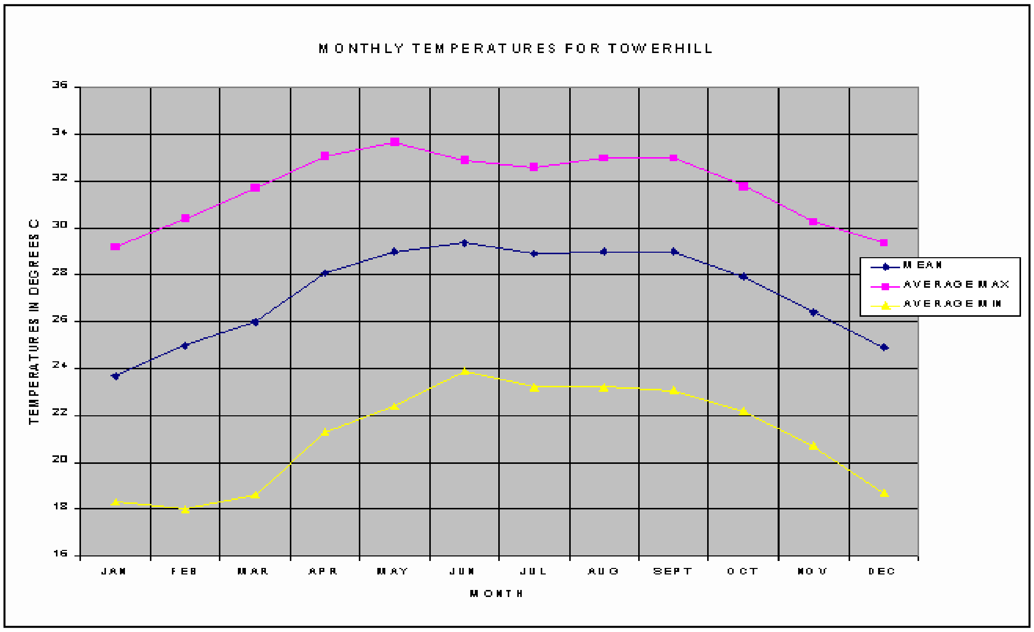
- ✓ A 1.5 - 2 °C increase in temperature;
- ✓ Subsequent increase in evaporation losses;
- ✓ Decreased precipitation – continuation of a trend of rainfall decline observed in some parts of the region;
- ✓ Projections by 2050 for the length of the rainy season – down by 7-8%;
- ✓ Projections by 2050 for the length of the dry season – up by 6-8%;
- ✓ Increased frequency of intense rains – up an average of 3% and projected to increase to 20% by 2050;
- ✓ Increased erosion and contamination of coastal areas;
- ✓ Sea Level Rise – median projection 40 cm by 2080 – causing increased
- ✓ salt water intrusion, augmented by storm surges; Strongest hurricanes more intense, increasing disaster losses;
- ✓ General increase in extreme events – droughts, floods; and
- ✓ Increased intensity of heavy rain events – rapid run-off/flash floods, causing soil

Erosion, run-off of contaminants, and adverse effects on coastal waters.

3.2.1 CLIMATE BASELINE

Mean monthly values for rainfall (Tower Hill, 1966-2006), temperature and maximum and minimum temperatures, corresponding to 1991 – 2008, were obtained from the Belize Sugar Industries Meteorological Station and the NMS. Mean monthly values for global solar radiation, vapour pressure, wind speed and number of rainy days were obtained from the Food Agricultural Organization (FAO) published data for Belize's meteorological stations (FAO, 1985). For the Melinda Met Station all data was obtained from the NMS.

Figure 23 Monthly Rainfall and Temperature Recorded at Towerhill, OW.



Specific climate change scenarios for 2028, 2050 and 2100 were derived from published transient experiments corresponding to General Ocean/atmospheric circulation models CSIRO and HADCM2 and were provided by Belize's NMS and PRECIS outputs provided by the Cuban specialists: the Simple Climate Model (SCM)/General Circulation Model (GCM) combination. Of these two, GCM with simple climate model MAGICC was -run using the greenhouse gases emission scenario IS92e with 2.5° C climate sensitivity. These climate change scenarios were available for temperature, precipitation, sea level and atmospheric CO2 concentration only.

Annual mean increments for temperature, precipitation and sea level with respect to actual values, as well as carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) atmospheric concentrations are shown in the following table for both climate models and for the IS92e greenhouse gases emissions scenario. Sea level rise is calculated here using MAGICC but other models like HADCM2 could give higher values than these.

3.3 THE AGRICULTURE SECTOR

Agriculture remains one of the major pillars of the Belize economy and is the foundation of the productive sector and rural areas. Almost 35% of GDP ($338 million at constant prices) and 41% of total employment is directly dependent on agriculture, fisheries & forestry. Ninety percent of all manufacturing (which constitutes 17% of GDP and 12% of employment) is based on inputs (sugar, citrus concentrate, animal feed, agriculture chemical, furniture, jams, jellies, chips, juices, milk, ice cream, sausages, packaging etc) from the primary sectors of agriculture, fisheries and forestry.

It is estimated that Belize has a farming population of approximately 12,000 farmers, operating a total land area of 265,000 acres (5% of the total land area), of which 146,000 acres are for crops and 119,000 acres are under pasture. Small farmers (those with less than 20 acres under cultivation) account for more than 75% of all farmers.

3.3.1 VULNERABILITY AND ADAPTATION ASSESSMENT

Crop Selection

The first vulnerability assessment of the agriculture sector studied the impact of climate change on maize, dry beans (as a substitute for R.K. beans), and rice. The results from the crop simulations suggested a general reduction in yields resulting from a shortened growing period because of warmer conditions under a doubling of carbon dioxide concentration. The effects of rainfall variability under the climate change scenario was minimal for maize, but resulted in lower yields for bean and rice for a 20% decrease in precipitation.

The choice of crops studied for the SNC was based on the availability of data. Two cash crops and one important small farmer crop were considered in this vulnerability assessment, these being sugarcane, grown in the north (Corozal and Orange Walk Districts) and papayas, grown in the northern districts of Corozal and Orange Walk and to a lesser extent in the Cayo District in western Belize. Cacao was also considered as this is a small farmer crop grown in southern Belize (Toledo and Stann Creek).

Methodology

The exercise evaluated, under various climate change scenarios, the expected climate change impacts in the agricultural sector as it pertains to changes in yields for ***Sugarcane and Citrus***. The DSSAT 4 and the CROPWAT crop modeling software were used to simulate yields for different results scenarios generated by the Hadley Center Regional Climate Model, PRECIS.

Other assessment activities also included

a) Projections of the economic consequences and implications of climate change on the sub-sector;
b) Presentation of results to main stakeholders via consultation workshops; and
c) Building capacity among key stakeholders in the use of DSSAT software.

The SNC project funded the participation of two consultants in the National Climate Change Support Programme (NCSP) two-week course held in Georgetown, Guyana which provided training in the use and application of models used in agriculture sector vulnerability assessments.

Vulnerability of the Sugarcane Sub-sector

The sugar industry is concentrated in the two northern districts close to the Mexican border and is the largest agricultural industry in the country, a high contributor to GDP, to export earnings, and employment. The area under cultivation represents approximately 30% of the total agricultural area, with farm size averaging about three hectares.

Land use in the sugar belt can be classified into four main groups with about 68,518 acres under sugar cane cultivation, 3,046 acres in other crops, 2,329 acres are used for livestock production and 30,885 acres are not cultivated (Santos and Garcia, 2008).

Conclusions Derived from the Simulations

The simulation model results used for this assessment were those obtained from the application of the Decision Support System for Agrotechnology Transfer (DSSAT) v4 model for sugarcane (CANEGRO). The calibration of the crop models could not be based on field experiments but rather conducted through simulations with the cultivars most used in the country (3 cultivars) and at different planting dates. The production years used were 1990, 1992 and 2002.

Validation was performed by comparing model outputs with historical data gathered for production yields over at least 10 years.

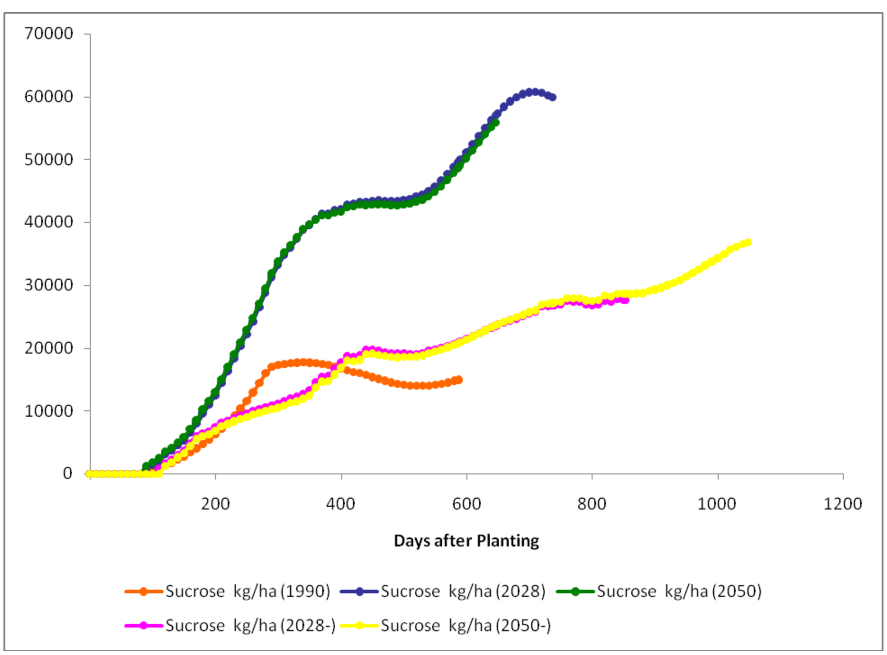
Sugarcane **-** Future climate scenarios of 1° and 2.5° Celsius warmer accompanied by a ±12% for the year 2028 and ±20% for the year 2050 change in precipitation were selected. The crop simulation models (DSSAT4) and CROPWAT were used to simulate the yields of sugarcane using the average and baseline climate data for control. The CROPWAT model projected 11.9% reduction in yield for sugarcane for 2028 with 12mm less rainfall and 17.4% reduction for 2050 with 20mm less rainfall. Using the 2028 scenario with an additional 12mm rainfall yields still fell by 4.5%. The temperature rise shortened the growing period of the crops, which lowered their yields. Changes in precipitation did not affect the growing season. However, it did affect the yield, especially when there were periods of low or high rainfall.

The DSSAT model on the other hand projected a yield of 14923 kgs/ha for 1990 or the baseline year. For the year 2028 with higher temperatures and precipitation the predicted yields were 59,256kgs/ha, while for the lower temperatures and precipitation the predicted yields were 27,657kgs/ha. For the year 2050 with higher temperatures the predicted yields were 58,884 kgs/ha while for 2050 with lower temperatures and precipitation prediction was for 36,748kgs/ha. This model then suggests that yields will increase with increment of rainfall and corresponding rise in temperatures. The period for growing cane will be more favourable throughout the year. This contrasts with the CROPWAT results because of the sunshine hours used in the model as well as other parameters used in DSSAT that is not used in CROPWAT.

Sugarcane is a C_4 crop that tolerates a wide temperature range and does well in well drained calcareous soils. Yields are expected to increase with CO_2 and will not be reduced significantly if improved crop management and irrigation and drainage is implemented.

With respect to season length it can be concluded that the days for the sugar cane to become mature is shortened. It went from a little over 220 days for the base year to 338 days for 2028 and reduced to approximately 90 day for 2050 which indicated that temperature is the more influential factor that influences growth. See figure below.

Figure 24 DSSAT4 Projections for Sugarcane



Citrus **-** CROPWAT was used to simulate the yields of citrus using the average climate data from Melinda for control... The model using actual sunshine hours predicted that there is no change in yields in the different scenarios when compared to the projected yields which is an indication that citrus will not be impacted much. However, the model using 8 and 9 hours sunshine day, projected a 1.4% reduction in yield for citrus for the base year, which is probably due to a dry month and not enough precipitation. For 2028 with 12mm less rainfall the predicted reduction was 3.4% in yields and 5% reduction for 2050 with 20mm less rainfall. Using the 2028 scenario with an additional 12mm rainfall yields remained the same. The temperature rise shortened the growing period of the crops, which lowered their yields. Changes in precipitation did not affect the growing season. However, it did affect the yield, especially when there were periods of low or high rainfall since no irrigation is used.

3.3.2 ECONOMIC IMPACT

Sugarcane production is an important activity in Belizean agriculture. Based on the actual sales and selling prices in 2005/2006, it is estimated that the Belizean Sugar industry contributed US$52.6 million to the country's foreign exchange earnings. Employment within the sugar industry is approximately 5,000 jobs, direct and indirect employment is estimated at 25,000 people and there are approximately 80,000 dependent on the sugar industry (MAF). Given these contributions, any factor affecting the industry has an impact on its contribution to the total GDP of agriculture and hence to the overall economy.

Using the DSSAT4 for the economic analysis indicated that using the base value of $40.00 per ton in 1990 and cost of production of $872 per acre with the simulated yields from the results indicate that the most efficient year would be 2028 with increased temperature and rainfall. The analysis also indicates that currently farmers are losing money with the current yields.

The direct impact, (US dollars) based on 2006 data, estimated using 10 %NPV, is summarized as follows:-

Sugarcane

a) Est. total yield reduction . …11.9 %

Est. total direct economic loss …. 11.9 x $52.6 x 1.1

US $ 6.89 mn (13% of total)

b) 2028 (+12mm precipitation)

Est. total yield reduction …. 4.5 %

Est. total direct economic loss …. 4.5 x $52.6 x 1.1

US $2.60 mn (4.94% of total)

c) 2050 (-20mm precipitation)

Est. total yield reduction …. 17.4 %

Est. total direct economic loss …. 17.4 x $52.6 x 1.1

US $10.067 mn (19.14 % of total)

In 2006 the value of citrus production was US $54.5 million. It had become the number one export commodity in recent years. The industry employs approximately 30,000 persons and there are additionally 70,000 persons who are dependent on the citrus industry.

For this industry the direct impact, (US dollars) based on 2002 data, estimated using 10% NPV can be summarized as follows:

Citrus

a) 2028 (-12mm precipitation):

Est. total yield reduction	…. 1.4 %
Est. total direct economic loss	…. 1.4 x $54.5 x 1.1
	US $0.839 mn (1.54 % of total)

b) 2028 (+12mm precipitation)

Est. total yield reduction	…. 3.4 %
Est. total direct economic loss	…. 3.4 x $54.5 x 1.1
	US $2.038 mn (3.74 % of total)

c) 2050 (-20 mm precipitation)

Est. total yield reduction	…. 5 %
Est. total direct economic loss	…. 5 x $54.5 x 1.1
	US $2.998 mn (5.71 % of total)

Like other agricultural sub-sectors, sugarcane and citrus production are expected to be influenced by climate change. Response options to mitigate the potential impact of climate change are similar for both crops.

3.3.3 RESPONSE OPTIONS AND CAPABILITIES

A most likely response with regard to crop production is the progressive adaptation of the cultivars to the new environmental conditions. This can occur as a natural or as a human-induced process, through either selection of varieties suited to new conditions or genetic improvement. To reduce the potentially negative effects of an increase in temperature during certain development and growth stages, varieties with modified cycles compared to the currently used cultivars would be required in the case of both crops. In the case of sugarcane, adaptation should be directed toward taking advantage of the potentially positive effect of an increase in temperature.

In response to an excess of soil water under an increased precipitation scenario in the case of sugarcane, better drainage will be needed as well as improved harvesting practices to maintain quality. In the case of citrus improved drainage infrastructure is needed. New cultivars with higher resistance to soil anaerobiosis would be appropriate. Resistance to diseases and pests, likely to become an increasing problem under scenarios with higher temperature and precipitation conditions relative to the baseline climate, should also be considered. The capability at the national level for testing new cultivars and conducting genetic improvement is reasonably inadequate.

Changes in management practices are also feasible as reactive measures to respond to climate change. This could include, for example, changes in planting dates to compensate for the crop cycle modifications induced by new weather pattern such as temperature conditions, rainfall distribution and intensity. Fertilization to compensate for N loss under excess soil water conditions, and irrigation under decreased precipitation will be necessary as part of the agronomic management.

Although the chances of timely adaptation to temperature changes are fairly good (which does not mean that there will be no negative impacts or costs involved), the response to precipitation changes is of greater concern. First, the uncertainties as to the direction and magnitude of the changes prevent appropriate planning. Second, the possibility of precipitation variability being augmented implies that current unfavourable conditions resulting from climate variability might be worsened. Third, adaptation to either positive or negative changes in precipitation (such as fertilization and irrigation, respectively) would be costly. A thorough cost-benefit analysis would therefore be required. Independent of their cost, responses to precipitation changes are considered to be technically possible.

Adoption of policy measures would be required (for example, credits or tax exemptions) to facilitate their implementation. Government-producer Associations partnerships with support from international organizations, such as those that assist in the development of irrigation capacities in the country, are appropriate mechanisms for facilitating the adaptation process. In addition, technological development applied to agricultural production, which is increasingly being paid attention to by national farmers, would improve crop yields and establish more favourable conditions for responding to environmental changes.

3.3.4 CONCLUSIONS

Belize is considered to be sensitive to long-term climate changes as a result of their potential effects on sectors of particular socioeconomic importance, such as agriculture and coastal development.

The effects of climate change on crop production would differ depending on the crop involved. While an increase in temperature might be detrimental particularly for certain crops, it could have a positive effect on some summer crops such as rice. With regard to precipitation, its increase could be detrimental to vegetable crops but favourable for rain fed perennial crops such as sugarcane and citrus. The effects of a decrease in precipitation would be opposite.

With appropriate response measures adopted in a timely manner, the overall sustainability of the sugar and citrus subsector and the overall agricultural sector would probably not be at a significant risk. The adoption of technical measures (such as genetic improvement and changes in management practices) would be feasible given the long-term experience of agricultural production in Belize. Implementation of policy measures and response strategies consistent with the new environmental and production conditions would be required.

In summary, there is need in Belize to develop appropriate technical capacities to respond to climate change in order to reduce the impacts on major economic activity sectors. However, considerable effort is still required to develop the relevant intra- and inter-sectoral plans and policies with the consensus of the government and the private sectors.

3.3.5 RECOMMENDATIONS

Some recommended adaptation measures to address the impacts of climate change on the sub-sector were also proposed in the assessment report. Some are listed below:-

- ✓ Altering inputs, varieties and species for increased resistance to heat shock and drought, flooding and salinization; altering fertilizer rates to maintain grain or fruit quality, altering amounts and timing of irrigation and other water management; altering the timing or location of cropping activities.
- ✓ Managing river basins for more efficient delivery of irrigation services and prevent water logging, erosion and nutrient leaching; making wider use of technologies to "harvest" water and conserve soil moisture; use and transport water more effectively.
- ✓ Making wider use of integrated pest and pathogen management, developing and using varieties and species resistant to pests and diseases; improving quarantine capabilities and monitoring programmes.
- ✓ Increasing use of climate forecasting to reduce production risk.
- ✓ Introducing forest conservation, agro-forestry and forest-based enterprises for diversification of rural incomes.

Climate change adaptation strategies should aim at maintaining, or even increasing, food production in key exporting developed and developing regions, or in regions key to regional food security. Any significant change in food production in these areas, including change resulting from climate change impact, has potential to affect global and regional availability, stability and access to food through direct and indirect repercussions on international and local markets.

The recommendations that are made above seek to optimize the available time, human and financial resources. Many of the structures required for adaptation to climate change are already in place, only requiring consistent implementation.

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3.4 COASTAL ZONE

3.4.1 METHODOLOGY

The vulnerability and adaptation assessments conducted as part of the preparation of the SNC all utilized the same approaches. Consultants conducted literature review, focus groups and public consultations, peer review, and validation sessions before final reports were accepted. That study for the Coastal Zone provided 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. The resulting report integrated the socioeconomic and biophysical aspects of vulnerability to climate change in the Belize Coastal Zone, and focused on (i) vulnerability by habitat and sector, (ii) evaluation of adaptation efforts and activities, and (iii) offered recommendations for improving adaptation and mitigation efforts.

Box 2 Definition of the Coastal Zone

> 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 sub tidal area within the 12 mile territorial limit and the 200 mile Exclusive Economic Zone (EEZ)".
>
> While the designated coastal zone is a rather extensive area, it was reduced, for the purposes of this study, 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.

The Belize Coastal Zone Management Authority and Institute (CZMAI) 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 of Belize plays an important role in its economy. 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.

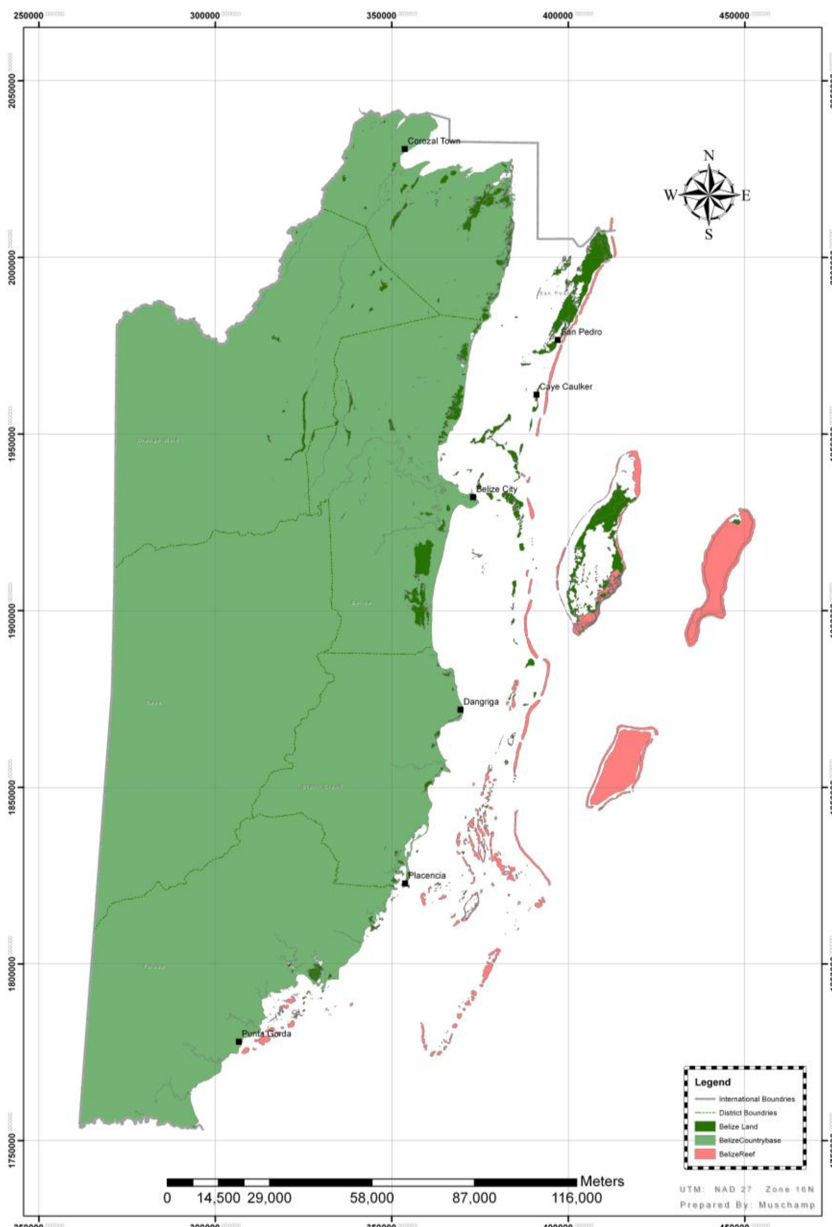
3.4.2 CORAL REEFS

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 most easterly Lighthouse Reef, Turneffe Atoll, and the most southerly Glover's Reef. 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. Figure 26 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, exacerbating the anthropogenic threats to the barrier reef system.

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 1m over the next 50 years are not expected to be sufficient to negatively impact even those species that occur at the limits of depth. This is a process that is generally reversible and is believed to 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. 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.

Figure 25 Map of Belize showing coral reef areas (pink)

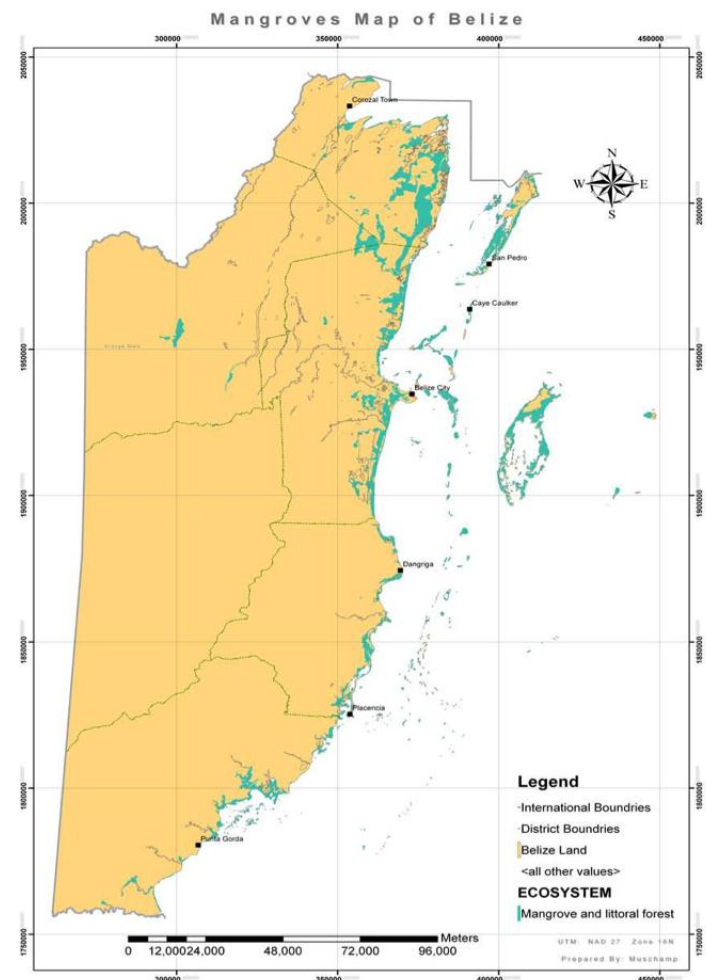


The report concluded that the reefs in Belize are good for most categories and would benefit from continued management. It has been theorized that the relatively high incidents of bleaching observed in Glovers Reef could be as a result of reduced water flow within the lagoon. This needs to be verified with additional monitoring.

3.4.3 MANGROVES

Mangrove refers 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.

Figure 26 Mangrove Distribution in Belize



The major threats to mangroves from climate change are changes in weather patterns and the increase in frequency and severity of climatic events. 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. It is widely held that healthy mangroves will be able to adapt to sea level rise by receding sequentially as the habitat changes to maintain its position in the ecosystem.

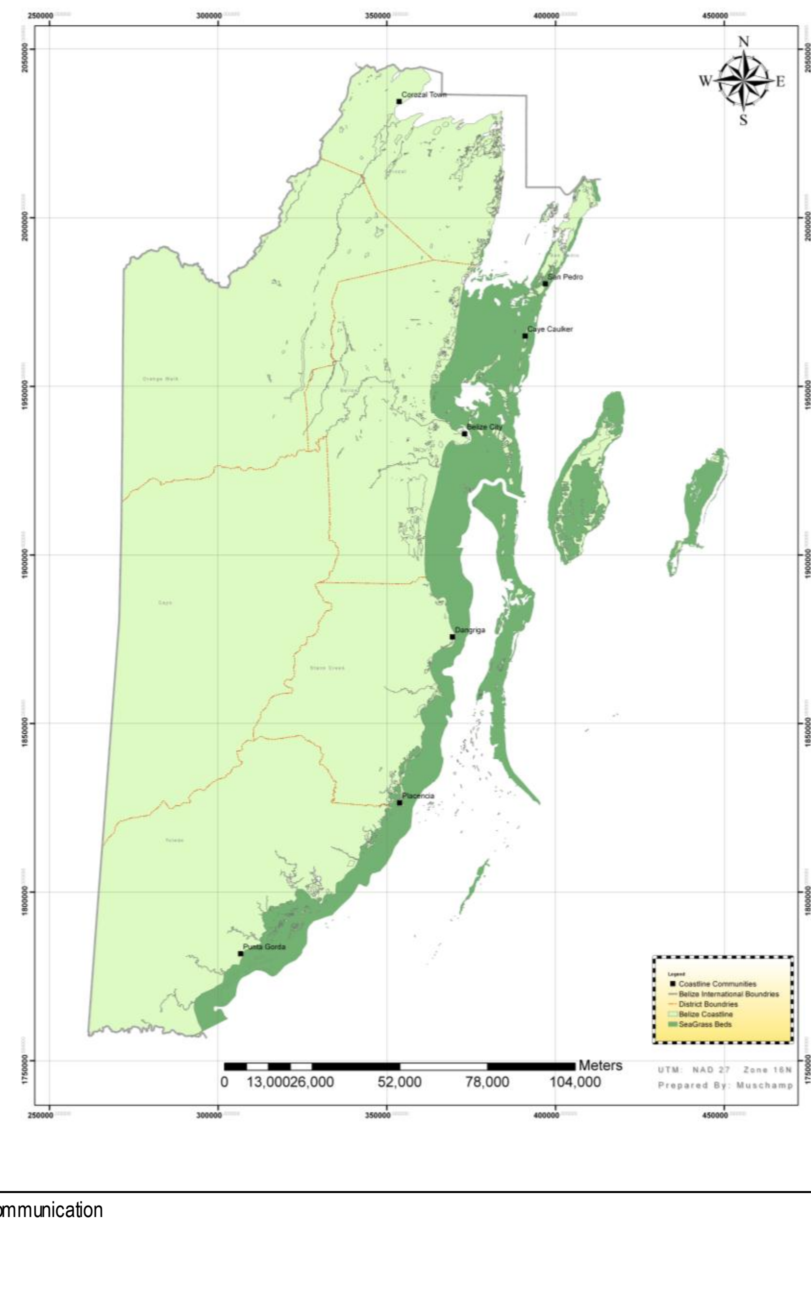
Major anthropogenic threats include mangrove clearance and loss of habitat. Large sections of the coast and cayes in Belize have been targeted for upscale residential and resort construction. The remaining mangroves are under additional threat, being impacted by any situation that causes the soil around the roots to go dry, losing the potential to function as carbon sinks for atmospheric carbon dioxide.

3.4.4 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*. Figure 27 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, which will reduce salinity and increase sedimentation, both of which will have a negative effect on sea grass beds.

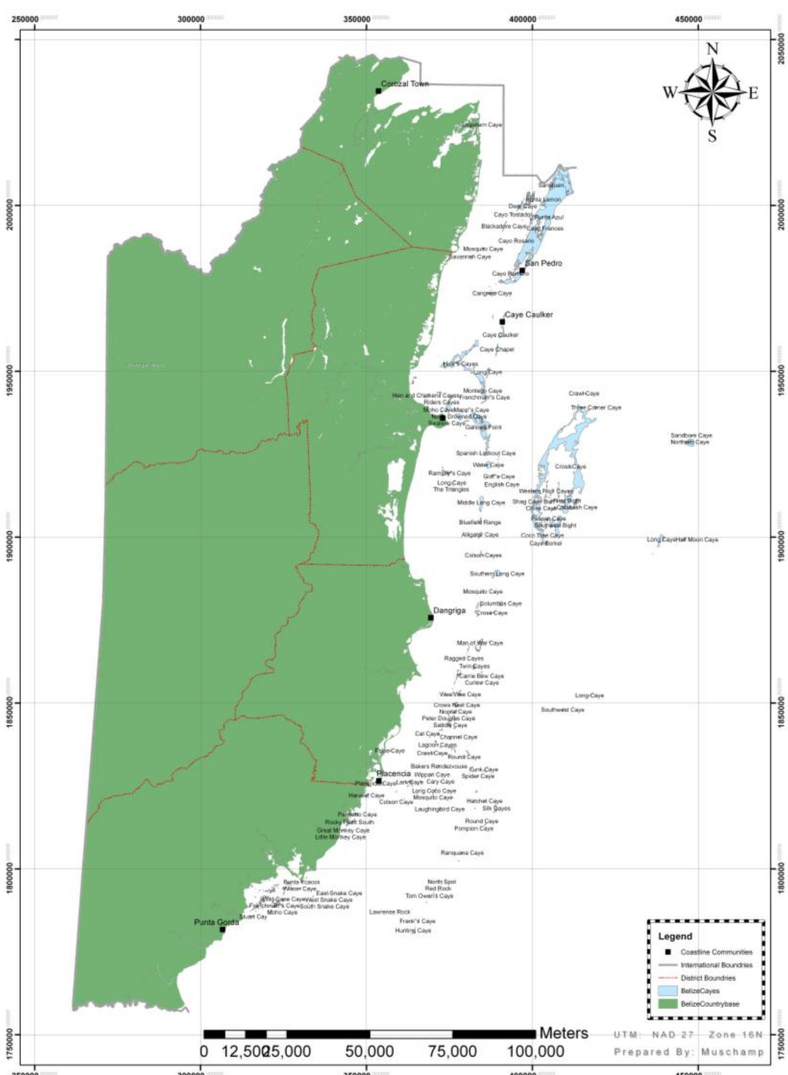
Figure 27 Map of Belize showing distribution of Sea grass beds (CZMAI data)



3.4.5 COASTAL AREAS AND CAYES

The country of Belize is estimated to have over 220 km of coastline. Most of the coast 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 26). From the Sibun going south, the coast rises gradually to a mean height of 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.

Figure 28 Cayes of Belize



There are some 1,062 mangrove and sand cayes within the barrier lagoon and the atolls. Most of the mangrove cayes are at or below mean sea level, while the remainder is 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 an increased sea level and damage from storm surges. Figure 28 shows the location of cayes in Belize.

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.

The coastal areas and cayes are important economically and socio-culturally. It is the preferred location for recreation, residence, and tourism. 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/tourism destinations in the country at the moment are San Pedro Town and Placencia Village. The Garifuna consider living near to the sea to be part of their cultural identity since many of their traditional beliefs and practices are connected to the sea. 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 southern beaches are well known as a nesting beach for Hawks-bill turtles, Least Terns, Sandpipers, Plovers and Laughing gulls. 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.

3.4.6 Socio-economic Threats

Socio-economically Belize relies heavily on resources and activities occurring in the coastal zone. Tourism, commercial, recreational and subsistence fishing, aquaculture and agriculture are the major economic activities in coastal and near shore areas. These activities can be quantified, but only recently has there been an 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.

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 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, and approximately 60% of income is derived directly from coastal and marine activities.

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. 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.

The primary threats to the Fishing industry are increased sea surface temperatures, changes in pH and loss of habitat.

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. 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, better suited for pond construction.

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. 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.

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.

3.4.7 COASTAL SETTLEMENT

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.

3.4.8 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 m^3 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, since increased sea levels could result in permanent saltwater intrusion and tidal effects extending further up the river basins.

3.4.9 INUNDATION

The assessment report of 1999 stated that approximately 60% of coastal areas were permanently inundated. 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.

3.4.10 ASSESSMENT OF CAPACITY OF THE COASTAL ZONE TO ADAPT TO CLIMATE CHANGE

The Government of Belize, as part of its macro development plan, has targeted the achievement of 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.

3.4.11 RESULTS OF ADAPTATION INITIATIVES

Belize's capacity to adapt to climate change was evaluated under the following headings: Governance, Economic, Social and Ecosystem.

Governance

Governance considers 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 considers the presence of the responsible agency/authority, its legal status, existing policies and/or strategies and the capacity of the persons involve. 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 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). Table 11 summarizes the current status of the agencies mentioned.

Several multi-agency bodies have been established to facilitate collaboration among 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 Advisory Committee. The purpose of the National Climate Change Committee is to provide support in the management of climate change in Belize. Its functions are described in its draft Terms of Reference. NEMO is another multi-agency body, with the Secretariat being responsible for coordination and implementation.

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 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 National Meteorological Service, as UNFCCC Focal Point, has developed a draft National Climate Change Adaptation Policy that has been subjected to national consultation before being offered to the Cabinet for adoption.

Table 11 Some Agencies that operate within the Belize Coastal Zone (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.	Fisheries Act	National Food & Agriculture Policy (2002-2020)	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.	Forest Act, National Parks Act, Wildlife Protection Act	The 1954 Forest Policy is still in use. A new Forest Policy is being developed.	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)	Belize Agriculture Health Authority is the arm of the Ministry that regulates the importation plants & animals

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 is in the process of developing a new set of regulations for offshore exploration and drilling.
Department of Environment	Monitoring of the state of the environment, development projects, and waste management	Environmental Protection Act, (Environmental Impact Assessment Regulations)	National Environmental Policy and Strategy, National Solid Waste Management Plan	Completed the inventory of POPs and is currently developing a country strategy for POPs.
National Meteorological Service	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)	Focal point for UNFCCC, and the Clean Development Mechanism.
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 SWMA is responsible and is currently implementing the Solid waste management project to improve the collection and disposal of solid waste.

There are other 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 a key factor 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. Most agencies indicated that they operate under significant finance and personnel constraints, which limited their ability to deliver basic services.

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. 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.

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 established a network 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.

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 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.

The table below summarizes the status of some of the recommendations made in the first Coastal Zone Vulnerability Assessment Report. Based 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.

Table 12 Status of some recommendations made in the first CZ Assessment report

Recommended Action	Status
Establish setbacks for undeveloped coastal areas	This is already in the legislation
Construct and improve seawalls	Work is being done by individuals on private property.
Relocate vulnerable coastal communities	There has been some voluntary migration inland away from Belize City
Monitor relative sea level rise and local wave climate	The Met Department established a series of Tide gauges as part of the CPACC project
Develop an education and public awareness campaign	Education and public awareness is done by individual agencies according to their particular programmes.
Develop a national water management system	Draft water policy and legislation have been developed
Obtain comprehensive knowledge of nation's water resources	Being done by the Hydrology Unit of the Met Department
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.
Adopt forest management plans	Sustainable forest management plans have been developed and adopted in the industry
Adopt agricultural practices based on availability of water	Included in the Ministry of Agriculture's policy for 2002 – 2020
Relocate agricultural activity away from the coastal zone	Not yet initiated
Make Integrated Coastal Zone Management an integral part of Belize's action plan for climate change	Not yet addressed
Reef and Mangrove Monitoring and Research	Currently being done
Establish a network of Marine Protected Areas	Already done
Improved land use and agricultural practices	Included in the Ministry of Agriculture's policy for 2002 – 2020
EIA requirements for coastal development	Already in place for large developments
Update and implement the national mangrove management plan	Underway
Initiate a programme for the planting of mangroves in critical areas	Initiated by NGOs
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.
Consider measures for reducing pressure on heavily exploited (fish) stocks	Currently being done by the Fisheries Department
Encourage the diversification into the exploitation of new stocks and expansion of the EEZ	Currently being done by the Fisheries Department
Improve the management of catch levels	Currently being done
Maintain and expand the mooring buoy system	Currently being done

3.4.12 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. 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. 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.

(i) Establish and Activate the National Climate Change Committee.

(ii) Revitalize and strengthen the Coastal Zone Management Authority
   a. Reintroduce a periodic forum to address the issues surrounding the state of the Coastal Zone.
   b. Conduct a series of country-wide Baseline Assessments within the major habitats.
   c. Develop an incentive programme that encourages the private sector to actively participate in adaptation to climate change.
   d. Revise and streamline the current legislations and policies that relate to the management of the coastal zone to eliminate overlaps and close existing gaps.
   e. Improve the coordination of interagency cooperation and exchange of information on matters related to climate change.
   f. Develop strategies to increase compliance particularly with regard to coastal development.
   g. Develop a Public Awareness and Education Strategy.
   h. Consolidate and Strengthen the MPA system.
   i. Expand and Streamline the Ecosystem Monitoring Programme.

3.4.13 REFERENCES

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3.5 Fisheries and Aquaculture

3.5.1 Introduction

The goal of the assessment was to evaluate, under various climate change scenarios, what impacts climate change may have on the Fisheries and Aquaculture industries of Belize.

The expressed objectives of the study were:-

- Determine the nature and level of vulnerability of the Fisheries and Aquaculture Industries to the threats posed by Climate Change.
- Increase the awareness of the impacts of Climate Change and enable stakeholders to participate in the formulation of projects designed either to mitigate the impacts or to build capacity to adapt to the changes.
- Allow for more effective national planning to deal with adaptation to climate change by enabling a wider range of stakeholders.

3.5.2 Species

Most of the fishing effort in Belize is focused on the capture of the Spiny Lobster (*Panulirus argus*) and the Queen Conch (*Strombus gigas*); these represent the largest fisheries within the industry.

The exported finfish species include groupers of the genera *Epinephelus* and *Mycteroperca*; snappers of the genera *Lutjanus* and *Ocyurus*; the hogfish (*Lachnolaimus maximus*); the king mackerel (*Scomberomorus cavalla*); the great barracuda (*Syhyraena barracuda*); and jacks of the genera *Alectis, Caranx* and *Trachinotus*. In 2006, finfish exports were valued at BZ$21.25 thousand. The Species harvested for local consumption include grunts (*Haemulidae*), snooks (*Centropomidae*), mullets (*Mugilidae*), porgies (*Sparidae*), triggerfish (*Balistidae*), and the tarpon (*Megalopidae*).

Various species of sharks, mainly of the *Carcharinidae* and *Rhincodontidae* families, are targeted. Catch commonly include the bull, blackfin, hammerhead, nurse, reef and lemon sharks.

A small-scale fishery for the stone crab (*Mineppe sp.*) and the blue crab (*Callinectes sapidus*) also exists, but the production obtained from this fishery has not been consistent, hence the activity has not been routinely monitored.

The shrimp fishery is conducted by both artisanal and industrialized trawl fishers over the last six decades. It is an important fishery in Belize. Marine shrimp tails landings peaked at 145 MT in the late 1980s (Carcamo, 2005) and has since dropped to approximately 21 MT in 2006. The fishery earned BZ$84.6 thousand in 2006 (Belize Fisheries Department, 2007). Pink shrimp (*Penaeus dourarum*) is the principal species captured, but *P. aztecus* and *P. schmitti* also appear occasionally in the nets.

Box 3 Capture Fisheries Industry Profile

Fishing in Belize was conducted profitably by the Buccaneers, the first fishermen of the colonial period (Craig,1966), when they, on St. George's Cay, conducted their business of smoking, drying, and salting turtle and manatee meat for sale to passing privateers, logwood cutters, and the occasional bona fide pirate. Today however, the product is not turtle or manatee but largely conch, lobster, fish or wild caught sea-shrimp which in 2006 collectively earned for the fishing industry, $BZ24 million dollars from the sale of products exported (Fisheries Department, 2007). The industry is an important contributor to the national economy, accounting for 3% of Gross Domestic Product (GDP) and, is a significant earner of foreign income.

The coastal waters of Belize have been supporting subsistence fishing for millennia as is evidenced at several Mayan archaeological sites and pre-historic effects of fishing documented by historians (Craig, 1966; Gordon 1981; Vail 1988; Jackson, 1997; Jackson et al., 2001). Fishing as a commercial activity, however, did not develop until the mid 19th century (Price, 1984). Then, between 1920 and 1960, the Belize fishing industry changed from a small scale domestic fishery, with periodic incursions into the Mexican market, to whole sale marketing of lobster (Panulirus argus), conch (Strombus gigas) and fin-fish to the more lucrative U.S. and Caribbean markets.

Habitat Description

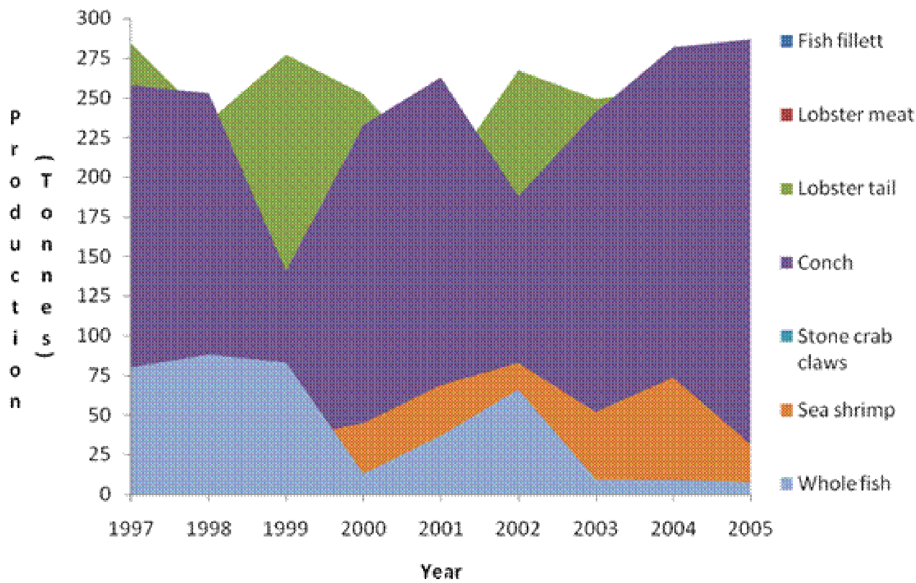
The Belize coast harbours complex ecosystems that include mangrove forests, river deltas, estuaries, sea grass beds and coastal lagoons which support many important species including crocodiles, manatees, turtles and seabirds

Marine habitat **-**The shelf area of Belize is dominated by the Belize Barrier Reef Complex, (220 km in length), three offshore atolls- (Lighthouse Reef, the Turneffe Islands and Glovers Reef), patch reefs, seagrass beds, several hundred cayes of sand and mangrove, extensive mangrove forests, and coastal lagoons and estuaries. In addition to the 220 km long barrier reef that runs almost parallel to the coast, 288 km of reef surround the outer atolls. The shallow lagoon between the mainland coast and barrier reef and inside the coral atolls provide ideal habitats for the development of often extensive seagrass beds which provide breeding or feeding areas for numerous commercially valuable species including lobster, queen conch, shrimp, demersal and inshore pelagics.

Production Volumes, Values and Trends

Historically, Belize's fisheries have been dominated by lobster and conch, with shrimp becoming important in the late 1980s to mid 1990s. Indications are that lobster, conch and shrimp may be at or beyond their Maximum Sustainable Yield (MSY) (Rankin, Seepersad & Singh 2004). Overall, reported landings peaked just below 2 t in the early 1970 (driven by conch) and again in the early 1990's (driven by shrimp), and, with the exception of a brief peak in shrimp production in the early 1990's production has shown an overall decline since the mid 1980s. Production trends, from 1995 to 2005, for the major fisheries (lobster, conch, fin fish and marine shrimp), are shown in Fig 29 below.

Figure 29 Reported Fisheries production in Belize based on Fisheries Department Statistics



Fisheries export statistics, for the year 2006, reflected earnings valued at BZ $23.36 million with Lobster contributing BZ $14.7 million, Conch BZ $6.7 million and Marine wild-caught Shrimp BZ $.085 million (Belize Fisheries Department, 2007). The Fisheries Sub-sector contributed 3% to Belize's Gross Domestic Product (GDP) in 2006 (Central Statistical Institute of Belize, 2007). Trends in income earned from exports of shrimp, fin-fish and lobster are presented in Annex II of this document.

3.5.3 Fresh Water Inland Fisheries Sub-sector

Fresh water habitat and fisheries species

The freshwater capture fishery is the least documented in Belize. The lotic and lenthic water bodies of Belize consist of 16 major watersheds which drain eastward to the Caribbean Sea and 15 well defined smaller catchments which drain portions of the coastal plain.

One hundred and eighteen (118) species of freshwater fishes have been documented in Belize. One hundred and twelve (112) of these species occur in northern Belize. These include open water or pelagic systems, attached substrate such as roots and trunks, as well as classical benthic habitats such as the river bottom or lagoon floor.

In Belize there are six (6) primary freshwater fin-fish species. These includes the Blue Catfish or "Baca" (*Ictalurus furcatus*), the Characins which includes the Billums (*Astyanax aeneus* and *Hyphessobrycon compressus*), and the South American Catfishes which includes the Gafftopsail Catfish or "Old Guy" (*Bagre marinus*) and the "Catto" (*Cathorops sp.*). This relates to species which live mainly in freshwater, but which have some tolerance to saline conditions, and which have some distant relatives in the sea. This group of fish includes "Cichlids" such as the "Mus-Mus" or Yellow Jacket Cichlid (*Cichlasoma friedrichsthali*), the "Tuba" or Yellowbelly Cichlid (*Cichlasoma salvini*), the "Crana" or Mayan Cichlid (*Cichlasoma urophthalmus*), the "Bay Snook" or "Bocona" (*Petenia splendida*) and the recently introduced Tilapia (*Tilapia mossambicus*). The other secondary freshwater species occurring in northern Belize include the Sword Tails (*Xiphophorus spp.*) and Mollies (*Poecilia spp.*), as well as the Obscure Swamp Eel (*Ophisternon aenigmaticum*) and the Ocellated Killifish (*Floridichthys polyommus*).

3.5.4 Socio-Economic Importance of Fisheries

The fishing industry of Belize provides direct employment for 2,131 licensed fishermen (2006). More than 76% of the license fishers are member of the five main fishermen cooperatives and in excess of 50% of these fishermen are between the ages of 15 and 35 years with most of them originating from impoverished rural and coastal communities. Also, the fishermen cooperatives employ 123 fulltime employees who are responsible for processing, packaging and administrating the daily activities.

Table 13 Cooperatives Total assets and producing and non-producing members – 2007
Source: Fisheries Department

Fishermen Cooperative	Location	Assets (US$)	Producing Members	Non-Producing Members	Total Members
Northern	Belize City	10.1M	474	399	873
National	Belize City	5.5M	331	179	510
Caribeña	San Pedro	0.29M	15	121	136
Placencia	Placencia Village	0.35M	34	32	66
Rio Grande	Punta Gorda	NA	12	30	42

3.5.5 Aquaculture Industry Profile

The aquaculture industry formally began in the early 1980's with the development of ten acres of experimental ponds in Southern Belize by a private concern, General Shrimp Limited. The commercial success of this endeavor led to the rapid expansion of the Aquaculture Sub-sector.

Although the culturing of other penaeid shrimp species such as the Caribbean White Shrimp (*Penaeus schmitti*) and the Pacific Blue Shrimp (*Penaeus stylirostris*) have been attempted in the past, the main focus of the industry has been and continues to be the Pacific White Shrimp (P*enaeus vanammei*).

The Aquaculture Sub-sector is now firmly established as a significant contributor to the Belizean economy. While there have been fluctuations in foreign exchange earnings generated by the aquaculture industry over the years this sub-sector and the entire Fisheries Sector continues to be a significant factor in Belize's GDP.

3.5.6 Impacts of Climate Change on Fisheries and Aquaculture

Impact of Climate Change on Capture Fisheries

There is still an incomplete understanding of the link between climate change and fisheries. Indications are that global average surface temperature has increased by at least 0.6^{0}C during the last 100 years and, this trend is expected to continue through the 21st Century. This means that fishery systems, fisherfolk and other economic and food systems are vulnerable to climate variability. Stock production, and to a lesser extent, catchability are known to be closely tied to climatological factors. Despite the resilience of many species of fishery resources, their ability to overcome changes in weather patterns, including increased frequency and severity of extreme events, such as hurricanes, are uncertain.

Aquaculture in Belize has been almost exclusively based on the farming of penaeid shrimps; the culturing of other species has been attempted in the past. These include the husbandry of: the Nile Tilapia (*Oreochromis niloticus*), the freshwater Australian Red Claw Lobster (*Cherax quadricarinatus*), the Redfish (*Sciaenops ocellatus*), and a number of African Rift Lake ornamental finfish species such as *Haplochromis sp.*, *Labeochromis sp.*, *Melanochromis sp.*, *Tropheus sp.*, *Psuedotropheus sp.* and *Aulenocara sp.* The culturing of these species has also met with commercial failure, except for the Tilapia, of which one large-scale commercial farm is in operation: This farm, registered as Fresh Catch Belize Limited, has been established since 2002. In 2004, the first exports of fresh frozen tilapia fillets were made from this farm to the US.

Box 4 Culture Species

Impact of Climate Change on Fisheries Habitat

Coral reefs, seagrass beds, mangroves, and littoral forest are all vulnerable to the impacts resulting from severe weather events, including sea level rise and increases in temperature.

*Coral Reefs***:** Coral reefs provide the habitat for a wide variety of reef fishes that are exploited. In Belize the barrier reef system is the focal point for the spiny lobster, conch and fin-fish fisheries. Over the past two-three decades, there has been widespread deterioration of coral reef worldwide. Much of the deterioration has been attributed to exploitation, pollution, disease, coastal development and more lately coral or thermal bleaching.

Seagrass Beds: Increase in sea temperatures may affect Seagrass beds. Seagrass beds are important nursery areas for many reef species, including the commercially important Spiny Lobster (*Panulirus argus*) and the Queen Conch (*Strombus gigas*). Seagrass beds are also important to fish.

Mangroves: Mangroves are an important habitat for many species. They provide spawning areas for several species of reef fishes, and nursery habitats for reef fishes and lobsters. Adults of several fish species are also harvested in mangrove lagoons (e.g. tarpon, snook, yellowtail snapper, and mullet).

Sea-level rise: Fish production would suffer if coastal wetlands and other habitats that serve as nurseries were lost as a consequence of sea-level rise. Mangrove communities would also starve from poor sediment distribution. Sea-level rise would exacerbate the processes of coastal erosion and salinization of aquifers, increase flooding risks and the impacts of severe storms along the coastline.

Lower Water Availability and Conflicts with Other Water Resource Users: The predicted contraction in water availability for aquaculture as a result of climate change and climate variability is not expected to have any impact on shrimp farming [See Table 13]. The orientation and magnitude of this impact has thus been characterized as '0' or 'no discernible impact' [See Table 14]. The impact on Tilapia farming has also been characterized as 'no discernible impact' [See Table 14]. Water availability and the conflicts that may arise are pertinent to Tilapia farming and in general inland aquaculture. However given that water availability is not seen as a limiting factor for Tilapia farming currently or in the near-, to medium-term future, and given the fact that there is no known competition with other resource users and the conflicts that may arise as a consequence of this, the impact is expected to be virtually non-existent [See Table 13]. The prospect of limited water availability as a function of climate change and climate variability is not pertinent to sea-based Cobia Cage Culture [See Table 13].

Table 14 Relationship between various Climate Change effects and their impacts on aquaculture in Belize

Primary Driver	**Generic Biophysical Effects**	**Implications for Aquaculture**		
		Shrimp Farming	**Tilapia Farming**	**Cobia Farming**
Changes in Sea Surface Temperature	More frequent Harmful Algal Blooms (HABs) and decrease in dissolved oxygen (DO) levels…	Not expected to have any significant impacts on existent land-based shrimp farming operations…	Not likely to have any effects on Tilapia farming operations given that these enterprises are geographically removed from the coast.	Given the current rarity which is not expected to change radically with Climate Change and Climate Variability for Belize, this should not be a major threat to the Cobia Cage Culture operation.
	Enhanced metabolic and growth rates.	Increased temperatures should thus bode well for shrimp farming assuming the other performance variables are maintained in their status quo position.	Increased sea surface temperature (SST) should have no direct impact on Tilapia farming given the geographical remoteness of these operations to the coast.	Increased SST should bode well for the Cobia Cage Culture operation and other similar venture fin-fish farming ventures
	Changes in timing and success of migration, spawning and peak abundance.	Although this could potentially impact the availability of seedstocks, it is not anticipated that it will have any direct impact on shrimp farming since the husbandry production cycle is a 'closed one' with hatchery spawned and nurtured seedstocks for the on-growing or fattening process…The issue of sustaining genetic diversity or 'fitness' relies on the occasional sourcing of broodstocks and seedstock outside of Belize from approved and certified hatcheries…	This is not relevant to Tilapia farming given that the species is not marine in origin.	Potential for some impact on Cobia Cage Culture operation given that although they currently import seedstocks, they are currently in the process to develop a hatchery for in-country seedstock production…The effects on the timing of spawning as a result of SST increase not yet known…Public and private sector research needed to close uncertainty gap.
Rising Sea Level	Loss of land	The production infrastructure is not expected to be immediately affected by sea-level rise… There may be the need to relocate ancillary infrastructure, such as pump houses that are located on lower ground, to higher areas over time.	Currently predicted sea-level rise poses no immediate threat to the production infrastructure given the Tilapia farming operations relative to the coast.	The greatest threat of sea-level rise will be to the sea-based aspects of the Cobia farming operations.
	Saline wedge penetration further upstream as well as saltwater intrusion into groundwater stores.	The intake of higher saline waters with the predicted fall in precipitation and freshwater outflows combined with the landward advance of the sea may mean a shift to the culturing of more oceanic shrimp species such as the Pacific Blue Shrimp *Penaeus stylirostris* and the Pink Shrimp *Penaeus duorarum*…Has cost implications in terms of R & D efforts.	Advance of saline wedge upstream and in groundwater stores should have little or no effect in short-term…Over longer timeframes should negatively affect production performance of the species currently being farmed in Belize…Has negative implications for production costs…May also require shift to more salt-water tolerant species and hybrids…	Increased salinities with rising sea-levels may have positive implications in terms of providing greater quantum of geographic space on continental shelf for cage culture.

Primary Driver	Generic Biophysical Effects	Implications for Aquaculture		
		Shrimp Farming	Tilapia Farming	Cobia Farming
	Loss of coastal ecosystems such as mangroves with potential loss of seedstock availability for aquaculture and increased exposure to wave and storm surges.	No direct impact on husbandry aspects of shrimp farming if focus remains on exotic Penaeid species in foreseeable future… Also potential for nutrient-enrichment or eutrophic pollution with decrease and loss of mangroves.	No identifiable impact on current Tilapia farming operations that are all located inland away from the coast…	Has negative implications for current Cobia Cage Culture operation, as well as possible future operations utilizing similar sea-based engineering construction located in sheltered sites in the lee of mangrove cayes…
Higher inland water temperatures	Increased metabolic rates, feeding rates, primary productivity and growth rates if dissolved oxygen levels kept at optimum.	Not applicable to coastal shrimp farming…May become applicable if technology to farm Penaeid shrimp freshwater systems with requisite level of ionic hardness adopted.	Beneficial especially during cooler months and in higher elevations where water temperatures are higher than inland savannahs and higher coastal plain…	Not applicable.
	Increased potential for stratification in pond systems.	Not applicable to shrimp farming using current technology.	Has negative implications for oxygen profile and nitrogenous wastes and consequently survivorship, yields and cost of production	Not applicable.
	Reduced water quality, especially in terms of Dissolved Oxygen (DO) and increased susceptibility of stocks to pathogenic diseases and parasites.	Not applicable to coastal shrimp farming unless shrimp farming technology to farm marine shrimp in 'hard' freshwater embraced…No immediate indications that it will in foreseeable future.	Pond will be able to sustain less fish biomass per unit volume or area. Potentially negative impact on intensive fish farming. Have negative implications for growth rate and survivorship unless DO deficit is taken up by injection of artificially produced oxygen. Has negative implication for Tilapia farming in terms of increases in operational costs.	Not applicable.
	Changes in timing and success of migration, spawning and peak abundance including broodstock and seedstock availability for aquaculture.	Not applicable to coastal shrimp farming unless shrimp farming technology to farm marine shrimp in 'hard' freshwater embraced.	No immediate impacts on Tilapia farming.	Not applicable.
Changes in precipitation and water availability.	Changes in fish migration and recruitment success, including availability of broodstocks and seedstocks for aquaculture.	Little or no impacts on shrimp farming if focus on exotic species remains, unless shift or inclusion of culturing marine shrimps in freshwater embraced	No immediate impacts on Tilapia farming given that species and hybrids being utilized are exotic and husbandry practice does not rely in any way on wild stocks inhabiting various inland waterways.	Impacts on broodstock availability unknown… Hatchery being established to be based on harvesting broodstocks from the wild in more immediate future which should not be impacted by Climate Change induced effects…

Primary Driver	Generic Biophysical Effects	Implications for Aquaculture		
		Shrimp Farming	**Tilapia Farming**	**Cobia Farming**
	Impacts on water quality, including salinity and DO profile.	Resultant increase in salinities for shrimp farming…May result in shift to more oceanic species such as *Penaeus stylirostris* and P*enaeus duorarum*…Implications for additional costs to industry in terms of R & D efforts that would be necessary for these species.	Decrease in DO has negative implication for survival, growth rate, yields and in general operational costs.	Cobia however pan-tropical and capable of survival and growth in both oceanic quality waters as well as seas with lower salinities.
	Prospects of lower water availability for aquaculture with implications for higher costs in maintaining pond water levels and from stock loss, as well as in relation to conflicts with other water resource users and possible changes or shifts to other species.	Issue of seepage and increase evaporation may become significant with negative implications for energy consumption in terms of additional pumping costs.	Water availability for crop and livestock agriculture as well as inland aquaculture not identified as a challenge	Not applicable.
	Changes in lagoon and river levels, especially in relation to retreat of shorelines with declines in precipitation and increases in drought over time.	No immediate impact to shrimp farming.	Increase in pumping costs associated with need to lift water to higher elevations as shoreline of water bodies retreat.	Not applicable.
Increase in intensity of storms	Large waves and storm surges and prospects of introduction of diseases and parasites into aquaculture facilities, as well as possibility of loss of stocks.	Have negative implications for capital and operational costs in terms of increased repair and maintenance costs, as well as replacement and adjustments in engineering costs vis-à-vis higher and more robust pond walls.	Greater risks will be from flooding associated with hurricanes and storm events in general…Threat of loss of stocks.	Have negative implications for both capital and operational costs in terms of investments in heavier engineered technology and replacement costs, as well as operational costs in terms of mitigations measures such as relocation of husbandry facilities.

Changes in Lagoon and River Levels

The predicted changes in the levels of lenthic and lotic waterways associated with climate change and climate variability are expected to impact Tilapia farming. This should be mainly in the form of higher pumping cost associated with the need to 'lift' or pump pond water to higher elevation as the shorelines of rivers and lacustrine systems retreat with decrease in precipitation. This impact has been characterized as 'moderate deleterious' in orientation. Shrimp farming and Cobia culture are not expected to be impacted by the retreat in inland water bodies (See Table 15) – This is mainly a function of geography.

3.5.7 MEASURES TO ADAPT TO CLIMATE CHANGE

Capture Fisheries Adaptation Measures

Climate change and/or or climate variability produce actual and potential impacts on fisheries resources. Climate related changes represent potential additional stresses on systems that are already under pressure Burkett et al (2001). Climate change exacerbates existing problems including ecosystem degradation. Given such interactive effects adaptation options are best addressed when they are incorporated in the wider integrated issues of coastal management and sustainable development plans.

Adaptation to impacts of climate change on fishery habitat

A general strategy to conserve fishery habitats would be an appropriate precautionary adaptation to the effects of climate change. Furthermore, the better the condition of these habitats, the more resilient they will be. Additionally, the greater the quantity of coastal habitats (mangroves, sea grasses and reefs that are important for fisheries), the less likely it will be that climate change will reduce these habitats below critical levels for fisheries. The promotion of marine protected areas and environmental conservation thus becomes a focus of the adaptation strategy (See Table 16). Programmes such as the Coastal Zone Management Strategy and the National Protective Areas Policy and Systems Plan should be implemented as they include measures that deal with long term sustainability of marine fisheries habitat. The creation and management of marine protected areas (MPA) is advocated, in recognition of their value in reducing the negative influence of climate change. The under utilization of "fish reserves" as an adaptation tool in response to climate change is globally recognized and should be looked at as complementary to the more widely used MPA in Belize. The preparation of a National Fisheries Management Plan would help in providing guidance to fisheries managers to enable them to adequately deal with the impact of climate change on fisheries management (See Table 16)

Adaptation to direct impacts of climate change on fishery stocks

Changes in ***stock distribution, recruitment*** levels and variability and adult ***biomass and production*** can be achieved by adjusting fishing efforts to levels that are consistent with the yield levels that can be sustained by the changed populations. Yield estimates, for the major fisheries (Lobster, conch, shrimp and fin fish) can be determined by the Fisheries Department using conventional assessment and management measures, adaptive management or co-management approaches. The method employed should be strategically determined by the department following consultation and discussion with local national and regional experts given the shared nature of the fisheries resources, the importance of the reef system to the Meso-American region and ongoing fisheries management and development programmes with Mexico, Guatemala and Honduras (The Meso-American Barrier Reef System Project-MBRS) and our sister CARICOM countries through the Caribbean Fisheries Mechanism (CRFM).

Socio-economic Adaptation Responses

Adaptation to impacts of weather conditions on cost of fishing and revenue flows

Weather conditions are expected to continue to deteriorate with increased winds and generally worsening sea conditions for boating. Given that the fishing fleet consists mostly of relatively small boats, the worsening weather conditions would best be addressed by increasing the seaworthiness of vessels and the general safety of fishers at sea. Fishers and boat owners would be encouraged to invest in the full complement of safety equipment. Government and the Fishing cooperatives might consider entering into a joint venture to finance vessel improvement and safety for fishers.

For tropical storms and hurricanes, conditions on fishing vessels can be adapted to by:

- Provision of mooring sites for vessels; particularly in protected areas afforded by mangroves;
- Facilitating the movement of vessels of all sizes from the sea to fisher specific "safe" sites above the reach of the storm surge, and provision of the means to secure them against wind damage and, provision of the means to safely store fishing gear
- Agreements between fishers and landowners on the outer cayes for use of "camp sites"

Impact on fishing communities and shore based facilities

The effects of storm conditions on fishery shore infrastructure would be best adapted to during the design and construction of new facilities (See Table 15). Consideration should be given to relocating facilities, particularly where they are located in areas that are vulnerable to wind, surge or erosion. This provides the opportunity to incorporate adaptation to climate change. However, relocation would be effective only if there is sound awareness of climate change impacts and adaptive design options and, having on hand credible information on what the impacts of climate change are likely to be on a specific site. Similar adaptations strategy applies to human settlements in coastal fishing communities; relocation and or re-construction using climate change adaptive design options.

Erosion of beaches at landing sites where vessels are typically hauled out can be addressed through beach stabilization and renourishment works. Haul-out ramps for small boats can be constructed. Fishers normally deliver their catch to one of two centralized cooperative in Belize City. Safe harbour/marina with protective structures can be considered to provide protection for fishers at their product delivery point.

Table 15 Climate change Adaptation Matrix for Critical Ecological and "Human" Habitats

Coral Reef	Mangrove	Fisheries	Coastal Community
Monitor change in reef in response to climate induced factors	Mangrove Monitoring and research	Monitoring fish catch and effort data	Monitoring socio-economic status of fishers in coastal communities
Establish Marine Protected Area	Develop & Implement re-planting programme	Establish Fisheries Reserve or expand no-take zone in Marine Protected Areas	Encourage engagement in non-fisheries related (tourism) economic activity
Adopt/develop conservation programmes, policies and plans	Promote/support mangrove conservation programmes, policies and legislation	Develop Fisheries Management Plan	Encourage diversification in fish species targeted
Conduct research on reef response to climate change	Monitor Compliance with EIA requirements for coastal mangrove alterations	Conduct research to aid and support sustainable fisheries management goals	Assess vulnerability of coastal communities to climate change impact; determining suitability of current structure and new construction
Develop & Implement a sustained public information programme	Develop & Implement a sustained public information programme	Develop & Implement a sustained public information programme targeting fishermen especially and the public in general	Develop & Implement a sustained public information programme on impacts of climate change and alternative livelihood programmes

The adaptation measures discussed above clearly highlights the important relationship between the fisheries sector and critical ecosystems that are meaningfully impacted by local and global climate change. There is an obvious need to devise programmes that could mitigate these impacts. Highlighted here are adaptation actions which can be taken to minimize stress through preserving the physical integrity of the ecosystems that are essential to a sustainable fishing industry.

Adaptation Measures Associated with Aquaculture

The adaptation measures to be adapted in relation to Climate Change and Climate Variability (CCCV) induced impacts on aquaculture covers the areas of enterprise in Belize, viz: shrimp farming and Tilapia Farming and Cobia Cage Culture. These adaptation measures range from technical prescriptions, such as the development and deployment of more heavily engineered cage designs for Cobia Culture and decrease in water exchange rates for inland pond systems, to policy interventions such as the development and implementation of site selection criteria for cage culture, and the definition of a zoning scheme for the industry [See Table 16].

Potential climate change induced impacts to the Aquaculture industry considered in the study include (a) the increase of harmful algal blooms; (b) increased metabolic rate and growth due to the same cause; and (c) changes in migration and spawning, all as the result of increased sea-surface temperatures. Recommendations were also offered for other impacts of climate change on the aquaculture industry, these including saline wedge penetration upstream, and loss of mangroves and seafront protection also due to increased sea levels. Higher (inland) water temperatures are expected to display effects such as increased Stratification of Pond Water, reduced Water Quality, increases in Pathogenic Diseases and Parasites, and changes in Fish Migration patterns. Changes in Precipitation and Water Availability can be expected to impact on seed stock. Recommendations are presented as the Adaptation Matrix in Table 16 below.

Table 16 Adaptation Matrix for short- to medium- term Climate Change and Variability Impacts

Climate Change Impacts	Magnitude & Adaptation Strategy					
	Shrimp Farming		Tilapia Culture		Cobia Farming	
	Mag. & Dir.	Adaptation Measures	Mag. & Dir.	Adaptation Measures	Mag. & Dir.	Adaptation Measures
Harmful algal bloom from increase in sea surface temperatures (SST)	0	N/A	0	N/A	-1	Establishment of site selection criteria for cage culture sites and identification of alternate sites to which cages can be temporarily relocated in event of HAB.
Increase in metabolic rate and growth performance from inc. SST	+2	Close monitoring of water quality and production performance.	0	N/A	+1	Close monitoring of water quality and production performance.
Changes in migration and spawning from inc. SST	0	N/A	0	N/A	0	N/A
Loss of land from sea level rise	-1	Integrate into EIA process impacts and adaptation measures in as a consequence of Climate Change…Preserve mangrove zone between sea and farm infrastructure	0	N/A	-2	Define and implement zoning scheme for cage culture and other aspects of sub-tidal aquaculture… Retain mangroves on cayes relevant to cage culture operations.

Climate Change Impacts	Magnitude & Adaptation Strategy					
	Shrimp Farming		Tilapia Culture		Cobia Farming	
	Mag. & Dir.	Adaptation Measures	Mag. & Dir.	Adaptation Measures	Mag. & Dir.	Adaptation Measures
Changes in estuarine dynamics including seedstock availability as a consequence of sea level rise	0	N/A	0	N/A	-1	Define and implement research on impacts of sea level rise on Cobia populations and availability of broodstocks and seedstocks
Saline wedge penetration upstream due to sea level rise	-1	Culturing of more oceanic penaeid stocks such as *Penaues stylirostris*.	0	N/A	+1	N/A
Loss of mangroves and seafront protection due to sea level rise.	-1	Definition and implementation of national zoning scheme to demarcate areas for shrimp farming including area for landward retreat of shoreline over time.	0	N/A	-2	Incorporation of more heavily engineered stock containment technology such as more weather proof oceanic cages.
Increase in metabolic rate and primary productivity as a consequence of higher inland water temperature.	0	N/A	+1	Maintaining water quality parameters such as dissolved oxygen (DO) at optimum.	0	N/A
Increase in stratification of pond water as a consequence of higher inland water temperature.	0	N/A	-2	Shift to embankment ponds that are shallower and that are marked by improved engineering design to promote improved mixing of pond water and consequently decrease in stratification.	0	N/A
Reduced water quality and increase in pathogenic diseases and parasites as a consequence of higher inland water temperature.	0	N/A	-1	Judicious monitoring and management of water quality particularly DO and nitrogenous wastes… Definition and implementation of training programme for small-scale farmers on water quality management.	0	N/A
Changes in migration, spawning and seedstock availability as a consequence of higher inland water temperature	0	N/A	0	N/A	0	N/A

Climate Change Impacts	Magnitude & Adaptation Strategy					
	Shrimp Farming		Tilapia Culture		Cobia Farming	
	Mag. & Dir.	Adaptation Measures	Mag. & Dir.	Adaptation Measures	Mag. & Dir.	Adaptation Measures
Changes in fish migration, recruitment, and availability of seedstocks as a consequence of changes in precipitation and water availability.	0	N/A	0	N/A	0	Closing knowledge gap on impacts of Climate Change on availability of Cobia broodstocks by defining and undertaking research project on said subject.
Changes in water quality, including salinity and DO as a consequence of changes in precipitation and water availability.	0	Possible shift to culturing of more oceanic species such as *Penaeus stylirostris* and *Penaeus duorarum*.	-1	Judicious management of water quality through close monitoring of water quality parameters such as DO and nitrogen profile.	0	Closing knowledge gap on Climate induced salinity changes on abundance and production performance of Cobia.
Prospects of lower water availability for aquaculture as a consequence of changes in precipitation and water availability.	0	N/A	0	Precautionary prescription for institution of water conservation measures by modifying husbandry practices such as decrease in water exchange rate and employment of recirculation technology.	0	N/A
Decline in lagoon and river levels as a consequence of decrease in precipitation.	0	N/A	-2	Decrease pumping cost by adapting recirculation technology and decreasing water exchange rates for status quo semi-intensive Tilapia farming operation in medium term future.	0	N/A
Large waves, storm surges, flooding and prospects of introduction of diseases and parasites as a consequence of increase in frequency and intensity hurricanes and other storm events	-1	Adapting planned approach to aquaculture and by extension shrimp farming development …Measures should include zoning areas for shrimp farming to allow for landward retreat of primary production and ancillary infrastructure with retreat of shoreline.	-1	Continued location of Tilapia farming operation away from flood plain and other flood risk areas… Development of flood risk insurance for husbandry stocks and primary containment infrastructure to cope with losses of stocks from storms.	-3	Development of flood risk insurance for husbandry stocks and primary containment infrastructure to cope with losses of stocks from storms…Investment in improved design including more heavily engineered primary containment engineering structures, as well as implementation of zonation scheme to select better cage culture sites.

Key: +3 = Major Beneficial Effect; +2 = Moderate Beneficial Effect; + = Minor Beneficial Effect; 0 = No Discernible Impact or Uncertain Impact; -1 = Minor Deleterious Impact;-2 = Moderate Deleterious Impact;-3 = Major Deleterious Impact; N/A = Not Applicable

3.5.8 CONCLUSIONS

Countries, communities, and individuals in the higher range of economic well-being have access to technology, insurance, construction capital, transportation, communication, social support systems, and other assets that enhance their adaptive capacity. Others will have limited adaptive capacity.

Proper adaptation included building capacities which will help to better inform decisions and enable use of information that will lead to enhanced ability to cope with change, particularly change associated with climate change. An important strategy recommendation that would help to build capacity is to take immediate action which would minimize stress to those ecosystems that support fisheries and aquaculture. Preserving the physical integrity of critical marine and fresh water environments is an essential first step towards the minimization of stress.

Secondly, warning signals of global climate change can be better intercepted when critical systems are monitored. Coral reef bleaching events, for example must be monitored, investigated, analyzed and reported upon. This is particularly relevant in light of the central role this particular ecosystem plays in supporting diverse fish resources. Stepping up the monitoring of this and other selected environmental factors, including sea surface temperatures, inland temperature, rainfall or precipitation will, in the long term, improve our understanding of the dynamics of fisheries/aquaculture climate change issues and lead to a more efficient, effective planned strategy for sustainable development.

Thirdly, innovation, through research on the ecosystem(s) should be strongly promoted while aquaculture activities are expanded to stabilize sea-food usage, husbandry of new marine and /or fresh water species and renewed economic activity and employment for sustainable livelihood. Targeted research programmes that investigate impact of climate change can be identified locally or regionally and can be supported internationally through bilateral and multilateral agreements.

Research findings must then be translated effectively into public policy and communicated to the public and funding agencies for continued support. Considering uncertainties, management policies should be flexible enough to adapt to potential changes in the resource market conditions. This means that policy would support, for example, the exploitation of lesser known species to ease pressure on the main stock. It also recognizes the need for close cooperation with other resource managers to ensure the adequacy of management practices in all sectors affecting fisheries. Since most of the public and particularly those in the fishing communities are uninformed of the problems accompanying overfishing, climate change programmes of information exchange, education and capacity building should be initiated.

Research also helps to identify capacity building needs and gives support to capacity building request to deal with likely effects of climate change.

The development of credible monitoring and research programmes, relevant policy prescriptions and a communication strategy that seek to address public concern in relation to climate change issues will enhance our ability to mitigate climate vulnerability and enhance our ability to adapt to climate change.

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3.6 Vulnerability and Adaptation Assessment of the Health Sector

Health Care System

The National Public Health System in Belize provides universal access to personal and population based services, essentially at no direct cost to the individual. This includes the provision of pharmaceuticals and other support services. The Government is the main provider of health services, though recently there has been an expansion of the private sector as it relates to secondary and tertiary care. The main financing source for the public sector is the consolidated fund of central government. A system of rural health centers with permanent staff is supplemented by mobile health services, community nursing aides, voluntary collaborators and traditional birth attendants working throughout the rural communities of the country.

The provision of hospital based care in these four regions includes inpatient and outpatient care, including accident and emergency, pediatrics, obstetrics and gynecology, internal medicine and surgical care. Clinical and non-clinical support services and some specialized tertiary services are also provided. A network of clinics, permanently staffed health centers and un- manned health posts is available to address the primary health care needs of the population.

Programmatic Areas

Promotional, preventive and curative services provided by the Ministry of Health are organized into programs addressing different technical areas for the purpose of managing health care delivery throughout the country. One such program is the Vector Control Program. This program has responsibility for the maintenance of a healthy environment that provides for the prevention and control of Malaria, Dengue and Chagas Disease. It executes, on an ongoing basis, a series of Malaria and Dengue control activities such as: active and passive case detection; presumptive and radical case treatment with a 14-day treatment scheme (five of which are supervised); adult mosquito control via indoor house spraying and spatial ULV spraying; chemical larvae control with Abate; and health education in schools.

Most communities in Belize have a voluntary collaborator, a community nursing aide or both. They serve as a link between the communities and the formal health system, and play an important role in the detection and treatment of Malaria cases. A section of the Vector Control personnel is dedicated to activities aimed at the control of the *Aedes aegypti* mosquito which is the main vector for Dengue in Belize. The activities include, premises inspection for the identification and destruction of mosquitoes breeding site; chemical treatment of domestic water containers which have the potential to become breeding sites for the *Aedes aegypti* mosquitoes; health education to householders; ULV spraying for adult mosquitoes control; and epidemiological investigation of suspected index dengue cases.

Unlike Malaria, Dengue does not have a dedicated surveillance system. Cases are diagnosed at the point of patient contact with the health sector and reported to the health information system of the Ministry of Health. Only a small number of cases diagnosed in the private sector are reported. Overall, the diagnosis and reporting of Dengue cases have been inconsistent over the years. Prior to the development of laboratory diagnosis capabilities in 2006, the guiding policy for the diagnosis was the following: Blood samples were taken from patients who presented themselves to a health facility with fever, body ache, retro-orbital pain and rash; the sample was sent to the Caribbean Epidemiological Center (CAREC) laboratory for testing, both for viral identification and serological reaction. If the results were positive, then the Vector Control program would issue an information bulletin to health care providers in the entire country outlining the prevailing symptoms as criterion for the diagnosis of suspected cases of Dengue. Report of cases to CAREC over the years has been inconsistent; sometimes only laboratory confirmed cases were reported, while for some years, it was both clinical and laboratory confirmed cases.

3.6.1 INTRODUCTION & BACKGROUND

Within the Health Sector, the Global Circulation Models for climate change projects that in tropical low latitude areas such as Belize, a warmer climate system resulting from a doubling in Carbon Dioxide concentration in the atmosphere will lead to increased frequency of warm spells/heat waves, intense droughts, and heavy rainfall events. It is projected that these conditions will exacerbate those that increase the risk and incidences of vector-borne diseases and illnesses.

This Vulnerability Assessment of the Health Sector, conducted under the Second National Communication Project served to describe present vulnerability and adaptive capacity; project future vulnerability and required mitigation measures as well as to identify the need for a more comprehensive assessment in order to determine with more precision, the future impact of dengue and other climate sensitive illnesses.

Dengue is the most important arboviral disease of humans, occurring in tropical and subtropical regions worldwide. In recent decades, dengue has become an increasing urban health problem in tropical countries. The disease is thought to have spread mainly as a result of ineffective vector and disease surveillance; inadequate public health infrastructure; population growth; unplanned and uncontrolled urbanization; and increase national and international travel. The main vector of dengue is the domesticated mosquito, *Aedes aegypti* that breeds in urban environment in artificial containers that hold water. Dengue also can be transmitted by *Aedes albopictus*, which can tolerate colder temperatures.

Dengue is seasonal and usually associated with warmer, more humid weather. There is evidence that increased rainfall, humidity and temperature can affect the life cycle of the vector and virus, thus increasing the transmission potential.

Classic Dengue Fever is considered endemic in Belize, and the Health Services has continuously monitored the occurrence of Dengue and Dengue Hemorrhagic Fever (DHF) and has expressed concerns over recent outbreaks of DHF in Brazil and other Central American countries. Belize has the environmental and socio-economic conditions for such outbreaks to occur; the conditions also exist for DHF to arise. The MOH resolved that is was timely that a vulnerability assessment be undertaken in order to determine the present and future level of risk of this disease. Since Dengue is a climate sensitive disease, it was expected that a change in climate parameters would impact its frequency and distribution in the country.

Objectives of the Assessment

The goal of this study was to:

- Describe the present level of risk for dengue and DHF in Belize
- Project the future occurrence of dengue based on present risk levels and expected population growth, in the absence of climate change.
- Utilizing selected socioeconomic and climatic scenario, project the future impact of dengue and DHF in Belize.
- Recommend adaptation strategies to cope with potential impact.

Methodology

The method used was determined after consultation with senior staff of the National Meteorological Service, the Statistical Institute of Belize, the Ministry of Health and the Vector Control Program, in order to see what modeling capability and data availability existed. The available options were to use mathematical models to predict future impact; descriptive analysis through literature review and expert judgment; the risk management approach or a combination thereof.

Consultation with other partners and stakeholders and comprehensive literature review, revealed the following:

No previous modeling studies had been conducted in Belize, linking the occurrence of dengue to socio-economic, climatic or environmental factors. The surveillance system of the MOH did not collect information on socio-economic risk factors for Dengue and the entomological data that was collected was inconsistent. The intensity and quality of data collection and recording, varies over time and among health regions.

The available data did not allow for modeling (multiple regression analysis) to predict changes in the dependent variable (incidence of dengue) for unit change in the independent variables (climate parameters and others). The absence of such models precluded the consultant from making projections on future impact of dengue utilizing mathematical models.

Taking into account the situation as described above and following the IPCC recommendations for V&A assessment where impact data is unavailable, the following methodology was adopted:

The Bottom-up, Risk-Based Hazard assessment framework combined with the Top-down approach to conduct the vulnerability and adaptation assessment. Under this model, the climatic, socio-economic and environmental drivers of dengue are identified; present risk (vulnerability) of dengue and adaptation capability of the country is described based on historic and current data. Based on future climate scenarios, the risk management process, and utilizing expert judgment, determination is made as to how the projected climate changes will impact on dengue and what proactive adaptation measures needs to be implemented in order to reduce vulnerability and minimize impact.

A cost benefit analysis of alternative adaptation measures or no adaptation was made in order to facilitate policy decision. The risk management process provides a systematic, informative and science-based tool to help decision makers analyze the risk of climate variability and change, and select optimal course of action.

Data acquisition and compilation

Data on climate history and future projected changes was acquired from the National Meteorological Service of Belize (NMS). The socioeconomic scenario used was that described as the IPCC emission scenario A2, which was selected by the NMS, in consultation with other sector of development. Data related to the frequency, distribution and trend of dengue and non-climatic risk factors was gotten from the epidemiology unit of the Ministry of Health, the Vector Control Program, the Statistical Institute of Belize and through a national prevalent entomological survey financed and implemented by the SNC project, in coordination with the Vector Control Program, in August of 2008.

Documentation for literature review was acquired from PAHO, CCCCC, SNC project management office, NCSP and the Internet.

It was anticipated that the available rural entomological data was incomplete and inconsistent, so that in order to generate valid information on the frequency and distribution of the *Aedes aegypti* mosquito and its breeding sites, an entomological survey was conducted. Three villages were randomly selected from each district and within each village; random selection of a representative sample was made. This survey produced a picture (snapshot) of the risk that the vector poses in the country. A one day technical workshop was held in Belmopan to train the entomological surveyors in preparation for the actual data collection exercise. The Entomological Cross-sectional Survey protocol addressed:-

- **Objectives of the Survey -**The objective of this survey was to generate the data required to estimate the *Aedes aegypti* indices such as: House index, Container index, Breteau index for rural Belize, and to determine what type were the prevailing breeding containers.
- **Methodology -** In consideration of the objectives of the study and due to time and resource constrains, a cross sectional survey design was utilized in order to gather prevalent information on *Aedes aegypti* mosquito habitats and density.
- **Target Population -**Since the study aims at measuring the prevalence of entomological risk factors for dengue in rural Belize, the target population was determined to be all rural households in the country. By

definition, the target population is that proportion of the population to whom the results of the survey is extrapolated.

- **Study Population -** Is defined as that proportion of the target population to whom the researcher has access and from where data collected. The study population comprised all households in the eighteen selected communities; hence all households were included in the sampling frame.
- **Sampling Process -** In order to get the required representative sample size for the survey, a random selection of three villages per district was done, followed by a random selection of households within each village. It was concluded that a combination of cluster and systematic random sampling procedures was appropriate for this setting. The cluster sampling entailed the random selection of three villages per district in order to have appropriate district representation; this was followed by systematic random selection of households within each village.
- **Sample Size -** For *Aedes aegypti* larvae survey, the determination of the number of house premises to be inspected in each locality depends on the precision required, level of infestation and availability of resources. Since the desired precision was 1% or less (ability to detect 1% larvae infestation), and the expected level of infestation was 2% or greater, the methodology proposed by the 1994 PAHO "Dengue Prevention and Control Guidelines" for sample size determination was utilized.
- **Data Collection Procedure -** Data was collected following standardized entomological protocols. Data collection was made on premises with water holding containers; premises with wet containers; premises with containers with larvae; larvae stage and larvae species. This data was utilized to estimate the: House index (HI), Container index (CI), and Breteau index (BI).
- Two Entomologist Technicians per district, employees of the Ministry's Vector Control Programme, were selected and trained to collect field data as per protocol. Data collection was carried out simultaneously in each district and the task was completed in three days.
- **Data Collection Instrument -** Standardized forms utilized by the vector control program of the Ministry of Health was used to record the entomological data
- **Statistical Analysis -** The Statistical Program for the Social Sciences (SPSS) 10.0 was used to conduct data analysis. Counts, Frequencies, Proportions and Percentages were generated and presented in tables and graphs. Outputs were the following: House, Container and Breteau Indices per village and average per district. Types of containers and container relative frequency. For detailed information on the results of the study, see Table 17 below, and the section dealing with the analysis of "Present Vulnerability to Climate Change".

Table 17 Entomological Indices by District and Village, Belize 2008

District	Village	House Index	Cont Index	Breteau Index
Corozal	Ranchito	4%	2%	4%
	Paraiso	3%	2%	3%
	Little Belize	9%	2%	9%
Orange Walk	Douglas	2%	1.4%	0.2%
	Fire Burn	0%	0%	0%
	Trial Farm	3.8%	1.3%	4.7%
Belize	Double Head Cabbage	3.9%	1.1%	3.9%
	Barrel Boom	4.2%	3.1%	4.2%
	Crooked Tree	7%	2.4%	9%
Cayo	Santa Familia	9%	6.32%	16%
	Ontario	16%	7.28%	22%
	Cristo Rey	9%	5.21%	17.14%
Stann Creek	Valley Community	0%	0%	0%
	South Stann Creek	14%	13.6%	24%
	Hope Creek	7%	3.8%	9%
Toledo	Blue Creek	4.9%	2%	4.9%
	Forest Home	4%	.9%	4%
	San Antonio	8.7%	3%	12%

Source: entomological Survey, Vanzie et al, 2008.

Disease selection

The decision to select Dengue as the disease to be studied in relation to its vulnerability to climate change was made by the Ministry of Health based on the following factors:-

- Classical dengue is endemic in Belize and hence the risk of occurrence of the fatal dengue hemorrhagic fever exists.
- Studies have revealed that the occurrence of dengue fever is sensitive to temperature, humidity and rainfall increase.
- The IPCC's Third Assessment Report (2001) projects an increase in average world surface temperature ranging from 1.4 to 5.8°C and change in seasonality and weather patterns over the course of the twenty-first century.

3.7 ASSESSMENT OF PRESENT VULNERABILITY AND ADAPTATION CAPABILITIES

This is an overview of the Dengue situation in Belize during the period 2002-2007. It highlights the existing risk of dengue to the population and makes future projections. It describes the frequency, distribution and trend of Dengue and its environmental, socioeconomic and climatic risk factors. Complete data on the occurrence of dengue could only be found for the years 1995, 2002, 2005 and 2007 reference Table 6 below. Data for other years between those mentioned was inconsistent and incomplete therefore was not utilized.

Table 18 Dengue Cases Recorded with complete data

Dengue Cases for Years with Complete Data				
	YEARS			
DISTRICTS	**1995**	**2002**	**2005**	**2007**
Corozal	1	9	8	72
O. Walk	21	7	3	17
Belize	46	22	19	159
Cayo	15	3	614	18
S. Creek	7	0	5	39
Toledo	10	0	1	3
Don't Know			2	23
Totals	100	41	652	331

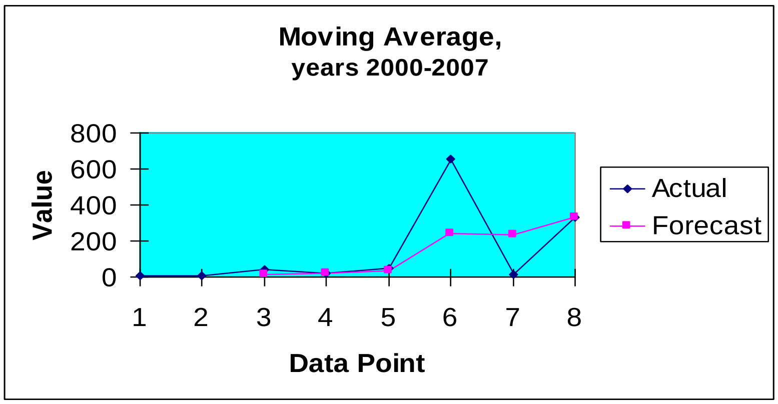
The total number of dengue cases in Belize for the year 2007 was 331, 48% (159) of which occurred in the Belize district. The risk of dengue per thousand inhabitants in the Belize District (1.7) is slightly lower than that of the Corozal district (1.9). The risk (Incidence) of a person developing dengue in Belize during the year 2007 as determined by epidemiologic data for that year was 0.00106. This is the same as saying that during the year 2007, 1.06 persons out of every thousand inhabitants developed dengue.

Incidence is an epidemiologic measure that is used mainly to: assess risk; to compare groups on a variable of interest; to identify trend in morbid events e.g. dengue, and to calculate future occurrence of disease based on projected population growth.

The Statistical Institute of Belize has projected the population to reach 368,693 for the year 2020 and 499,836 inhabitants for the year 2050. Based on this projected population growth, the expected number of dengue cases for the years 2020 and 2050 are 391 and 530 respectively. The main assumption in this calculation is that with the exception of population growth, all other risk factors remain the same. However, according to the Global Circulation Models, global temperatures are expected to increase by 2˚C to 4.5˚C by 2100, with the best scenario being 3˚C. This temperature increase is expected to be accompanied by increase in the frequency and intensity of extreme events that are beyond the coping capacity of the population and for which adaptation measures will have to be incorporated into national development plans.

The combined incidence for the years with complete data was estimated to be 0.00105, or 1.057 persons per thousand inhabitants. There is no significant difference between the combined incidence and that of the year 2007. The calculation is accomplished by dividing the sum of the cases for those three years, by the average population for those same years multiplied by the years of observation (3 years).The overall trend of dengue occurrence in Belize (fig.7) as suggested by 2002-2005 data, is toward the increase in all districts.

Figure 30 Dengue trend, 1995 - 2007



The required data to describe distribution of cases by serotype was not available. This was because the majority of reported cases were based on clinical diagnosis. Due to the few cases that were sent to the regional laboratory each year, especially at the beginning of a suspected outbreak, it is now known that over the years, the four serotypes of dengue viruses have circulated in Belize. The years of first appearances of the different dengue serotypes are as follows:-

Table 19 Dengue serotype emergence

Year	Number of cases	Serotype
1978		1
1982	482	4
1997	141	3

Data for 1978 was unavailable. The identification and characterization of dengue viruses was done in Puerto Rico through CAREC. It is believe that Den-type 2 has also circulated in Belize.

3.7.1 GROUP DISTRIBUTION OF DENGUE

The age distribution as reflected in Figure 31 has no outstanding feature. It should be noted nonetheless, that countries which have experienced DHF outbreaks refers higher attack rate among children than adults. The severity of dengue and DHF is also greater among children.

Figure 31 Age districution of Dengue cases - 2007

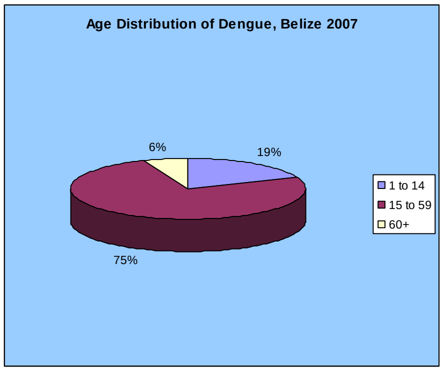
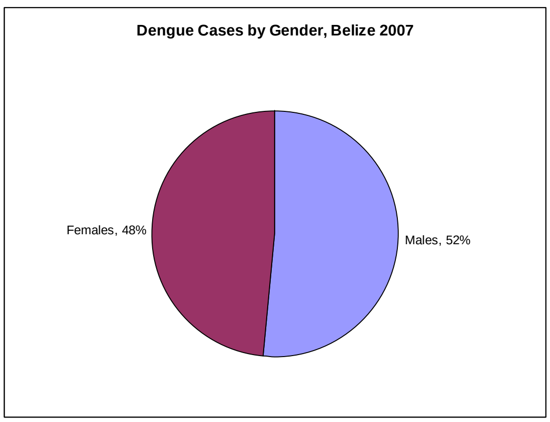


Figure 32 below depicts the distribution of dengue cases by gender. The incidence among males is slightly higher (4%) than in females. The lower percentage of cases among children and females could be a reflection of the practice, particularly in the rural areas, of protecting mothers and children from nuisance mosquitoes and other insects through the use of bed nets.

Figure 32 Dengue Cases by Gender - 2007

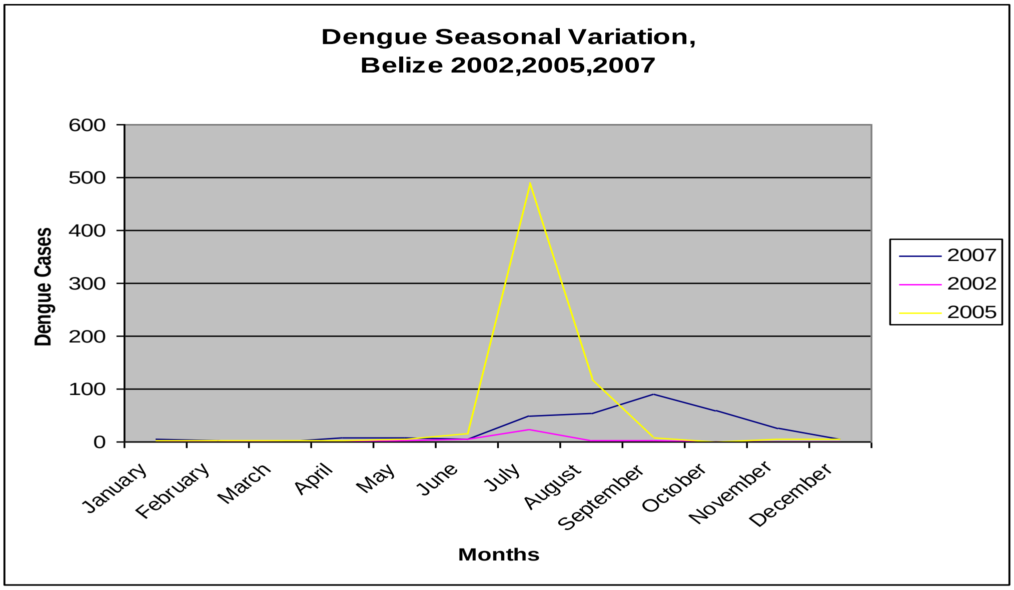


Seasonal variation

A Line graph was constructed with cases by month in order to see if there were any indications of seasonal variation in the occurrence of dengue. Cases for the years 2002, 2005 and 2007 were utilized since these were the only years for which complete data per month was available. Figure 33 below shows a clear pattern in the occurrence of cases, with the majority occurring between June and October.

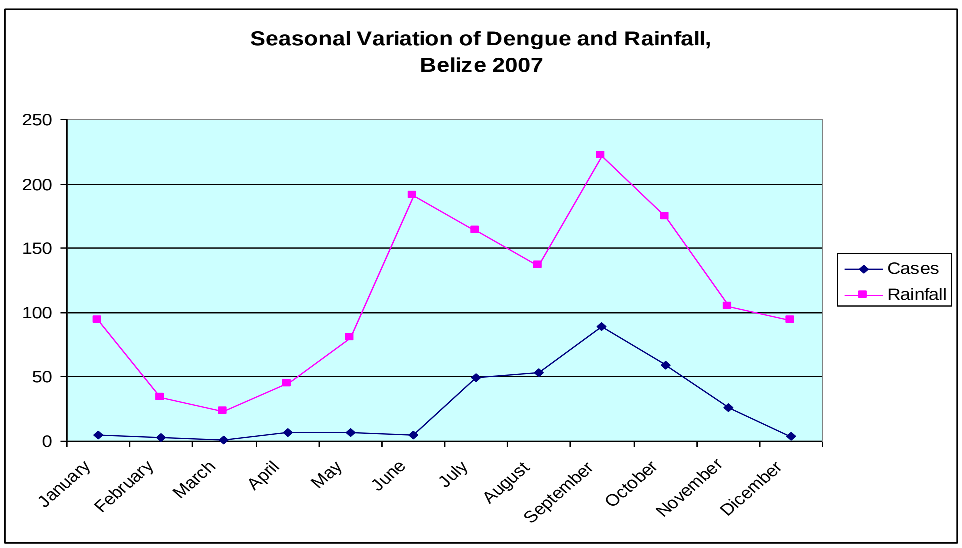
There are a relatively low number of cases during the dry season which is from January to end of May; this is followed by a sharp increase in the middle of June extending to the middle of October. Between October and December, there is a gradual decrease in the number of cases to an average of five or less. The same pattern is seen in each of the years included in this analysis. It is interesting to observe that the increase in cases lags approximately two weeks behind the increase in rainfall, as can be seen in the graph below.

Figure 33 Seasonal variation of Dengue in Belize – 2002, 2005, 2007



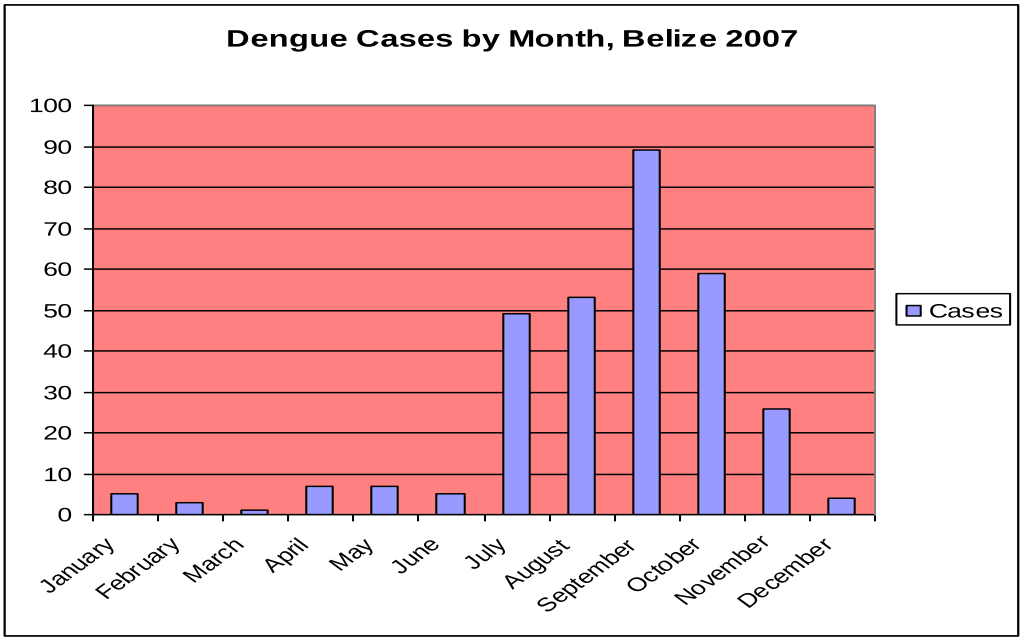
The seasonal variation in the occurrence of dengue cases follows the same rainfall pattern as outlined in Figure 34 below. A correlation analysis to assess the relationship between Dengue and rainfall produced the results represented graphically below.

Figure 34 Seasonal Variation between dengue and rainfall



The Person product moment correlation (r) was estimated to be 0.758418. This value of "r" suggests a strong correlation between rainfall and the occurrence of dengue. In layman terms what this means is that rainfall is directly or indirectly influencing the incidence of dengue. This however, does not come as a surprise since containers, potential breeding sites for the *Aedes aegypti* mosquito, becomes productive only when they are filled primarily by the rain.

Figure 35 Incidences / Cases of dengue by month 2007



The case distribution by month is shown in Figure 35 above. Most cases occur during the July-October period. These are the months with the highest rainfall in the country. Due to lack of data, it was not possible to compare the seasonal variation of dengue for the western and southern districts to that of the center and north. It would be interesting to see if the dengue epidemiological curve in the south anticipates that of the north, since the pattern of rain in these two regions varies significantly.

3.7.2 VECTORS

The presence of the *Aedes aegypti* mosquito is fundamental to the occurrence of dengue in any ecosystem. The concept of epidemiological triangle of disease transmission is well known by public health practitioners. It says that three fundamental elements need to coexist in order for disease transmission to occur. These elements are: the host, the agent and the environment; transmission can not take place in the absence of any of these three elements. Other elements (factors) which are characteristics of the host, agent or the environment, may facilitate or protect against transmission.

As it relates to dengue transmission, the host is human; the agent is the dengue virus and the environment is represented by the vector and climatic parameters. All three elements required for the transmission of dengue are present in Belize on a permanent basis and for that reason; the disease has become endemic showing periodic epidemics when characteristics of these elements are such that transmission is enhanced.

The main dengue vector in Belize is the *Aedes aegypti* mosquito. To date studies have not revealed the presence of other vectors such as the Aedes albopictus. Since the environmental conditions as it relates to temperature, humidity, rainfall and altitude are within the ideal ranges in all districts, the entire country is considered to be at risk of dengue transmission. The level of risk is determined more by life style and socio-economic conditions of communities, than by geographical location.

An entomological cross-sectional survey was organized and conducted in August of 2008, by the Belize SNC project with the support of the Vector Control Program of the MOH. The main objective was to collect reliable data on the frequency and spatial distribution of the *Aedes aegypti* larvae in the country. The mosquito density as measured by the Breteau, House and Container indices, gives an accurate indication of the existing level of risk of dengue transmission. The findings of the study were the following: 17% of surveyed communities had a Breteau index below 2%. This is the threshold (even though disputed) below which dengue transmission is unlikely. Thirty nine (39) percent had Breteau indexes between 2 and 5 per cent; this level of larvae infestation supports the maintenance of endemic dengue and low level outbreaks. Eight communities (44%) had larvae infestation as determined by the Breteau index, between 6 and 24 per cent; the probability of dengue outbreak is very high in these communities (See table/graph 1E, 2E, 1C).

Since the selection of participating communities and households within communities was randomly done, and since the sample size selected was large enough to detect larvae infestation as low as of 1% (precision), the internal and external validity of the study is such that the results of the study can be extrapolated to the entire rural Belize. Due to time and resources, the survey was not conducted in urban areas, but the review of available urban data suggests that the level of infestation is greater there. Further studies would have to be conducted in other to quantify vector density in the urban setting. The study also showed that the most productive containers found in the rural areas were drums and tires.

Correlation analysis was done between Breteau Index (BI) for all villages surveyed, and climate variables (rainfall, temperature) taken at weather station near each village. The analysis was done for every day of the month of August up to day 28, which is when the study was conducted. Moderate correlation was found for days 25th and 26th between rainfall and Breteau index. The Person Product Moment correlation for the 25th and 26th were 0.437 and 0.362 respectively. This finding suggest that increased rainfall 3 to 4 days before the survey was carried out, might have played a role in creating the conditions for the female mosquito to lay her eggs. No correlation was found between BI and temperature for any of the days analyzed.

3.8 TOURISM

3.8.1 INTRODUCTION

Tourism is an important industry in Belize for economic growth, tax revenues, and foreign exchange earnings. Nearly US$200 million in tourism expenditures in 2006 represented about 17% of GDP for Belize. However, as a tropical, coastal nation, Belize is highly vulnerable to variable climate and weather patterns as well as tropical cyclones. This vulnerability is particularly relevant for the tourism sector, given the small scale and nature-based character of tourism in Belize.

Vulnerability in this context can be understood as the degree of sensitivity to and inability to cope with the negative impacts of climate change (McCarthy *et al.*, 2001; Bijlsma *et al.*, 1996). Klein and Nicholls (1998) have suggested that vulnerability is multi-dimensional, with biogeophysical, economic, institutional, and socio-cultural elements. The vulnerability of a system to climate change is a function of its exposure to negative effects and its ability to cope with those effects (McCarthy *et al.*, 2001). Sterr *et al.* (2003) suggest that biogeophysical effects must be first understood before the vulnerability of socio-economic sectors can be assessed. Vulnerability assessments enable policy makers to anticipate the consequences of climate change and prioritize adaptation measures in order to minimize exposure to risk (Sterr *et al.*, 2003).

Belize is considered a small island developing state (SIDS) because of its low-lying coast, its coastal communities, and its open vulnerable economy (UNDESA, 2005; NAR, 2003). Small island states are considered "extremely vulnerable" to climate change and rising sea levels (IPCC, 1997). Like many SIDS, Belize is economically, socially, and physically vulnerable to climate change. As a small, open economy, Belize depends on imports for many basic goods, and relies heavily on tourism for foreign-exchange earnings to meet the demand for imported goods. The potential impacts of climate change pose a particular risk to poverty and hunger, which already hinder human development in Belize. Due to its small size, land resources are constrained. SIDS are often already at risk from other environmental hazards such as flooding, tropical storms, and deforestation; the effects of climate change are expected to exacerbate these risks and introduce new ones (Tompkins *et al*., 2005).

This study presents an assessment of the vulnerability of the tourism sector in Belize to the impacts of climate change. The vulnerability of tourism in Belize to climate change stems from three biogeophysical impacts. Rising sea levels pose risks for flooding, inundation, saltwater intrusion, and erosion, which threaten water supplies, infrastructure, and coastal areas. Warmer sea water threatens the coral reefs along the coast of Belize that comprise the longest barrier reef in the western hemisphere and attract thousands of tourists for snorkeling and scuba diving activities. Also, warmer sea surface temperatures are associated with increasing frequency and intensity of tropical cyclones or hurricanes, which threaten coastal settlements and infrastructure. Based on present spending levels, 45% to 70% of the tourism sector is highly vulnerable to the effects of climate change.

3.8.2 TOURISM IN BELIZE

The tourism sector in Belize is young relative to the agricultural and forestry industries that contributed to the early economic growth of the country. Tourism in Belize was originally developed around small-scale, adventure or nature-based recreation activities, and the scale of the development of hotels, resorts, and other infrastructure reflected this ecotourism niche. Belize is endowed with abundant tourism resources, including the second-largest barrier reef system in the world, numerous limestone caves, and tropical rainforests. The barrier reef was one of the earliest attractions, and development of the islands of Ambergris Caye and Caye Caulker as well as the coastal village of Placencia provided accessibility for visitors interested in snorkeling, underwater diving, deep sea fishing, and other water-based recreation activities. Significant resort and hotel development in the town of San Pedro has made it the country's largest tourist destination, and more recently, a destination for foreign retirees and migrant expatriates.

Since the 1980s, tourism has expanded rapidly in the Cayo District; tropical rainforest walks, medicinal plant trails, Mayan archaeological sites, and limestone cave tours attract visitors to western Belize and the twin towns of San Ignacio and Santa Elena. National parks and protected areas such as Blue Hole National Park, Crooked Tree Wildlife Sanctuary, and Cockscomb Basin Wildlife Sanctuary attract wildlife enthusiasts and bird watchers. The small size of the country allows for tourists to visit both coastal/island and inland destinations within a small time frame, though only less than half of visitors reported that they visited inland attractions (BTB, 2004).

Average annual growth in overnight visitors was nearly 4.5% from 1999 to 2006, though growth has slowed since a peak of 10.6% in 2003 (BTB, 2007). Approximately 95% of overnight visitor arrivals were for leisure purposes. Belize is the primary destination for over 70% of visitors, as just 29% visit more than one country during their travels (BTB, 2004). More than half of overnight tourists (61.7%) come from the USA (see Table 1), and nearly all international air passenger service to Belize originates there. The second most important region of origin for tourists in Belize is Europe, which constitutes about 14% of visitors. The number and share of Mexican tourists has sharply declined overall in the last decade. Cruise ships have brought more than 500,000 day visitors per year since 2003. When data for overnight visitors are combined with that of cruise ship visitors, annual tourist visitation in Belize amounted to nearly one million in 2006 (BTB, 2007).

Tourism is the single largest contributor to GDP and the largest source of foreign exchange earnings for Belize. In 2006, tourist expenditures reached nearly BZ$400 million dollars, which equates to 16.8% of GDP (BTB, 2007) (see Table 2). The increase in the numbers of tour operators and registered guides has outpaced the growth in arrivals, but given the continued increase in tourist spending, this may be due to changes in the type of tourist and the preferred recreation activities. The popularity of cave tours in the Cayo district has flourished, and because of the risks to personal safety and fragile artifacts, many of these sites require booked tours with certified tour operators.

Table 20 Arrivals of overnight visitors by nation of origin, 199 - 2006

Nationality	1999	2000	2001	2002	2003	2004	2005	2006
USA	92,695	104,717	106,292	104,603	127,288	137,376	145,977	151,510
Europe	24,746	27,674	29,115	29,115	33,530	32,770	33,466	34,373
Canada	8,430	9,205	9,492	9,185	9,831	11,925	13,580	15,553
Belizeans living abroad	14,545	14,106	12,999	11,896	7,799	7,698	7,705	8,365
Guatemala	12,162	17,313	15,652	21,184	17,632	15,949	13,907	13,616
Mexico	8,258	8,688	7,739	8,413	6,312	6,851	5,893	5,855
Other	19,959	14,062	14,045	15,126	18,182	18,272	16,045	18,037
TOTAL	180,795	195,766	195,955	199,521	220,574	230,832	236,573	247,309
Annual Change	2.7%	8.3%	0.1%	1.8%	10.6%	4.7%	2.5%	4.5%

Source: BTB, 2007

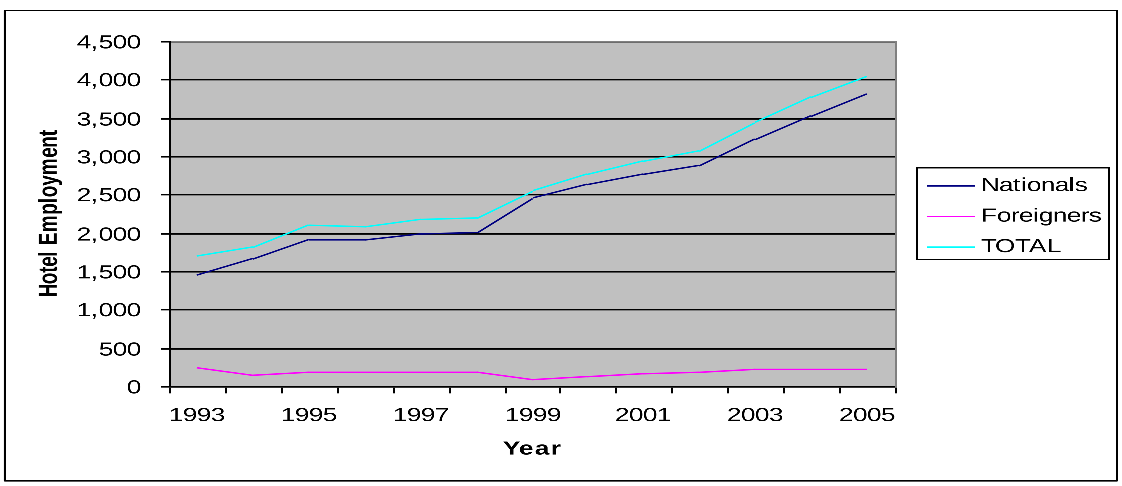
Table 21 Economic impact of tourism in Belize, 1999 - 2006

	1999	2000	2001	2002	2003	2004	2005	2006
Tourist expenditures (BZ$ millions)	222.9	240.4	241.0	265.6	311.4	345.3	349.4	398.8
Tourist expenditures (% of GDP)	15.2	14.5	13.9	14.3	15.9	16.7	15.8	16.8

Source: BTB, 2007

The economic impact of tourism in Belize is most readily evidenced by its contribution to employment of Belizean citizens. Hotel employment of Belizean nationals alone has more than doubled in the last decade (see Figure 1).

Figure 36 Hotel employment in Belize, 1993 - 2005



Source: BTB, 2007

As of 2006, there are 561 hotels and 5,789 rooms in Belize (BTB, 2007), which illustrates the small-scale nature of tourism in Belize (average property size is 10.3 rooms). Hotels in Belize employ 4,347 persons; restaurants employ another 4,531. There are nearly 200 tour operators and 1,145 registered tour guides (BTB, 2007).

Natural resources are important attractions for Belize tourism. The barrier reef, cayes, national parks, and wildlife sanctuaries appeal to many visitors seeking tropical experiences in nature that are not readily available in their countries of origin. Visits to selected protected areas for 1998-2006 are provided below in Table 3.

High levels of visitation to the Hol Chan Marine Reserve reflect its proximity to the popular destinations of Ambergris Caye and Caye Caulker.

Table 22 Visits to selected protected areas, 1998 - 2006

Protected Area	1998	1999	2000	2001	2002	2003	2004	2005	2006
Guanacaste National Park	2,567	2,788	1,184	1,452	2,445	2,288	2,306	n/a	1,564
Crooked Tree Wildlife Sanctuary	1,483	1,619	947	1,116	1,440	1,299	2,359	n/a	2,180
Cockscomb Basin Wildlife Sanctuary	4,078	3,603	5,189	6,085	6,343	10,062	9,194	n/a	4,163
Blue Hole National Park (Inland)	7,098	6,162	10,080	8,853	8,485	7,880	10,448	n/a	8,818
Half Moon Caye National Monument	7,310	7,940	12,317	10,071	10,207	7,141	9,803	n/a	9,502
Hol Chan Marine Reserve	40,048	37,059	36,887	38,687	55,701	74,375	87,136	73,619	54,625
TOTAL	64,582	61,170	68,604	68,265	86,623	105,048	123,250	n/a	82,858

Source: BTB, 2007

Ambergris Caye and Caye Caulker are the most popular destinations, followed by the Cayo District and the coastal village of Placencia (BTB, 2004). Snorkeling, diving, and island tours are the most popular activities, followed by archaeological site visits and jungle tours.

The Government of Belize and the tourism industry recognize the need to protect the quality of its natural resources and maintain a pristine environment in order to sustain the tourism industry. The projected impacts of climate change have acute implications for tourism and the natural resources on which it depends. As such, this issue warrants thorough and comprehensive consideration by all stakeholders.

3.8.3 METHOD

The concept of vulnerability has been associated with several related terms, including risk, hazard, and exposure (Patwardhan *et al.*, 2003; Shukla *et al.*, 2003; IPCC, 2001b). The IPCC (2001b) describes vulnerability as the degree to which a system is susceptible to or unable to cope with the adverse effects of climate change including climate variability and extremes. McCarthy *et al.*, (2001) defined vulnerability as the residual impacts of climate change after implementation of adaptation measures. Therefore, vulnerability can be generally understood to be a function of climate-related hazards, socio-economic exposure, and adaptive capacity. Patwardhan *et al.* (2003) describe vulnerability as systemic, and they suggest that the focus of adaptive capacity should be to reduce exposure, according to the following framework:

Risk = Hazard (climate) x Vulnerability (exposure)

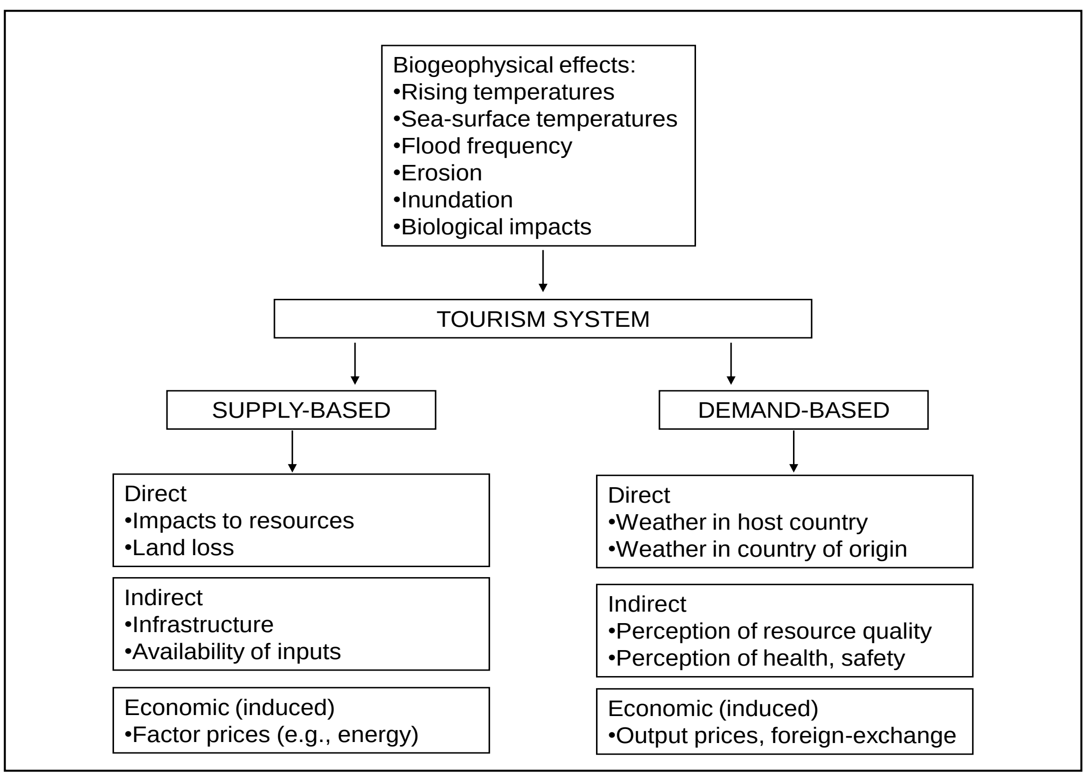
The IPCC (1997) recommends a fully-integrated approach to assessing vulnerability to climate change, where biogeophysical attributes (e.g., land area) are integrated with economic, social, and cultural characteristics, including non-market goods and services. Pulwarty (2006) recommends an integrated approach to vulnerability and capacity assessment that is based on input from a country advisory panel as to the vulnerability of a particular sector. The Pulwarty approach suggests the development of a conceptual model that is relevant to the sector and the country.

Sterr *et al.* (2003) indicated that vulnerability assessments of socio-economic sectors depend on an understanding of the extent to which biogeophysical effects will occur in the study area. They highlight flood frequency, erosion, inundation, and biological effects as the direct biogeophysical impacts of climate change on the tourism sector.

The method of analysis for this assessment is based on a conceptual framework for tourism vulnerability as well as a survey of tourism businesses in two locations in Belize (Ambergris Caye and Cayo District). The conceptual framework presented in Figure 2 is based on an economic approach to vulnerability assessment and considers tourism as an economic system. In this framework, sources of vulnerability to climate are either supply- or demand-based. Climate influences the tourism sector either in the *production* (supply) of tourism services (through the quality and availability of infrastructure, resources, or materials) or in the *consumption* (demand) of tourism services (through tourist perceptions of weather, resources, amenities, or costs). Sources of vulnerability can be evaluated based on the degree of risk or exposure, and the adaptive capacity of the sector. Where applicable, vulnerability responses are categorized as related to either mitigation or adaptation strategies. Impacts are categorized as direct, indirect, or induced, depending on whether the effects are a physical function of climate change or a socio-economic function the tourism system.

The vulnerability of the supply (or production) of tourism services may be directly affected by impacts to tourism resources and land loss. The vulnerability of resources includes impacts to ecosystems, coral reefs, beaches, forests, and wildlife. The vulnerability of land loss is associated with sea-level rise and relates to the risks of flooding, inundation, and erosion, which has significant implications for islands and coastal areas. Indirect sources of supply-based vulnerability include impacts to infrastructure, including transportation systems (*e.g.*, port, airport, and highways), telecommunications, and tourism-related business (*e.g.*, hotels, restaurants, and tour operators). Natural and manufactured attractions and the availability of inputs (*e.g.*, water, accommodations, food, beverages, and labor) may also be vulnerable. Induced or economic sources of vulnerability relate to the potential effects on factor prices such as labor, supplies, or energy. Dependence on imports may increase the supply-based vulnerabilities.

Figure 37 Conceptual framework for tourism vulnerability assessment



The vulnerability of the demand for tourism services may be directly affected by weather in the host country as well as the country of origin. Warming temperatures and changes in precipitation in the host country may affect visitor preferences and the overall comfort and enjoyment of activities. Warmer temperatures in the country of origin may reduce demand for trips to tropical countries. Indirect sources of demand-based vulnerability include tourist perceptions of the quality of natural resources and attractions (*e.g.*, coral reefs, beaches, wildlife, and other natural resources) as well as perceptions about health and safety conditions (*e.g.*, risk of vector-borne diseases, tropical cyclones). Induced or economic vulnerability of the demand for tourism relates to the associated effects on tax revenues, prices of tourism services, and the foreign exchange fluctuations. Demand may also be influenced by rising costs of transportation, attractions, accommodations, and food, particularly if mitigation measures include emissions charges.

A survey of hotels, guesthouses, restaurants, bars, and tour operators in two locations in Belize was conducted in June 2006. Interviews with business owners and managers included questions about the vulnerability of their business, economic impacts of past climate-related events, knowledge of climate change, and appropriate adaptive measures. There were 132 respondents to the survey; 96 were located in Ambergris Caye and 36 were located in the Cayo District.

3.8.4 VULNERABILITY OF THE SECTOR

The vulnerability of the tourism sector in Belize to the impacts of climate change is assessed using the conceptual framework presented in Figure 1 along with the results of the survey of tourism-related businesses. Vulnerability is discussed in terms of supply- and demand-based risks.

Supply-based vulnerability

The supply-based vulnerability of tourism in Belize is a function of the sector's exposure to climate hazards as well as its capacity for adaptation. The supply or production of tourism services is directly vulnerable to the effects of climate change in terms of risks to natural resources and attractions and the availability of inputs.

The vulnerability of coral reefs is among the most significant threats to the tourism sector in Belize, as reef-based activities attract more than 80 per cent of tourists who visit Belize. Healthy reefs provide numerous economic benefits, generating income from both tourism and fishing and protecting the shoreline. As early as 1990, tourism based on reefs and beaches contributed almost US$90 billion per year to the economy of the Caribbean region (Reaser *et al.*, 2000). Coral bleaching has been associated with increasing sea surface temperatures. Buchheim (1998) concluded that a conservative temperature increase of 1-2 degrees Celsius would cause regions between 20-30 degrees north to experience "sustained warming that falls within the lethal limits of most reef-building coral species". The Belize Barrier Reef lies near the lower latitude of this range, along with much of the Caribbean Sea, where extensive bleaching events occurred in the mid-1980s during anomalous increases in sea temperatures (Buchheim, 1998). The IPCC (1997) notes that the reefs of the Caribbean Sea already live near their thresholds of temperature tolerance. The first recorded bleaching event in Belize occurred in 1995, and was followed shortly thereafter by a mass bleaching event in 1998, with the bleaching of some individual colonies by more than 90 per cent (WRI, 2005). Coral reefs have also been significantly affected by tropical cyclones in 1998, 2000, and 2001, which reduced coral cover at numerous locations along the barrier reef. Coral reefs are also threatened by dredging, over-fishing, gill netting, trawling, and physical damages from recreation.

The supply or production of tourism services is also affected by climate in terms of risks to infrastructure (from tropical cyclones and flooding) and the loss of coastal land (from rising sea levels). Low-lying islands such as the offshore cayes and atolls of Belize are especially vulnerable to rising sea levels associated with climate change because the land area rarely exceeds 3-4 meters above sea level (IPCC, 1997). Small-island developing states (SIDS), as Belize is characterized, are highly susceptible to the impacts of sea level rise, which could possibly be the most "catastrophic" danger they face (Schmidt, 2005). The vulnerability of coastal areas is exacerbated where mangroves have been removed for development. This threat has been identified as highest along the barrier reef, near Belize City, and near Placencia in southern Belize (WRI, 2005).

More than forty documented hurricanes and tropical storms have passed over Belize in the 20th century. Of the seven hurricanes designated as Category 3 or higher, six have occurred since 1950. Since most tourism development has occurred on off-shore cayes and in coastal areas, the sector faces significant exposure to the risks of increasing storm frequency and intensity. Tropical cyclones are considered to be among the two major geophysical causes of loss of life and property (Anthes, 1982). A statement by climate experts called upon leaders of government and industry worldwide to respond with immediate and sustained action to evaluate building practices, land use, insurance, and disaster relief policies that have served to exacerbate vulnerability to hurricanes (Emanuel *et al*., 2006). This same concern poses serious threats for Belize; the survey of tourism businesses for this study found that more than a quarter of respondents on Ambergris Caye (25.3%) and nearly half of respondents in the Cayo District (45.7%) lack insurance protection against natural disasters.

Inland tourism may be less vulnerable to the impacts of climate change than coastal tourism, yet inland destinations still face risks of damage from hurricanes and tropical storms, river flooding, and losses in biodiversity.

The results of the survey of tourism-related businesses indicate that 54% of respondents from Ambergris Caye and 51% of respondents from Cayo are "highly" or "somewhat" aware of climate change (see Figure 3). Nearly one third of respondents from Ambergris Caye rated their knowledge of climate change as "insufficient;" given the inherent vulnerability of this island and its coastal businesses, these results have significant implications for public education and outreach.

Availability of inputs represents another source of indirect vulnerability of climate change to the tourism sector in Belize. Much of the building materials, food, beverages, and energy supporting the sector are imported from overseas (primarily the USA and UK), and rising fuel costs have already forced increases to many products and services. Rising sea levels threaten the viability of coastal and island real estate, which has the potential to escalate housing costs and strain the supply of labor. A study by the UN Food and Agriculture Organization indicates that developing countries will experience an 11% decrease in the amount of cultivable rainfed land and an associated decline in cereal production due to climate change, and the most significant declines are anticipated for sub-tropical regions, including Central America (FAO, 2005). The FAO also includes the spread and emergence of diseases in livestock and plant pests among the impacts of climate change.

Demand-based vulnerability

The vulnerability of the demand for tourism depends on the tastes and preferences of tourists and the price elasticity of demand for tourism products and services. People will continue to travel, however the activities and destinations they choose will most likely change. Perry (2006) suggests that tourists are flexible in choice and decision making, but tour operators and local tourism managers are less flexible. Since little is known about the preferences and priorities of tourists toward environmental features and the implications of climate change, an assessment of demand-based vulnerability of tourism in Belize would be enhanced by a contingent visitation analysis (Richardson, 2007). A visitor survey would be used to elicit responses from tourists about their visitation behavior contingent upon various climate scenarios and changes in environmental features.

Tourism demand in Belize may be directly affected by climate change in terms of changes in the weather of the host country and the country of origin. Maximum temperatures during the peak tourist season in Belize average about 30º Celsius (or 85º Fahrenheit), which is within the range of optimal air temperatures for water-based activities (Hall and Higham, 2005), but may be at the upper bound for comfort in the inland forested regions of the Cayo District, where the stagnant heat is not tempered by sea breezes.

Weather in country of origin may also affect the demand for tourism in Belize. More than 80% of overnight visitors to Belize come from the USA, Canada, and Europe (BTB, 2007), and there is concern that rising temperatures and milder winters in the home countries may reduce the appeal of Belize and other tropical destinations for leisure travel in favor of destinations closer to home. The findings of Amelung *et al*. (2007)

suggest that climatically ideal tourism conditions are likely to shift poleward, which would negatively affect tropical destinations such as Belize.

Tourism demand in Belize may be indirectly affected by visitor perceptions of the quality of tourism resources as well as perceptions about risks to health and personal safety. The vulnerability of the tourism sector in Belize is underscored by its dependence on coastal resources. Reef-based activities attract the greatest level of participation among tourists in Belize, according to the Visitor Expenditure and Motivation Survey, administered by the Belize Tourism Board (2004). Snorkeling and diving attract 57.2 and 24.3 per cent of tourists, respectively, while river trips, caving, and birding attract 23.7, 19.6, and 12.9 per cent of tourists, respectively. In terms of sites, the cayes attract 70.3 per cent of tourists, while archaeological sites and national parks attracted only 37.4 and 29.5 per cent, respectively. These statistics suggest that the perceptions of reef quality may be an important factor in the assessment of the vulnerability of tourism demand to climate change. A study of tourist preferences for environmental features in the Caribbean found that roughly 80% of tourists in Bonaire would be unwilling to return in the event of coral bleaching from climate change; more than 80% in Barbados would be unwilling to return in the event of beach erosion from rising sea levels (Uyarra *et al.*, 2005). These findings have negative implications for return visitors to the cayes (where reef-based activities are important) and Placencia (where beach features are important). The 2003 Visitor Expenditure and Motivation Survey (VEMS) found that approximately 18% of tourists in Belize had visited before (BTB, 2004); the Uyarra *et al.* (2005) findings suggest that return visitors to coastal destinations could be substantially reduced if environmental features are affected by climate change.

Incidence of tropical diseases such as malaria and dengue fever are relatively rare in Belize, but an increase in prevalence would be costly in terms of reduced demand from wary travelers. The geographical distribution of these vector-borne diseases, along with water-borne, heat-related, and food-borne diseases is expected to expand as a result of warming temperatures. Risks of personal safety related to tropical storms are a potential factor for vulnerability, although the peak tourism season presently does not coincide with the hurricane season.

Overall, given the present distribution of tourism activities and expenditures in Belize (and assuming no adaptation measures), approximately 45% to 70% of the tourism sector is highly vulnerable to the effects of climate change. At current spending levels, this range corresponds to BZ$ 180 to BZ 280 million (or US$90 to $140 million), and is related to the proportion of tourism that is centered on the cayes, atolls, and coastal zones, and depends on the barrier reef and coastal resources for sustainability. The vulnerability is directly related to rising sea levels, increasing temperatures (and coral bleaching), and the increasing frequency and intensity of tropical storms. This estimate is based on secondary data and the results of other studies, and would be improved by additional research on the possible demand response to changes in environmental features.

3.8.5 ADAPTIVE CAPACITY

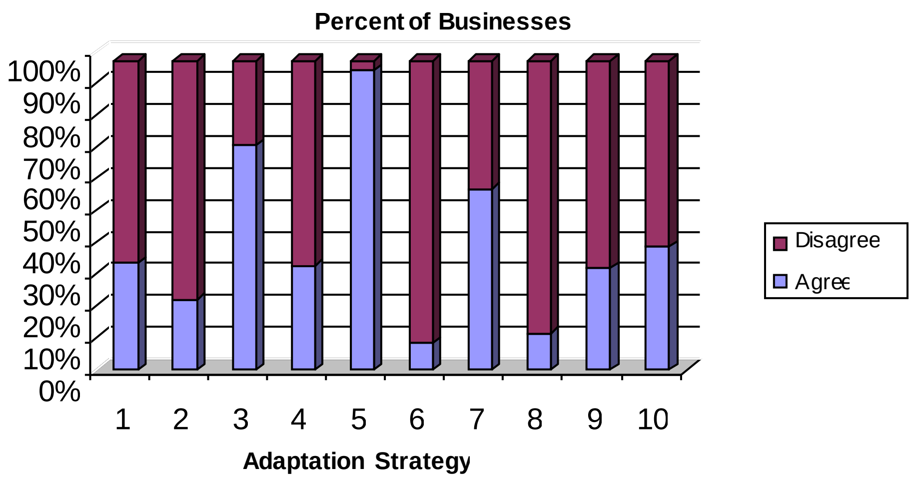
Since tourism in Belize contributes a relatively small fraction of overall greenhouse gas emissions, a strategy to mitigate the impacts of climate change would only be marginally effective. Thus, the focus of the response from the tourism sector is on adaptation. From a national perspective, Belize has limited capacity to adapt to the exposure of its tourism sector to the impacts of climate change. The country is constrained by unsustainably high levels of public debt, which consumes increasingly greater portions of national income. Public debt now hovers around US$1 billion, which is roughly equivalent to GDP; debt service has nearly tripled since 1990 and currently represents over a quarter of GDP (UNDP, 2005). Belize has limited access to capital, and credit rating agencies have downgraded the country's debt to their lowest possible levels. The economy, which was historically based on preferential trade agreements with the UK, USA, and the European Union, faces significant uncertainty because of free trade policies and the erosion of trade pacts enforced by the World Trade Organization.

However, the tourism sector and the ministries that regulate natural resource and land uses possess significant capacity to devise adaptation measures through their planning, marketing, and policy making authority. Belize is rich with abundant natural resources, and tourism policies that focus on reducing the exposure of the tourism sector to the impacts of climate change would increase its adaptive capacity. Examples of adaptation strategies include the construction of sea wall defenses to stem coastal erosion, restoration of natural defenses (*e.g.*, mangrove swamps, vegetation, and land levels), beach nourishment, and greater attention toward disaster preparedness planning. Tourism marketing strategies could be modified to more significantly promote inland attractions, such as limestone caves, tropical rainforests, and Mayan archaeological sites, in an effort to further diversify the tourism portfolio. Coastal development should be planned with caution in light of the physical vulnerability of beaches, construction, and infrastructure. The feasibility of installing artificial reefs should be considered as part of a strategy to offset some of the potential losses stemming from the negative impacts to reef-based tourism and to divert some of the pressure of visitor impacts from existing Marine Protected Areas on the barrier reef. Also, the very unique Blue Hole Marine Park exists at such a depth that its attributes are likely to be more resilient to the effects of coral bleaching; although it is intended for more experienced divers only, the marketing of its attraction could be viewed as an adaptation strategy to the vulnerability of shallow coral reef diving sites.

Most importantly, an emphasis on education and public awareness of the vulnerability to climate change, both in the public sector as well as among private businesses, is essential. While many business survey respondents indicated that they had considered the potential impacts of climate change in their business plans or strategies, most of those who had not cited a lack of expertise, knowledge, and technology as their reasons. Responses to many of the survey questions revealed the insufficient awareness and understanding of climate change and its potential impacts, which underscores the need for greater education and outreach.

Respondents to the survey of tourism businesses were asked about their perceptions of possible adaptation strategies for Belize. The strategies that were supported strongest were to strengthen national research (71%) and to increase public awareness (94%), suggesting that information-based adaptation strategies would be most effective. There was very little support for strategies such as the development of alternative energy sources (22%), relocation of vulnerable coastal settlements (8%), and the construction of sea walls for protection (11%). Responses are presented below in Figure 38.

Figure 38 Perceptions of possible adaptation strategies for Belize



1. Promote energy efficiency
2. Develop alternative energy sources
3. Strengthen national research
4. Discourage construction in coastal zones
5. Increase public awareness
6. Relocate vulnerable coastal settlements
7. Enhance disaster preparedness plans
8. Construct sea walls
9. Restore mangroves
10. Promote reforestation

The conceptual framework presented in Figure 37 can be a useful basis for identifying and prioritizing adaptation measures. For example, given the importance of reef-based activities for tourism in Belize and the vulnerability of reefs to the impacts of climate change, a coordinated preservation effort could be developed to focus on preventing boats from anchoring in reef areas, educating for sustainable fishing, reducing agricultural pollution, and reducing cruise-ship generated waste. The infrastructure supporting the tourism sector is vulnerable to rising sea levels and the increasing frequency and intensity of tropical storms, but this vulnerability may be mitigated by an increasing investment in reinforcement, resilience, and relocation of physical structures. The construction of sea walls may provide added defense against the impacts of climate change. Increasing linkages with local agriculture may reduce the dependence on some imports. Additional research regarding tourist preferences and priorities for environmental features and recreation activities may reduce uncertainty and provide useful information for future planning and marketing of destinations in Belize. Projected impacts of climate change and associated adaptation measures are presented below in Table 24. These measures are suggestions for consideration and deliberation; other appropriate measures may be identified through stakeholder planning.

Table 23 Climate change impacts and adaptation

Impacts	Adaptation measures
Increasing temperatures/hot weather	Building design to increase airflow; trees for shade
Rising sea levels/erosion	Sea wall defenses; mangrove restoration; beach nourishment; trees for protection
Tropical storms and hurricanes	Storm-proof construction and reinforcement; trees for windbreaks
Coral bleaching	Marine protected areas; pollution control; coral regeneration
Droughts	Rainwater collection systems; water tanks
Water availability	Conservation; tourist education and awareness

3.8.6 CONCLUSIONS

Tourism in Belize generates roughly BZ$400 million (or US$200 million) in expenditures per year, directly representing about 17% of GDP and indirectly supporting numerous other sectors from inter-industry trade.

Tourism-dependent nations—especially Small Island developing states such as Belize—are vulnerable to the effects of climate change. The conceptual framework presented in this assessment can be useful in assessing the economic vulnerability of the tourism sector to the effects of climate change such as rising sea levels, loss of coastal land, and warming sea temperatures. Furthermore, the framework can be useful in identifying and prioritizing adaptation measures. An assessment of economic vulnerability should consider the exposure of the tourism system to the hazards of climate change as well as the adaptive capacity of states and communities. Climate effects will vary based on behavioral responses; lower income countries have much less capital to invest in adaptation and mitigation measures, and this condition intensifies the existing risks.

The application of this conceptual framework to the tourism sector of Belize highlights several areas of supply- and demand-based economic vulnerability to climate change, including the risks to coastal land and infrastructure, exposure to resource damages such as coral bleaching, and an associated reduction in demand because of resource changes or risks to personal health and safety. A preliminary assessment of Belize's tourism sector suggests that it is highly vulnerable to the effects of climate change through both its exposure to climate impacts and its weak capacity for adaptation. Adaptation measures that reflect these specific sources of vulnerability should be considered in light of the country's limited capacity to moderate the harmful effects of climate change. Such measures include diversifying the portfolio of tourism offerings to emphasize inland attractions, planning for coastal development with greater caution, and considering the feasibility of artificial reefs as underwater attractions to alleviate some of the existing pressures on Marine Protected Areas.

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3.9 Water Resources

Figure 39 below represents the watersheds and the sub-watersheds of Belize. The Hydrology Unit of the NMS recognizes 18 major watersheds and a number of sub-watersheds.

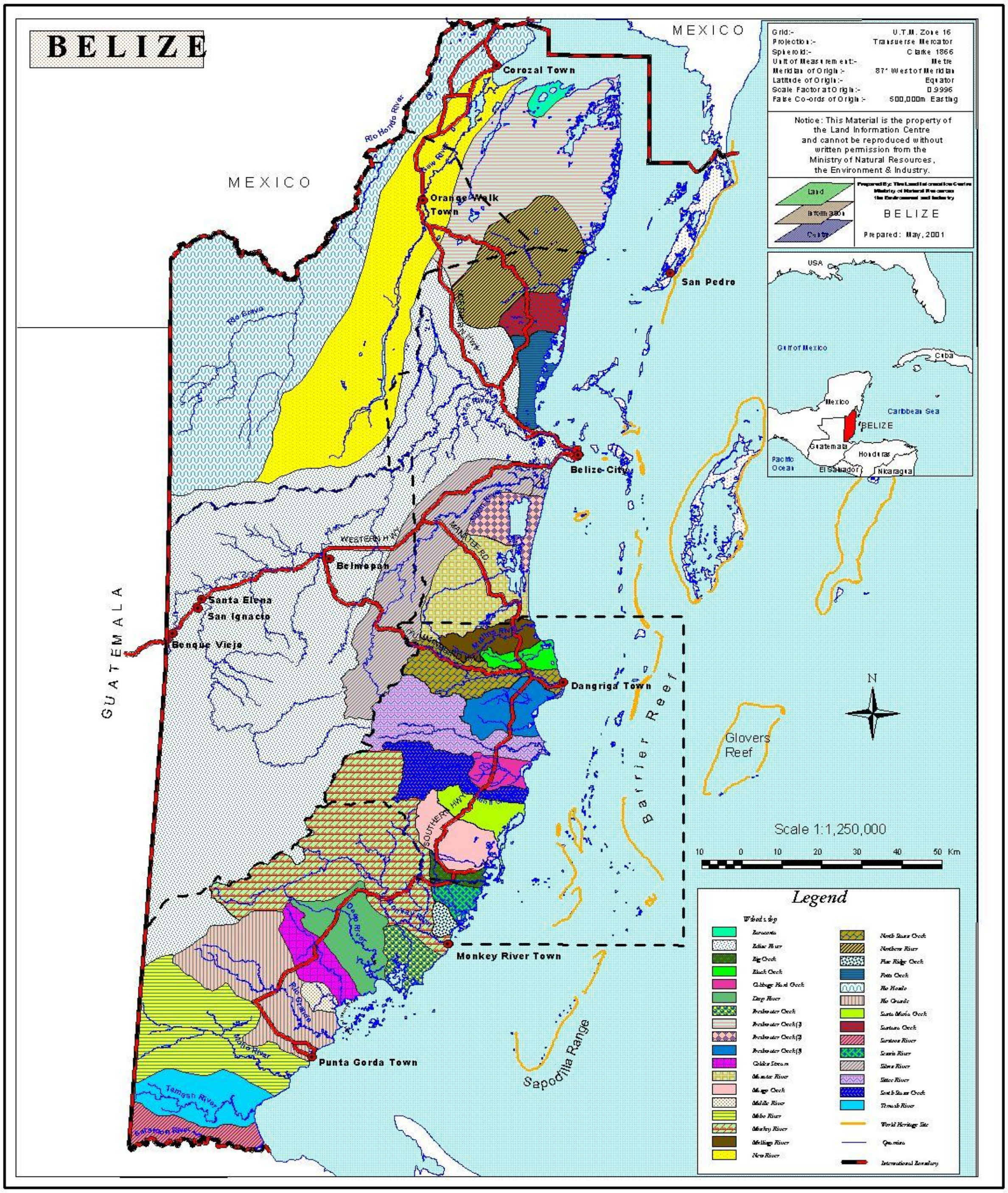
A pilot water resources vulnerability and capacity assessment was conducted in Belize under the sponsorship of the Caribbean Community Climate Change Centre. The site selected was the North Stann Creek River

Watershed (NSCW). The NSCW covers an area of 281 square kilometres and a maximum elevation of 900 metres above sea level. It extends from near the center of the Belizean coastline westwards to the Maya Mountain divide. The population of the watershed is estimated at 12,243 (April 2008), with the main urban area, Dangriga Town, providing home to 10,800 residents. The NSCW is Belize's main citrus producing area which contributes significantly to the Gross Domestic Product (GDP) and employs in excess of 500 workers within the NSCW area. In addition, there are more than 200 citrus growers who depend on the successes of the citrus industry.

The study utilized the future data on climate conditions provided by the Cuban Meteorological Institute (INSMET) to conduct water balance calculations on the hydrologic soil complexes in delineated water management units, using geographic information systems and water resources tools to determine runoff. Water availability was determined using the rainfall projections provided by INSMET and the evapo-transpiration calculated using the PRECIS model temperature outputs and the Thornthwaite's formula.

Potable water demand studies were conducted using population estimates and historical per capita water consumption. The agricultural water demand was calculated using the area under cultivation and the crop reference water requirements. The total water demand was the sum of the potable and agriculture water demands. The vulnerability of the water resources is indexed to the ratio of the water demand and the water availability.

Figure 39 Map of the Major Watersheds in Belize
Source: Department of the Environment



Box 5: Water Resources Vulnerability Index[x]

$$\text{VULNERABILITY INDEX} = VI = \frac{\text{Water Demand}}{\text{Water Availability}}$$

The results indicated that considering all seasons and the relative influences of the sub regions, the sub-catchments above the Melinda Rainfall District Collection Centre have the greatest impact on the NSCW water resources vulnerability to climate change. Generally, the NSCW is not vulnerable to climate change impacts. Water resources in the NSCW will become critically vulnerable during 2012, 2032, 2061, and 2085. The North Stann Creek water resources vulnerability index was calculated on annual and seasonal basis. It involved the determination of the inflows in the form of the water availability and the demand, in the form of the outflows, abstraction for potable water, and agriculture water for the citrus cultivation and runoff. Generally, high water demand and low water availability will produce high vulnerability while low water demand and high water availability will result in low vulnerability

For hydrological/climatological purposes, the country was divided into three regions; the northern; central; and southern. Climate change impacts on the water sectors in these regions were not uniform and, as such, each region are considered separately.

In the northern region, there is projected to be a decrease in precipitation, which will likely result in a reduced recharge for groundwater in the north. Compared to other regions of the country, the north is less endowed with water resources and its existing water resources are more intensively used with irrigation of rice and papayas and by the sugar agro-industry.

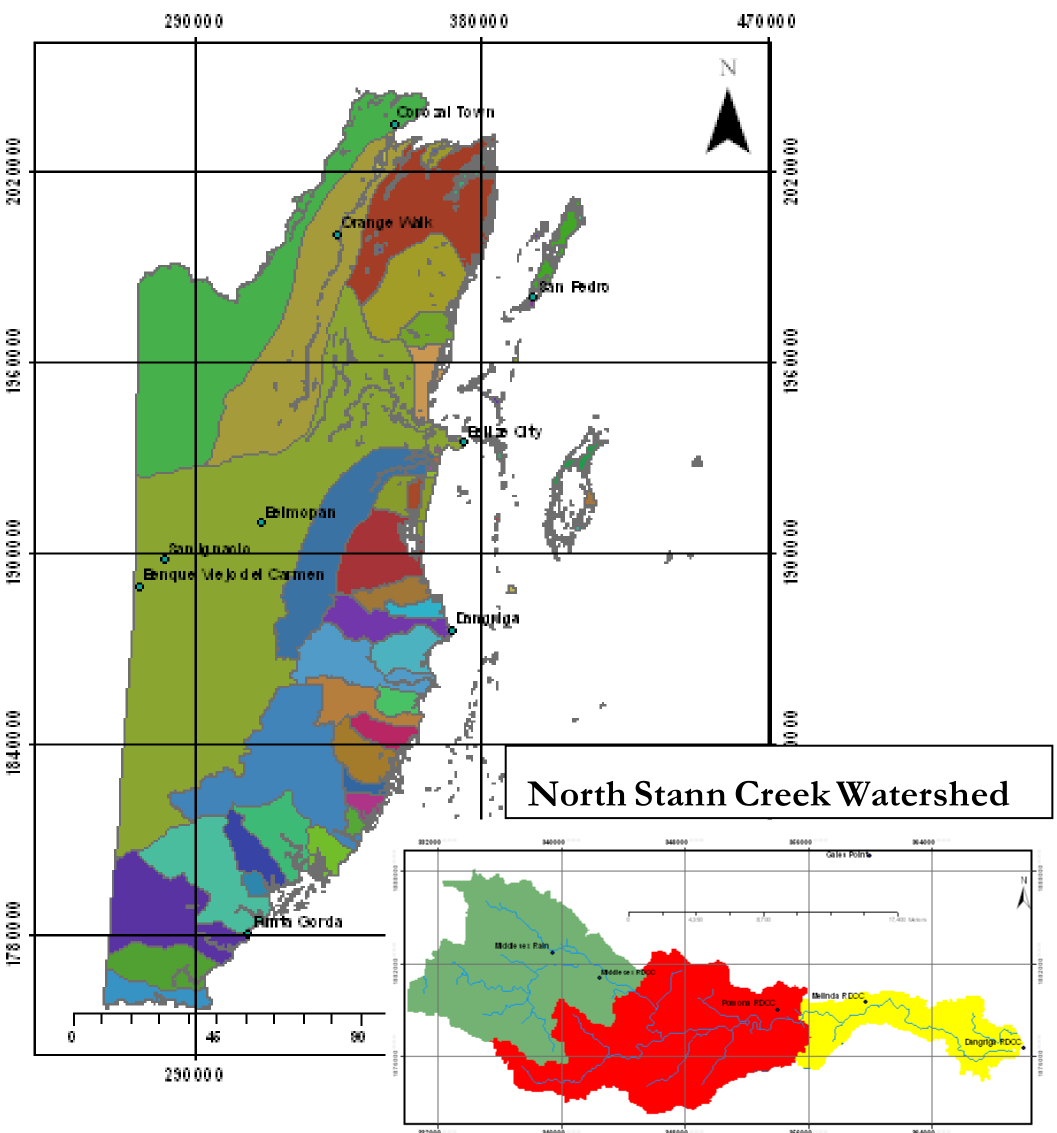
A similar scenario is likely in the central region. There is also intensive use of water in this region; this region is most densely populated since it includes the Belize and Cayo districts. Given that the southern region is least populated and has the most water resources, decreases in water runoff are not likely to have major negative effects.

An impact of climate change on the water sector is likely to be a continued deterioration in water quality brought about by a combination of decreased water runoff, agricultural pollution and increased urbanization. This will increase treatment costs for potable water as well as result in greater competition for the use of this increasingly scarce resource. This could be the genesis of water conflicts.

Any reduction in availability of water especially for agriculture is likely to have an impact on food security. The northern and central regions of the country are the country's bread basket, where the overwhelming percentage of one of its major staples, rice, is cultivated. A comparatively smaller percentage of the country's rice is grown in the south using rain fed methods, but it is mainly in the north that intensive use of water for rice occurs.

Yet another impact of climate change on the water sector is increased frequency of salt water intrusion. This will increase as sea levels rise. Salt water intrusion is regarded as the displacement of fresh surface water or groundwater by the advance of saltwater due to its greater density. It usually occurs in coastal or estuarine areas (e.g. either from reduced runoff and associated groundwater recharge or from excessive water withdrawals from aquifers) or increasing marine influence (Bates et al 2008). Monitoring along the Belize River has found evidence of salt water intrusion as far upstream as the Philip Goldson International Airport, which is only a few miles downstream from Double Run, the location of the water intake that BWSL uses to supply Belize City. Saltwater intrusion may also be possible in Dangriga, where BWSL's water intake is only some two miles from the coast. The economic impact on the water sector arises when potable water supplies are affected by this intrusion resulting in increased treatment costs and decreased water quality.

Figure 40 Location of the North Stann Creek Watershed



Climate change is also likely to bring to the fore, issues with national security implications. This is because some of Belize's major rivers originate in neighbouring countries which are likely to experience similarly negative climate change impacts. Actions by these countries could affect the flow of water to Belize. For example, Belize's main waterway, the Belize River, has marginally in excess of 30% of its upper watershed in Guatemala. There are reported high levels of poverty in Guatemala, most notably in its provinces that are adjacent to Belize's western border. There are also more intensive agricultural practices that are likely to negatively impact water quantity and quality flowing eastwards to Belize. A somewhat similar situation obtains in southern Mexico, the source of the Rio Hondo.

3.10 RECOMMENDATIONS

Measures to improve efficiency should be applied by the commercial water suppliers, in extraction from the sources, storage, and delivery to customers. This will be important in the context of reduced water availability occasioned by climate change.

Another recommendation is to conserve the country's water resources. The study estimated that the agriculture sector was the country's single largest user accounting for marginally in excess of 43% of the over 15 B gallons used in 2007. A sizeable portion of the water used in this sector is used in low efficiency surface irrigation systems that cause high water losses. In virtually all instances, agricultural companies that source their water for irrigation from rivers have no incentive to be efficient in water usage since the water is "free". The recommendation is to provide incentives to encourage the use of more efficient irrigation equipment to minimize water losses and encourage conservation of the resource.

CHAPTER 4 PROGRAMMES CONTAINING MEASURES TO MITIGATE CLIMATE CHANGE.

Belize has not actively designed and implemented projects to mitigate climate change. However, some energy sector projects implemented or underway have the potential or actually result in reduction or avoidance of greenhouse gases emissions. The SNC Project Execution Group approved assessments of mitigation impacts in the sectors of electrical energy generation through hydro-dams, co-generation, solid waste management, and solar panel applications. The energy sector was also surveyed since it was one of the larger sources of GHG emissions in the first national inventory.

4.1 INTRODUCTION

As reported in the INC, prior to 1996, Belize was almost entirely dependent on the importation and combustion of fossil fuels for energy generation. That situation changed during the latter half of that decade. A hydro-dam system designed to generate a maximum of 27 megawatts under optimum conditions of water supply from the Mollejon facility was constructed as the first of a three-phase power generation project. This represented approximately 50 percent of electrical energy needs at that time.

No mitigation studies had been undertaken to examine the potential to reduce emissions due to energy generation. However, the second greenhouse gas inventory provided relevant data needed to calculate the impact of the introduction of renewable energy sources on national emissions. To the extent possible further studies were conducted to calculate the greenhouse gas emissions that were averted by the introduction of hydropower into the national grid in 1995, and the impacts of further expansion of the system by 2005 with the introduction of a reservoir and additional generating capacity. Projections are that, after assessing the potential impacts of proposed additional hydro-generation facilities and the proposed co-generation facility, GHG emissions will decrease. The assessment also determined the impact of the avoided GHG emissions resulting from the application of solar panels at an entire village level for electrical power generation, as well as the impact of replacing thousands of incandescent bulbs with compact fluorescent tubes.

4.2 ABATEMENTS IMPACTS OF ENERGY PROJECTS

4.2.1 IMPACTS OF HYDRO-ELECTRIC POWER GENERATION

The construction of hydro-dam for the generation of electricity was a measure designed to reduce the countries dependency on fossil fuels for local electrical power generation, and the dependence on power imported from Mexico. The fact that the project also reduced the emissions of GHG was an additional environmental benefit. Various other activities have been undertaken in the energy sector to improve and increase electrical energy generation and distribution which has resulted in some changes in the GHG emissions. The only supplier of energy to the Belizean consumer is Belize Electricity Limited (BEL). BEL, however, has been moving away from the generating aspect of the industry and focusing mainly on the transmission, distribution and sale of energy. They source their energy from three main suppliers, BECOL, Comisión Federal de Electricidad (Mexico) CFE and HydroMaya. BEL still has a small generating capacity of 36.2 MW which is used to help with the peak demand of 70.0 MW if necessary, as well as for the purposes of block-start. BEL therefore still relies on fossil fuel to a limited extent for some of its in-house generation.

Although Belize Sugar Industry (BSI) is not a commercial energy generating company, the company generates over 60% of the power necessary for its sugar cane processing. The company purchases some of the additional energy required from BEL. BSI's bagasse project has been delayed and is not expected to be on line until 2009. This project will generate renewable energy using bagasse, which will be used to supply BEL with16 MW of power, thus further reducing BEL's need for the 36.2 MW generated from fossil fuel.

4.2.2 THE BELIZE SUGAR INDUSTRY CO-GENERATION PROJECT

The general project is to analyze/assess the mitigation (abatement) potential and status of Greenhouse Gases Emissions through Hydropower Generation and Biomass Co-generation of Electrical Energy in Belize. The consultants analyzed/assessed the greenhouse gases abatement (mitigation) impact of the Macal River Hydro Project and the potential of the Belize Sugar Industries (BSI) Bagasse Co-Generation Plant on greenhouse gases emissions in Belize. The project is centered on the power-generating sector and actions put in place to minimize the use of fossil fuel for this industry. The project seeks to determine what impacts (whether positive or negative) have been made or will be made on the greenhouse gases emitted by the Energy sector in Belize. It will indicate whether, if any, changes have been made in the type and quantity of GHGs emitted.

The country of Belize covers some 8,867 sq. miles and is occupied by 311,500 people, (Abstract of Belize 2007) a population density of 35.1. While the distribution of the population is almost even with 152,500 occupying the urban areas and 148,800 the rural areas, the majority of the population is located in the Belize District with Belize City being the most highly populated area in excess of 63,000 people. The entire country is electrified by Belize Electricity Limited, which has a customer base of over 70,000. BEL shows an average growth rate of 9% per annum. This increase dictates the constant need for additional energy generating sources. If clean generating sources cannot be realized, Belize's dependency of fossil fuel will increase. As the rates of fuel continue to increase, the cost of electrical energy will continue to escalate resulting with a decrease in the country's development as well as major socio-economical problems. Families will become marginalized and will be unable to afford electricity.

While BEL supplies energy to the entire country, there are still 1,394 privately owned generating systems that supplies energy to their respective establishment. This does not account for the private generators that are used for standby purposes. Similarly over 1,000 households supply their household with light using gas and 6,859 use kerosene for lighting purposes. The use of the kerosene and gas for light is concentrated in the Toledo and Cayo Districts.

The First Greenhouse Gas Inventory was completed in 1999 using 1994 as the reference year, while The Second Greenhouse Gas Inventory was based on two reference years 1997 and 2000... However, each reference year reported is actually the median of a three-year period. This study included the recalculation of the first Greenhouse Gas Inventory, which was done for the baseline year 1994. The results of the recalculation did not show any significant difference in emissions.

The results of this study show that total emissions due to the energy sector activities for 1997 were 609.47 Gg and 619.87 Gg for the year 2000. By reviewing only that which is generated by BEL or that which is purchased by BEL, we find that it does not give the total picture as was compiled previously for the energy sector. However what is clearly demonstrated is that the use of Hydro generated energy contributes tremendously to a cleaner environment and serves to mitigate GHG emissions.

While the BSI program is delayed, the stored volume bagasse remains approximately the same and thus produces an estimated 385,794 Gg CO_2. It is expected that the GHG emissions from sector will be reduced upon completion of the project that proposes to utilize all the bagasse.

Table 24 Trends in Energy Generation

FUEL TYPES			*1994*	*1997*	*2000*	*2007*
Liquid Fossil	Secondary Fuels					
		Gas / Diesel Oil	545	824.35	645.12	69.52*
		Other Oil				
Liquid Fossil Totals			545.00	824.35	645.12	69.52
Solid Fossil	Primary Fuels	Anthracite (a)				
Total			545.00	824.35	645.12	69.52
Biomass total						
		Solid Biomass (Bagasse)	293,244	297,352	301,525	385,794
* This figure represents only what BEL generates from Diesel fuel						

4.2.3 POTENTIAL IMPACT OF CO-GENERATION (BIOMASS) OF ELECTRICAL ENERGY

This study analyzed the beneficial effect of using biomass fuel to generate electrical energy as a replacement for diesel fuel generation. It will examine the Belize Sugar Industries/Belize Electricity Limited project that will utilize industrial waste from the sugar factory to produce a significant proportion of Belize's electrical energy needs.

The general project is to analyze/assess the mitigation (abatement) potential and status of Greenhouse Gases Emissions through Hydropower Generation and Biomass Co-generation of Electrical Energy in Belize. The consultants analyzed/assessed the greenhouse gases abatement (mitigation) impact of the Macal River Hydro Project and the potential of the Belize Sugar Industries (BSI) Bagasse Co-Generation Plant on greenhouse gases emissions in Belize. The project is centered on the power-generating sector and actions put in place to minimize the use of fossil fuel for this industry. The project seeks to determine what impacts (whether positive or negative) have been made or will be made on the greenhouse gases emitted by the Energy sector in Belize. It will indicate whether, if any, changes have been made in the type and quantity of GHGs emitted.

BELCOGEN/BSI

Belize Sugar Industries Limited, the sugar-cane processor, is the only private sector lead, owned and managed sugar factory, processing 1.25 M tons of cane in the northern region of Belize. Ninety five percent of the sugarcane is grown by independent cane farmers under the Belize Cane Farmers Association who represent 9000 farmers.

This industry is regulated through the Sugar Act of 2001.

Figure 41 Aerial View of BSI Sugar Factory

Belize Cogeneration Energy Limited (BELCOGEN) is a 100% owned subsidiary of Belize Sugar Industries Limited. BELCOGEN is an Independent Power Producer (IPP) established to manage the US$62 million, 31.5 MW renewable energy power plant project. This project is designed to meet the Government's National Security Interest of reducing the reliance on imported energy supply, fulfill the policy of promoting renewable energy sources, to provide the much needed additional capacity of Energy to the National Grid, and to facilitate displacement of Fossil Fuel based Energy and reduce Foreign Exchange Demand.

The project is the initiative of BSI as Project Promoter, and BSI has engaged Booker Tate as the Project Developer. This project, upon completion, will supply approximately 20% of the National Energy Demand by 2009. This project had been scheduled to be completed as early as 2006 but had encountered a number of setbacks. It is now expected to be completed in 2009.

BELCOGEN will generate power and steam to supply BSI's Tower Hill Sugar Factory and BEL's power grid. The BSI Sugar factory uses approximately 1.25 M tons of cane, harvested from 60,000 acres, to produce 97 thousands long tons of sugar creating 430,000 tons of waste, bagasse. BELCOGEN will utilize the 430,000 tons of bagasse to generate:

1. 585,000 tons of process steam for BSI
2. 32.5MW Cogeneration Power as follows:

    Extracting Condensing Steam Turbine 15 MW

    Back Pressure Steam Turbine 12.5 MW

    Two Parallel HFO Generators each 2.5 MW

3. Up to 16.5 MW to be sold to BEL as base load Power
4. Generate 106 GWh for supply to BEL
5. Generate 44 GWh for supply to BSI

BELCOGEN has signed a 15 year power purchase agreement with BEL to supply 16.5 MW of base load power and a 20 year power purchase agreement with BSI to supply 9 MW of power and 135 t/h of process steam.

Green House Gases Status

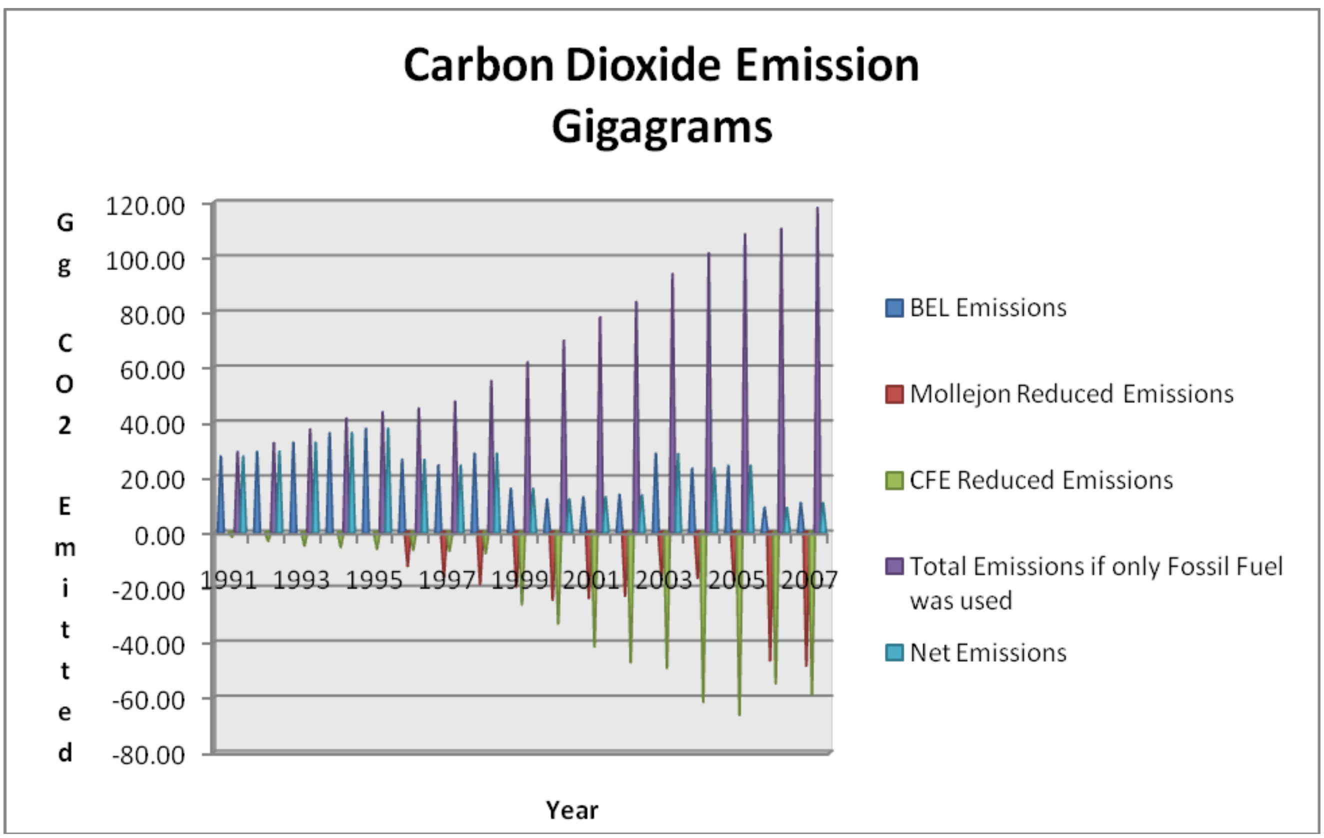
Over the period of 1991 to 2007 BEL's energy output increased from 111.57 GWh to 451.06 GWh. The generation of this energy has changed from being supplied from only fossil fuel generating stations to a combination of fossil fuel, hydro and purchase from Mexico. While growth or demand for energy took place and increased over 400%, it might have been expected that the emissions of green house gases would have increased proportionally. Table IV indicates that GHG emission should have gone from 29.16 Gg of CO_2 to

117.88 Gg CO_2. This was not the case. As BEL searched for ways of meeting the power demand, the advent of renewable energy sources entered the development process. While there was a constant increase between the periods of 1991 to 1995, from 1996 to the present shows declining dependency on fossil fuel. This was a result of the Mollejon Hydro project that came on line in 1995 and was fully operational in 1996. The advent of this plant showed the reduction of GHG to 26.39 Gg. While the following years showed a constant decrease in GHG emissions as the Hydro systems became more operational, the overall effect appears to be fluctuating. This is evidenced as two opposite forces tried to reach a balance. As the energy demand increased, the emissions of GHG started to increase. This was mitigated by two factors. The first was the clean energy produced by the Mollejon run-of-the-river plant. This was complemented with power being purchased from Mexico. While the power purchased from Mexico resulted in less GHG produced in Belize, it must also be noted that one of Mexico's sources of energy generation is the burning of fossil fuel. GHG does not respect borders, thus Mexico's generation of GHG will contribute to the global problem.

In 2006 a major decrease in the emission of GHGs from the energy sector was noted. This was the result of the Chalillo Dam's completion and its full operation for the year 2006. With Chalillo operating in 2006 and 2007, as well as HydroMaya, there is evidence that these projects have significantly reduced GHG emission down to 10.65 Gg. This is easily compared to the 1991 levels when Belize was dependent solely on fossil fuel energy generation, GHG emission was 27.59 Gg. In 2007 after the completion of the Chalillo and Mollejon project, even with the purchase of power from Mexico, BEL's emission fell to 10.65 Gg. This is more than a 50 % reduction of emission with energy demand increasing to 4 times the requirement in 1991.

As stated before there are indications that with the completion of the Vaca Hydro project and the BSI/BELCOGEN bagasse project, the country's dependency on fossil fuel will reduce to almost nil, similarly the GHG emission of CO_2 will be reduced to an almost negligible quantity from this source.

Figure 42 CO_2 emissions from different sources



Conclusions

Belize Electricity Limited (BEL) has contributed to the energy industry's reduction of GHG emissions over the sixteen-year period since the company produced less electricity by fossil fuel generation during this time. Instead, the company supplied electricity to the consumers through hydroelectric sources or procuring energy from Mexico. In 1994, BEL consumed 94% of all fuel used for energy production. This consumption decreased to 86%, 82% and 42% for 1997, 2000 and 2007 respectively. This trend continues with the advent of the Vaca Falls project. This decreasing trend in emissions will continue as the bio-generation project of BSI comes on stream in 2009. Not only will the BELCOGEN project assist in BEL reducing the use of fossil fuel, but GHGs emitted by the decaying bagasse will also decrease as BELCOGEN use the biomass for energy generation.

The environmentally friendly energy generation from both the Hydro system and bagasse system benefits extends into the economic value of the energy. Presently BEL is seeking an increase in the electricity rates paid by the consumer. This is due to increasing fuel prices. The purchase of energy from Mexico is also tied to fossil fuel prices. With the complete BECOL project – Chalillo, Mollejon and Vaca, and the BSI/BELCOGEN project, electricity rates should not be dependent on fossil fuel prices. This should allow the cost of electricity to either go down or become stabilized. Also, the closing of the Caye Caulker plant, which uses only fossil fuel, should also result in the further reduction of emissions and high electrical rates.

Other areas of concern would be the additional diesel generating sources that are coming on line. One such example is the Belize Aquaculture Limited (BAL) Company and the Belize Natural Energy (BNE) proposed generating company. Both of these projects depend on the combustion of fossil fuel.

The discovery of oil in Belize places the nation in the position of balancing the need for economic benefits derived from the oil and maintain an environment with minimal negative impact. While this is a national decision, the high energy rates charged by BEL have caused both the slow industrial growth of the nation as well as financial strain on the population. The fossil fuel wells should provide opportunities to contribute to economic growth while reducing dependency on imports of certain commodities. Technology exists to mitigate the emissions from the utilization of fossil fuels, but it requires continuous monitoring by the state agencies, and incentives to the industry to ensure that the proper measures are applied.

For Belize to remain a sink and make its contribution to the mitigation of Global Warming (and climate change), various actions and activities should be further investigated and developed.

a. Continue the Various Hydro Projects – Complete the Vaca station and investigate the capabilities of the other rivers in Belize, especially the Southern Rivers

   - Hydro generation is cleaner & should be cheaper

b. Investigate the possibility of BSI project expanding in the immediate future

   - This would help to increase the sugar industry's life – jobs, farmers would not need to sell their farms etc
   - BELCOGEN/BSI should investigate the possibility of expanding to burning other biomass

c. Minimize purchases from CFE

   - Belize needs to move towards being energy self sufficient as well as manage its power quality and reliability
   - Approximately 50% of CFE generation is from fossil fuel and this does not help the region

d. BEL should aim to reduce and/or clean its diesel generating plants

   - Presently we have limited control of fuel prices. These are constantly increasing and BEL keeps requesting a raise in the electrical rates. This will further stifle the economic growth and development of the country as well as, the consumers will not be able to afford the rates. – power cost increases

- Diesel generation plants must be design to be cleaner
- Diesel plants should try to utilize their waste, exhaust – heat etc, to regenerate- cleanup the waste rather than emitting major pollution, not only CO_2 other carbon waste and by products – oil base

e. Belize needs to develop and implement a National Energy Policy

f. Belize must continue to reduce the GHG footprint by implementing the necessary specific programs needed for mitigation

4.2.4 POTENTIAL IMPACT FROM THE RECOVERY OF METHANE FROM LAND FILLS (PROPER SOLID WASTE MANAGEMENT)

The Solid Waste Management Authority has been activated and plans are underway to begin construction of a properly designed solid waste treatment facility. This phase of the project is to serve the communities of Belize City, the City of Belmopan, and the western towns of San Ignacio, Santa Elena, and Benque Viejo. This study will examine the abatement impact of this system compared to the existing situation of garbage dumps.

The energy and waste sectors had been major sources of emissions for the first reporting period. Since then some important changes have occurred in Belize. Belize has reduced its electrical power generation from diesel fuel by constructing and commissioning hydro-electric systems. The solid and liquid waste sectors have also seen some developments, so the positive impacts of these changes will be assessed through the four above-listed projects.

The study sought to analyze the potential of utilizing the methane (CH_4) component of the landfill gas (LFG) that is expected to be produced at the proposed Mile 22 (Western Highway) Regional Sanitary Landfill, Belize, C.A., for electrical energy generation, as a viable economic and environmentally friendly operation to abate/mitigate the GHG emissions that would otherwise result in the no project scenario. The assessment was based on the potential implementation of a landfill gas collection, control and utilization project at the proposed landfill.

It was assumed that construction would start in 2009 for the proposed Mile 22 Regional Sanitary Landfill, and in 2011 the landfill would start to receive municipal solid wastes from the Western Corridor, consisting of the Belize District, San Pedro, Caye Caulker and the Cayo District.

The proposed landfill to energy utilization project would consist of the installation of an LFG collection system to extract LFG from the landfill to fuel a power plant or various plants, using internal combustion engine generators. It was also assumed that the gas collection and control system/flare, is installed as landfilling progresses, with flaring of landfill gas commencing as of 2012, while the amount of MSW (municipal solid waste) in place and LFG generated, would increase to a level where the installation of the power plant becomes economically feasible. The revenue streams for the potential landfill gas to energy project would come from the sale of electricity to Belize Electricity Limited (exporting power to the grid) and from the sale of Certified Emission Reductions (CERs) of greenhouse gases on the international carbon market.

Summary of relevant information and assumptions used in the study:

- Construction should start in 2009 at the Mile 22 Regional Sanitary Landfill and be operational in 2011, receive MSW until the year 2041, or a design life of 30 years. By 2018 the cumulative MSW in place should be 1,115,813 metric tonnes.
- The landfill site comprises of some 100 acres or 40 ha.

- The landfill site will be underlain by a relatively impermeable layer of clay some 40 to 50 ft. thick. At final grade the landfill will achieve an average height of 10 meters.

The results of the Central America Landfill Gas Model used in assessing the production and predicted recovery of LFG indicated the following:

Scenario #1: Mid Range Gas Recovery Rates, 75% GCC&S (Gas collection and control system) coverage from 2012 to 2040 and 85% GCC&S coverage from 2041 onwards:

1. Projected gas recovery in 2012 is estimated to be approximately 116 m^3/hr and should increase steadily to a maximum of 3,609 m^3/hr in 2042.
2. After site closure LFG recovery is expected to decline rapidly, reaching 1,400 m^3/hr in 2048.
3. Two power generation start up options were analyzed under this scenario, each with the sale of CERs and without sale of CERs and a flaring only option:
    - In the ***2014 to 2048 power generation option***, it was estimated that in 2015 there would be sufficient LFG available to support a 1.0 MW power plant through 2018. In 2019 LFG production increases and there would be sufficient LFG available to support an additional 1.0 MW power plant boosting capacity to a total of 2.0 MW until 2026. In 2027 LFG production should be able to support an additional 1.0 MW power plant, boosting total capacity to 3.0 MW until 2034. In 2035 LFG production is expected to support an additional 1.0 MW power plant, boosting total capacity to 4.0 MW until 2043. In 2044, LFG production will decrease to an extent that requires the reduction of generating capacity by removing the first 1.0 MW plant reducing total capacity to 3.0 MW until 2045. Finally, in 2046 LFG production continues to diminish and only a 2.0 MW plant can be supported, requiring the removal of a second 1.0 MW plant, leaving total generating capacity at 2.0 MW until 2048. Maximum generation capacity under this option is 4.0 MW.
    - The ***2018 to 2048 power generation option*** is similar to the 2014 to 2048 option only that power generation start up is in 2019 with a 2.0 MW plant**,** while in the latter option, start up is in 2015 with a 1.0 MW plant.
4. A schedule for increasing and declining power plant capacities based on predicted LFG recovery was provided in the report.
5. Regarding the environmental impacts of the proposed LFGTE (Landfill Gas To Energy) project, specifically the abatement/mitigation of GHG (Greenhouse Gas), assuming start up of the LFG collection and control system/flare in 2012 and power generation as indicated above, it was estimated that the implementation of the landfill gas to energy project at the Mile 22 Regional Sanitary Landfill, would result in emissions reduction of 223,721 metric tonnes of CH_4 (methane) or 4,698,143 metric tonnes of CO_2e (carbon dioxide equivalent) or 4,698 Gg of CO_2e for the period 2012 to 2048. VOCs (Volatile Organic Compounds) and HAPs (Hazardous Air Pollutants) emissions would also be reduced as a result of the combustion of the LFG, whether in the internal combustion engine or by flaring. Though, the combustion process itself also produces some emissions to the atmosphere, such as CO (Carbon Monoxide), NOx (Nitrogen Oxides), SOx (Sulfur Oxides) and PMs (Particulate Matter), depending on the emission control system of the power generation options.

Scenario # 2: Low Rate Gas Recovery, 40% GCC&S coverage from 2012 to 2040 and 60% GCC&S coverage from 2041 onwards:

1. Projected gas recovery in 2012 was estimated at approximately 62 m^3/hr and increaseing steadily to a maximum of 2,547 m^3/hr in 2042.
2. After site closure LFG recovery is expected to decline rapidly, reaching 988 m^3/hr in 2048.
3. One power generation start up option was analyzed under this scenario, with the sale of CERs and without sale of CERs and a flaring only option:

- In the ***2018 to 2048 power generation option***, it is estimated that in 2019 there will be sufficient LFG available to support a 1.0 MW power plant through 2032. In 2033 LFG production increase and there would be sufficient LFG available to support an additional 1.0 MW power plant boosting capacity to a total of 2.0 MW until 2040. In 2041 LFG production is expected to support an additional 1.0 MW power plant, boosting total capacity to 3.0 MW until 2043. In 2044, LFG production decreases to an extent that requires the reduction of generating capacity by removing the first 1.0 MW plant reducing total capacity to 2.0 MW until 2046. Finally, in 2047 LFG production continues to diminish and only a 1.0 MW plant can be supported, requiring the removal of another 1.0 MW plant, leaving total generating capacity at 1.0 MW until 2048. Maximum generation capacity under this option is 3.0 MW.

4. A schedule for increasing and declining power plant capacities based on predicted LFG recovery was included in the report. A summary of LFG Model Outputs was included as Annexes to the report.
5 Regarding the environmental impact of the proposed LFGTE project, specifically the abatement/mitigation of GHG, assuming start up of the LFG collection and control system/flare in 2012 and power plants as indicated above, it was estimated that the implementation of the landfill gas to energy project at the Mile 22 Regional Sanitary Landfill, would result in emissions reduction of 129,970 metric tonnes of CH_4 or 2,729,369 metric tonnes of CO_2e or 2,729 Gg of CO_2e for the period 2012 to 2048. VOCs and HAPs emissions are also reduced as a result of the combustion of the LFG, whether in the internal combustion engine or by flaring. Though, the combustion process itself would also produce some emissions to the atmosphere, such as CO, NOx, SOx and PMs, depending on the emission control system of the power generation option.

The project economics, at 10% discount rate, analyzed various options for the two scenarios, including power generation, project duration and project type (power generation or flaring) and sale of CERs. Using the **Mid Range Recovery Rates** for LFG collection, the results of the analysis indicate that the landfill gas to energy project prefeasibility, under the 2014 to 2048 power generation option with sale of CERs (NPV of US$12,115,000 and IRR of 38% and an initial capital investment of US$2,470/kW.) and the 2018 to 2048 power generation option with sale of CERs (NPV of US$14,222,000 and IRR of 35% and an initial capital investment of US2,470/kW.) are favorable enough to proceed to a feasibility study phase, if electricity sales price (US$0.10/kWh) and CERs (US$5.00/metric tonne of CO_2e) prices were assumed and/or higher.

The **Low Rate Gas Recovery Scenario**, 2018 to 2048, representing the lower bound of economic analysis, indicates that the power generation option with the sale of CERs is also favorable with an NPV of US$6,279,000 and an IRR of 33% and an initial capital investment of US2,750/kW. Flaring only options do not seem to be attractive under this scenario, most likely because of the overall low levels of LFG generation and the opportunity cost of flaring the LFG instead of generating electricity.

The MSW site characteristics, final average height of 10 m or 33 ft>30 ft, mean annual precipitation of 1691 mm or 66.6 inches>25 inches and the composition and amount of MSW in place (in 2017 there will be approximately 1,039,370 tons>1,000,000 tons) when power generation is planned to start, in addition to the environmental benefits and revenue streams derived from the sale of the electric power and CERs, makes the Mile 22 Regional Sanitary Landfill a suitable candidate for further feasibility study and analysis.

4.3 Avoided Emissions from Solar Panel Utilization at the Village Level

San Benito Poite is a remotely located village in southwestern Belize, at least sixteen miles from the nearest link to the national electrical power grid. During the last quarter of 2004, solar photovoltaic power systems were installed at every home and community building that existed in the village at the time of the project. A complete system consisted of one or more solar panels, a charge controller, one or more deep cycle batteries, a 500W inverter, a power box with 4 DC circuit breakers, wiring, and mounting.

Details of the installation were obtained from records in the village:

1. 85 homes had 1-panel system installed
2. The school had a 3-panel system installed
3. 4 churches each had 1-panel system installed
4. The teacher's house had a 1-panel system installed
5. The community center had a 3-panel system installed
6. 5 street light systems were installed

Figure 43 Solar Panel Equipment in San Benito Poite Village, Toledo District, Belize

Surveys revealed that previously, the village of San Benito Poite was dependent on firewood for cooking (97%), and almost all residents depended on kerosene lanterns for lighting. Prior to the solar electrification project in 2004 there was only 1 respondent who had access to a gasoline powered generator. About 63% used kerosene lamps, while 50% used candles for lighting; and only one family had its own solar system.

The study to assess the impact of the project found that Total Electrical Power Use from Solar Project installation in village was 780 kWh/month using the energy saving Compact Fluoroscent Light (CFL) lights that were provided compared to 2,600 kWh/month if incandescent lights had been used.

GHG Emissions Analysis

Analysis of the Greenhouse Gas Emissions avoided by this project is based on the village power use and the common methods of providing power if the solar project had not been done. One very common method for supplying power to a remote village is to set up a diesel generator for the village and to wire to each home. Another common method is to extend the electrical grid as provided by the monopoly Belize Electricity Limited.

Electrical power had been used by one family in the village at all hours of the day, but generally there were easily discerned peak patterns for an hour just before sunrise and for three hours just after sunset. The total electrical power use from the solar systems in the village is already noted.

For estimation of the avoided emissions, all calculations will be based on the most common alternatives if the project had not happened; thus the greenhouse gasses avoided were calculated on a village use of 2,600 kWh/month.

Alternative #1: A Diesel Generator for the Village

A 20kw diesel generator would be a typical size to provide the necessary power for a village of this size. During the 20 off-peak hours each day, the generator would run at only 25% of its power rating, and during the 4 peak hours each day, the generator would run at 50% of its power rating. This relates to typical values of 0.6 gallons of diesel per hour during off-peak hours, and 0.9 gallons of diesel per hour during peak hours.

Thus calculations can be made using the following values:

- 5,694 Gallons of Diesel per year
- 139,000 BTU/gallon of diesel
- 1055.05585262 J/BTU
- 74100 kg CO_2/TJ of diesel

A significant total of 61.9 metric tonnes of CO_2 emissions was avoided each year by this project compared to the use of a diesel generator for the village.

Alternative #2: Extending the power grid of the monopoly Belize Electricity Limited

San Benito Poite is 15 miles from the nearest village of Santa Teresa, which is 8+ miles from the power grid of BEL. While it would not be cost effective to extend the power grid to San Benito Poite, the Government of Belize and other organizations have a history of subsidizing the extension of the electrical power grid to provide service to remote villages. Therefore this report examines the carbon emissions avoided from this alternative. There are two sources of greenhouse gases to consider – from the power generation of BEL, and from the deforestation needed to run power lines for the 15 miles of right-of-way from the nearest village.

For the power use, no national carbon emissions per kWh have been determined for Belize. An average for the US power grid has been determined and is available under the eGRID system, which is listed at 7.78×10^{-4} metric tons CO_2 / kWh. Given that Belize has a higher percentage of fossil fuels in its generation profile than the US, using this number provided a conservative answer with regards to GHG emissions; resulting in 24.27 metric tonnes of CO_2 from grid-based power generation averted each year. With 15 miles of 30 foot wide right-of-way through mostly rainforest area (>80% forested), the carbon loss due to this deforestation would have been: 996 metric tonnes of Carbon Equivalent averted from one-time permanent deforestation. (Source: Miller and Palacio, 2008).

CONCLUSIONS AND RECOMMENDATIONS

One constraint was that there was no structure or systems in place to ensure sustainability of the project. A system should be put in place immediately to look after continuity of the solar system.

4.4 REDUCTION OF EMISSIONS BY REPLACING INCANDESCENT BULBS WITH COMPACT FLUORESCENT TUBES

The Replacement of Incandescent Bulbs with Compact Fluorescent Bulbs was a joint project of the governments of Cuba and Belize. A total of 169,810 bulbs were provided by the Government of Cuba for this project, and 168,912 of these were successfully exchanged at 69,810 locations across the country of Belize.

Many households across Belize continue to use and benefit from the free compact fluorescent bulbs they were given as replacements for their incandescent bulbs. Based on our survey results, 45% of recipients have had one of their CFLs replaced. Accepting that 69,810 homes exchanged bulbs; this would indicate 31,414 bulb failures across the country. This leaves 137,498 operating CFLs from this project (81.4%).

GHG Emissions Analysis

Assumptions:

- The Cuban reports of 168,912 bulbs installed was accurate
- The survey results of 0.126% of the homes involved can be fairly extrapolated
- Compact Fluorescent bulbs use 25% of the power of the incandescent they replaced
- The average incandescent bulb in Belize is 66.2W, as bulbs commonly come in 75W and 60W, as well as 25W, 50W, and 100W
- The average light bulb is on for 4.5 hours
- The eGRID value of 0.00078 metric tonnes of CO_2/kWh is a conservative figure to use in Belize

Results:

- 13,775 MWh of electricity could have been saved annually
- 11,213 MWh of electricity are being saved after bulb breakage
- 8,724 metric tonnes of CO_2 are being saved annually (Miller and Palacio, 2008)

Economic Analysis

- Results showed that 63% of the respondents indicated that they were paying less (electric bills) because of the CFL.
- Given that the average incandescent light bulb being replaced used 66.2 watts and that compact fluorescent technology uses 75% less power than incandescent, at a cost of BZ$0.35/kwh the average home saved $56.22 per year in electricity costs. The average person in the survey used to pay $61.95 monthly so this represented 7.6% savings in electricity costs to the typical customer.
- The cost of electricity had continued to increase, so that the customer might not have realized the savings.
- During potential peak hours just before and just after dark, this project may have reduced peak demand 6.8 MW. It also saved BEL from having to purchase more than 11,200 MWh annually. Given that BEL already purchases expensive diesel based power from Mexico to meet the demand in Belize, this project helped BEL significantly in trying to keep electricity costs lower and increasing national security.

Conclusions

- These projects contributed to the mitigation of greenhouse gas emissions in Belize.
- Due to the fact that these projects were completed for social, economic, and poverty alleviation purposes, the recipients identified both these reasons for the projects and as advantages of the solar systems and/or compact fluorescent lights provided to them.
- None of the recipients indicated that global climate change mitigation was an advantage, although this study clearly indicates such. This opens a door for education about global climate change issues in Belize.

- While greenhouse gas abatement was not a goal of either project, the significance of these measures with respect to emissions from this developing country should be recognized and appreciated at the local, national, and international levels.

CHAPTER 5 STEPS TAKEN TO IMPLEMENT THE CONVENTION

5.1 INTRODUCTION

The National Meteorological Service has been the agency in the forefront of the implementation of the Convention since Belize signed on. There have been some significant achievements from 1992 until the date of preparation of the SNC.

5.2 POLICY

The initiative to refine and adopt a national climate change adaptation policy was advanced through a number of consultative meetings aimed at finalizing some instruments applicable to the management of climate change. The NFP and the NMS reactivated the National Climate Change Committee, first established in 1995, to enable oversight of the preparation of the SNC. The Project Execution Group that provided the direct oversight was therefore a sub-group of the National Climate Change Committee.

The NCCC was also kept informed of national, regional, and international activities, including progress in the negotiations, related to climate change through periodic briefing meetings conducted by the NFP and the Alternate. A revised set of Terms of Reference for the NCCC was developed, although the process to finalize and adopt these would be completed outside the term of the SNC Project.

5.3 SYSTEMIC OBSERVATIONS AND RESEARCH

5.3.1 BELIZE'S ACTIVITIES IN THE IMPLEMENTATION OF GLOBAL CLIMATE OBSERVING SYSTEM (GCOS)

Introduction

Belize reported on its activities relating to its systematic observations program and its progress in implementing the GCOS Implementation Plan. This report was produced in response to SBSTA's invitation to the Parties to submit to the secretariat, by 31st January 2009, information on national activities in implementing the GCOS action plan. The revised UNFCCC reporting guidelines on global climate observing systems were very helpful in the preparation of this report.

The National Meteorological and Hydrological Service (NMHS) of Belize is the leading governmental authority in providing the nation with climate-based products derived from systematic and accurate monitoring and data collection and data analysis. The Service collaborates and provides technical support and training to our systematic climate observing network partners across the country.

The NMHS is the focal point for GCOS related activities and is committed to meeting its observational requirements to address national, regional and global climate change issues. It recognizes the importance of adequate high quality, systematic and comprehensive observations to effectively assess climate change and its potential impacts, to develop effective mitigation and adaptation strategies, as well as to assess risk and vulnerability. The NMHS is also aware that to achieve the level of observations required, considerable effort is necessary from all stakeholders. However, not much progress has been made in implementing GCOS related activities. The greatest obstacle is budgetary constraints and other more urgent national priorities that lower the priority of systematic observation programs. This has significantly reduced the maintenance and monitoring of systematic observing systems of our network stations. Improvements in the national observing networks have been extremely slow.

Common Issues

Planning

The National Meteorological and Hydrological Service (NHMS) in Belize coordinates all climate related measurements nationwide. As the GCOS focal point, the National Meteorological and Hydrological Service will establish a Task Group with responsibility to coordinate and enhance capacity for climate observations in keeping with GCOS requirements. Its task will be to produce a plan on national climate observation needs and actions to be taken in the atmospheric, oceanic and terrestrial domain. Top priority will be to undertake a survey visit of all the systematic observation systems in order to identify the extent of assistance needed to rehabilitate degraded stations. The Rehabilitation Project is expected to begin in March when each station will be rebuilt. Second priority is to expand the network and train personnel to do the observations. This plan includes replacing unreliable stations with automatic observing platforms. Any expansion may not include all stations that are closed, but new partners may need to be identified.

Quality Control, International Data Exchange and Data Analysis

a) Quality control is undertaken in keeping with World Meteorological Organization standards where manual observations and coding practices are monitored and data quality checked, including homogeneity.

   However, errors caused by inaccurate transcription, evaporation loss, loss during measuring and general exposure can go undetected especially for older records. For older records, systematic errors may also arise due to changes in the measurement techniques before the World Meteorological Organization standard of observations was implemented.

b) There are no policy barriers with respect to international exchange of essential climate variables. Climate data are transmitted on a monthly basis to the International Data Centers.

5.3.2 ATMOSPHERIC ESSENTIAL CLIMATE VARIABLES

Currently, none of Belize's weather stations are part of the GCOS (GSN) network. However, its activities are relevant to GCOS. The NMHS operates a network of 1 synoptic station, (21) climate stations, and (26) rainfall stations including the Synoptic and Climate stations.

The Philip SW Goldson International Airport (PSWGIA) is the only synoptic station and is operated by the National Meteorological and Hydrological Service. Hourly observations are conducted during the day and every three hours in the night. Datasets for hourly observations include temperature, humidity, wind speed and direction, atmospheric pressure, cloud types, amounts, and occurrence of rain/showers, thunderstorms and fog.

Observations for Dry, Wet, Maximum and Minimum Temperatures as well as rainfall from the other network stations are made at 09:00 LST (1500 UTC). Eight of these report sunshine. Ten report 1ft and 4ft soil temperatures. There are 11 evaporation pans in the network.

The rainfall values reported for the daily observations represent data collected during the previous 24 hours, ending 09:00LST (1500 UTC). Readings are taken by private sectors such as industries, non-governmental organizations (NGOs), intergovernmental organizations, and government personnel.

Hourly and daily data are entered in the CLICOM data base on a regular basis. Quality assurance of all data is consistent with WMO guidelines. The CLICOM data base is a computer database programme that provides standardized quality control procedures, storage and manipulation of a large number of elements.

The PSWGIA station has about 45 years of uninterrupted time series of meteorological data. The time period from the other stations vary in length from a few years to a few decades.

The PSWGIA station provides a monthly climatological summary message (CLIMAT) to the international data centres on a regular basis.

The challenge the NMHS is currently facing due to budgetary constraints is the infrequent inspection of network stations to ensure that exposure of instruments and the integrity of observations are kept within WMO standards. As a result, significant data gaps continue to exist at most of the stations.

Climate data from suitable stations were used to construct climate projections for temperature and rainfall. This information was used to conduct vulnerability assessments in Tourism, Agriculture, and Coastal Zone, Fisheries, Health and Water Resources sectors and to design adaptation strategies.

Table 25 Essential Climate Variables for GCOS

Contributing networks specified in the GCOS implementation plan	ECVs[a]	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2010	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
GCOS Surface Network (GSN)	Air temperature	0	0	1	1	1
	Precipitation	0	0	1	1	1
Full World Weather Watch/Global Observing System (WWW/GOS) surface network	Air temperature, air pressure, wind speed and direction, water vapour	0	0	1	1	1
	Precipitation	0	0	1	1	1
Baseline Surface Radiation Network (BSRN)	Surface radiation					
Solar radiation and radiation balance data	Surface radiation					
Ocean drifting buoys	Air temperature, air pressure					
Moored buoys	Air temperature, air pressure					
Voluntary Observing Ship Climate Project (VOSClim)	Air temperature, air pressure, wind speed and direction, water vapour					

Contributing networks specified in the GCOS implementation plan	ECVs[a]	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2010	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
GCOS Surface Network (GSN)	Air temperature	0	0	1	1	1
	Precipitation	0	0	1	1	1
Ocean Reference Mooring Network and sites on small isolated islands	Air temperature, wind speed and direction, air pressure					
	Precipitation					

[a] Parties should note that the list of ECVs given for each network is indicative of the expected observations from that network. A single response/data entry is expected for each network except for those networks for which precipitation is reported, where a separate response/data entry is requested owing to its particular importance with regard to the Convention.

Belize has one radiosonde station located at the PSWGIA which is a part of the GCOS Upper Air Network (GUAN). Upper air observations are performed once a day outside of the hurricane season and twice a day during the hurricane season from mid-July to mid-October. The data are analyzed by trained operators and then stored and sent to the National Climate Data Centre (NCDC) in Asheville, USA. Effective data quality control is a multi-tiered process involving the upper air observer, National Centres for Environmental Prediction (NCEP), NCDC and the administrative officer. Measurements are in compliance with WMO coding requirements. Metadata records are submitted to the appropriate international data centre.

Table 26 National contributions to the upper-air atmospheric essential climate variables

Contributing networks specified in the GCOS implementation plan	ECVs	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2010	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
GCOS Upper Air Network (GUAN)	Upper- air- temperature, upper- air wind speed and direction, upper- air water vapour	1	1	1	1	1
Full WWW/GOS Upper Air Network	Upper- air- temperature, upper- air wind speed and direction, upper- air water vapour	1	1	1	1	1

5.3.3 OCEANIC ESSENTIAL CLIMATE VARIABLES

There were three (3) tide gauges and marine meteorological stations in Belize. One station was destroyed by Hurricane Mitch in 1998. The other two deteriorated due to lack of maintenance and are now non-functional. As a result, there is no continuous sea level and sea surface temperature data. One tide gauge will be installed by the end of February 2009.

5.3.4 TERRESTRIAL ESSENTIAL CLIMATE VARIABLES

The Hydrology Unit within the National Meteorological Service of Belize currently manages and maintains 27 hydrological observation sites in all but two of the country's 18 major watersheds. The Unit is responsible for collecting and analyzing data on the quantity, quality, and variability of Belize's water resources. There are two watersheds in the extreme south with no stage gauge monitoring sites. The plan for the near future is to expand the hydrological monitoring network into these remote watersheds in southern Belize.

Table 27 National contributions to the terrestrial domain essential climate variables

Contributing networks specified in the GCOS implementation plan	ECVs	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2010	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
GCOS baseline river discharge network (GTN- R)	River discharge					
GCOS Baseline Lake Level/ Area/Temperature Network (GTN- L)	Lake level/area/ temperature	0	**0**		0	0

5.4 CAPACITY BUILDING

Belize has made efforts to build capacity to address climate change issues in both the public and the private sector. The National Meteorological Service has sought to enhance its staff capacity with the further education of its staff members. Two staff members were enrolled in the UWI, Barbados Campus pursuing bachelor's programmes in Meteorology, during the period of the preparation of the SNC. The upgrade and expansion of the headquarters of the NMS, in conjunction with the installation of a new Doppler 500 KM Radar (completed in late 2008) and training of the technicians, also enhanced the capacity of the NMS in the delivery of services.

It was not only the staff of the NMS who increased knowledge and understanding of the phenomena of global warming and climate change. Representatives of the private sector were also provided opportunities to learn by participating in regional and international meetings and training workshops. For example, of the three Belizean delegated who participated in the CCCCC facilitated training course on the use of Agricultural Modeling Tools held in Guyana 2008, two were from the private sector, while the other was a staff member of the Ministry of Agriculture. The two consultants were those engaged in conducting the vulnerability assessments of the agriculture sector. On another occasion, another private-sector consultant undertook training in vulnerability assessments along with staff member from the Fisheries Department and the NMS in Trinidad, also completed in 2008.

5.5 PUBLIC AWARENESS AND EDUCATION

Since the preparation and the publication of Belize's First National Communication, many organizations and institutions have become involved in education and public awareness on the theme of climate change. These range from the government's Ministry of Education and the Ministry of Natural Resources and the Environment, to agencies such as World Wildlife Fund Belize among others.

Early during the project period the PEG had decided not to design and implement a single awareness and education programme, because of the many that were already underway, but instead to support those initiatives being implemented by the MNRE. Later during the period of preparation of the SNC, one of the Meteorologists in the National Meteorological Service was designated as the Coordinator for Public Awareness and Education programmes related to climate change. The project provided support in many different ways, but also enables the NMS to produce various materials for education of the public, a few being specifically targeted to certain focus groups of stakeholders.

5.5.1 NATIONAL SYMPOSIUM ON CLIMATE CHANGE

A National Symposium on Climate Change was held in Belize City in November 2007. This was planned to coincide with the worldwide launch of the United Nations Development Programmes (UNDP) 2007/2008 Human Development Report. Presentations covered topics such as reports on a number of the vulnerability and adaptation assessments (coastal zone, fisheries and aquaculture, water resources, and tourism) completed by that time a Belize Tourist Board initiative on the implementation of environmentally friendly best practices for the Hotel Industry, and the impact of the bark beetle infestation on the Mountain Pine Ridge Forest Reserve. The one-day symposium also enabled presentation by the World Wildlife Fund on "Enabling Adaptation to Climate Change"; "Youth Adapting to Climate Change" by a local Youth Environment Group; and "Regional Efforts in Climate Change" by the CARICOM Climate Change Centre headquartered in Belize. The session ended with the formal launch of the Human Development Report by the UNDP Resident Representative and the National UNDP Environmental Programme Officer.

5.5.2 YOUTH INITIATIVE REGARDING CLIMATE CHANGE

The Y-FOCUS Club is an independent, voluntary, youth body with national membership that has undertaken to place climate change issues on its agenda. Its primary aim is to foster contact, communication and cooperation amongst youth in Belize. It seeks to build the community through volunteer service, peer-peer education and intervention programs. They actively seek to obtain, understand and address their concerns by utilizing appropriate steps or methods inclusive of finding ways of enforcing any relevant statutory instruments.

The group is a member of CYEN- the Caribbean Youth Environment Network and is a non-profit organization dedicated to improving the quality of life of Caribbean young people by facilitating their personal development and promoting their full involvement in all matters pertaining to the environment and sustainable development. The organization promotes education and training, Caribbean integration and community empowerment as tools to develop an ethic amongst young people that assists in the conservation and protection of natural resources within the Wider Caribbean.

Their areas of attention include:

- Environmental Education
- HIV/AIDS outreach initiatives
- PSE preparations classes with Lake Independence Schools
- Community Clean-up campaign
- Walk Against Crime
- Development of annexed Y-FOCUS Environmental Club
- Capacity and leadership training

Objectives of Climate Change mitigation amongst young people

- To raise awareness about climate change among youth in the Caribbean by utilizing the media, the internet, as well as other innovative communication methods inclusive of popular and other participatory cultural activities
- To develop the capacity of young people from participating Caribbean countries in energy auditing and business development related to climate change.
- To lobby governments to implement national policies addressing climate change and share experiences with other small island developing states, and
- To lobby support from public, private, government and non-government sectors to support initiatives and entities as Y-FOCUS, to advocate and mitigate awareness and interventions on climate change to provide for youth and national development.

5.5.3 SCHOOL CONTESTS ON CLIMATE CHANGE

Following a successful competition held in each district during April and May 2007, the Ministry of Natural Resources and the Environment announced the six national winners of the "On-the-Spot" Painting Competition.

For the second year, the MNRE hosted the annual "On-the-Spot" Painting Competition. In May 2008, six judges representing the National Institute of Culture and History, the National Meteorological Service and the Ministry of Education completed the task of judging 420 entry paintings, each submitted by a primary school student who participated in the "On-the-Spot" Painting Competition.

The competition was held under the theme *"Belizeans Changing Behaviors to Adapt to Climate Change."* This activity formed part of the commemoration activities for Belize's 3rd Annual Natural Resources Week.

Figure 44 Teachers being provided background material for the painting Competition

The competition had been preceded by a serious of countrywide presentations by the staff of the Ministry of Natural Resources and the Environment. The presentations focused on the same theme as the competition and were designed to pass on information to teachers, who would then be able to impart the same information about climate change and adapting to the phenomena. The second year of the programme saw considerable increase in participation since schools from all six districts were able to participate.

The winning posters were retained by the NMS for future use in educational and awareness projects about climate change.

5.6 OTHER INITIATIVES

Progress has been made in a number of sectors or sub-sectors since Belize completed the First National Communication. Examples of such initiatives include a preliminary study aimed at formulating an Energy Sector Policy for the country; inception of a Sustainable Land Management Project; assessment of the value of the Barrier Reef for its physical and ecological benefit, and introduction of green technology (environmentally friendly practices) by the hotel industry. These all involve voluntary participation of government and non-state stakeholders, and each could or would contribute to Belize's mitigation or adaption to climate change over the short-, medium-, and long-term.

Energy Sector Diagnostic

In July 2003, The Public Utilities Commission, with the support of the United Nations Development Programme (UNDP) and the Government of Belize commissioned a sector diagnostic of the energy sector in Belize. This included a review of the technical specifics of the sector and an analysis of the context for renewable energies in Belize.

The findings of that study are summarized as follows:-

- Given the current energy mix (imports 71%, indigenous 29%), energy security and improving energy autarky should be significant issues for policymakers;
- Belize does not have a formally stated energy sector strategy nor policy although there may be an implicit one;
- The current electricity mix with 50% imported from Mexico is not sustainable given that demand is growing at 9% p.a.
- The use of renewable energies is technically, environmentally and economically feasible and given the exigencies of the internal and external environment, is highly recommended;
- There are barriers to the use of Renewable Energy Technologies and to the development and implementation of a formal energy policy;
- Policymakers cannot afford to disregard regional and international agreements and the significance of existing and future commitments (particularly in trade) to the development of the energy sector;
- Belize needs to take immediate and decisive action if it is to comfortably meet electricity and energy demand forecasts without increasing its vulnerability and/or compromising its future development.

According to the World Energy Outlook 2002, there is expected to be rapid growth in the demand for energy to the year 2030, at a rate of 1.7% annually. In fact, by that time it is predicted that the world will be consuming two-thirds more energy than it did in 2002, and the developing countries will replace the industrialized world as the largest group of energy consumers. Fossil fuels, and in particular oil, will remain the dominant sources of energy, though renewable energy will increasingly contribute to power generation.

The Study concluded that Government had, through its various instruments and policy statements indicated a commitment to development, through the pursuit of economic and social strategies that are intended to address poverty alleviation and growth.

Energy, because of its established links to the development process through issues such as poverty alleviation, the environment, and economic growth, is a central part of the development equation. Thus, it must be a consideration for Belize and its policymakers as they contemplate the country's medium and long-term development strategies. Development does not need energy per se but rather the services that it provides. The country's ability to develop in accordance with its defined strategies, in the medium term and beyond is inextricably linked to its approach to energy, the diffusion of energy services and energy security.

The issues to be addressed included:

- How best to reconcile private profitability, market efficiency and cost reduction with security of supply, public service obligations and development goals.
- How best to increase efficiency of production, transmission, distribution and consumption.
- How best to reduce negative environmental impact through the use of technology and alternative energy sources.
- Complementary policy reforms and capacity considerations.

For Belize to meet the electricity demand associated with an average 9% annual growth rate and the increasing demand for fuel in the transportation sector, energy sector planning should be established as a priority, but it must be done carefully. Due diligence must be awarded to analyzing the country's growth options and potential with a trans-temporal and trans-generational commitment. Energy intensity is used to "measure" a country's performance and growth. Traditionally the greater the energy consumption, the greater the economic growth and thus the greater per capita GDP. Today, it is possible to decouple the economic growth/energy consumption parallel because economic growth can be achieved without a corresponding growth in energy consumption. Countries such as Belize, with a transitioning economy and a clear and necessary commitment to sustainable development have an opportunity to leapfrog and avoid the pitfalls associated with inefficient energy consumption.

Given the current interest of central policymakers and strong multi-stakeholder support, Belize is in a strong position to plan for the next ten years. Towards this end, it is necessary to create an enabling mechanism that will create a new "energy road map."

The following immediate (less than one year to implement) activities are recommended:

- Develop a "National Energy Policy" that defines the core elements of and participants in the National Energy Strategy and encourages the development of sustainable and renewable energy technologies. Ensure clear roles, responsibilities and measurable objectives;
- Design and implement processes for the collection of credible energy sector data and information;
- Create the National Energy Implementation Plan 2003-2015. To develop the plan, it is necessary to perform an update of resource assessment taking into consideration isolated as well as on – grid renewable energy technologies, and also develop the feasibility studies of the resources already identified. In the resource assessment exercise particular attention should be awarded to a credible energy balance, incorporating specifically the type and frequency of use of biomass and wood, a wind mapping exercise and the feasibility of ethanol production and application.

CHAPTER 6 OTHER INFORMATION

6.1 ASSESSMENT OF REEFS AT RISK PROJECT

The Reefs at Risk in the Caribbean project was launched to help protect and restore these valuable, threatened ecosystems by providing decision-makers and the public with information and tools to manage coastal habitats more effectively. The project focused on compiling, integrating, and disseminating critical information on these precious resources for the entire Caribbean region. This information was intended both to raise awareness about the threats to and value of Caribbean reefs and to encourage greater protection and restoration efforts.

Conducted by the World Resources Institute in cooperation with over 20 organizations working in the region, the project enabled a unique, region-wide look at the threats facing Caribbean coral reefs. The collaborative process of data gathering and analysis produced the first regionally consistent, detailed mapping of these threats. The project provided decision-makers and the public with important insights on links between human activities that stress and damage reef organisms and where degradation of reefs could be expected to occur, or were already occurring. The maps created by the Reefs at Risk project will assist regional and national organizations in setting priorities for conservation and natural resource management. The analytical tools and threat indicators will also allow managers to determine the source and scale of threats affecting those many reef areas for which more detailed monitoring information is unavailable. Figure 45 below shows how the region was demarcated for the purposes of the study. Belize was located in the western Caribbean sub-region.

Figure 45 Reef Area regions of the Caribbean for the Reefs at Risk Study

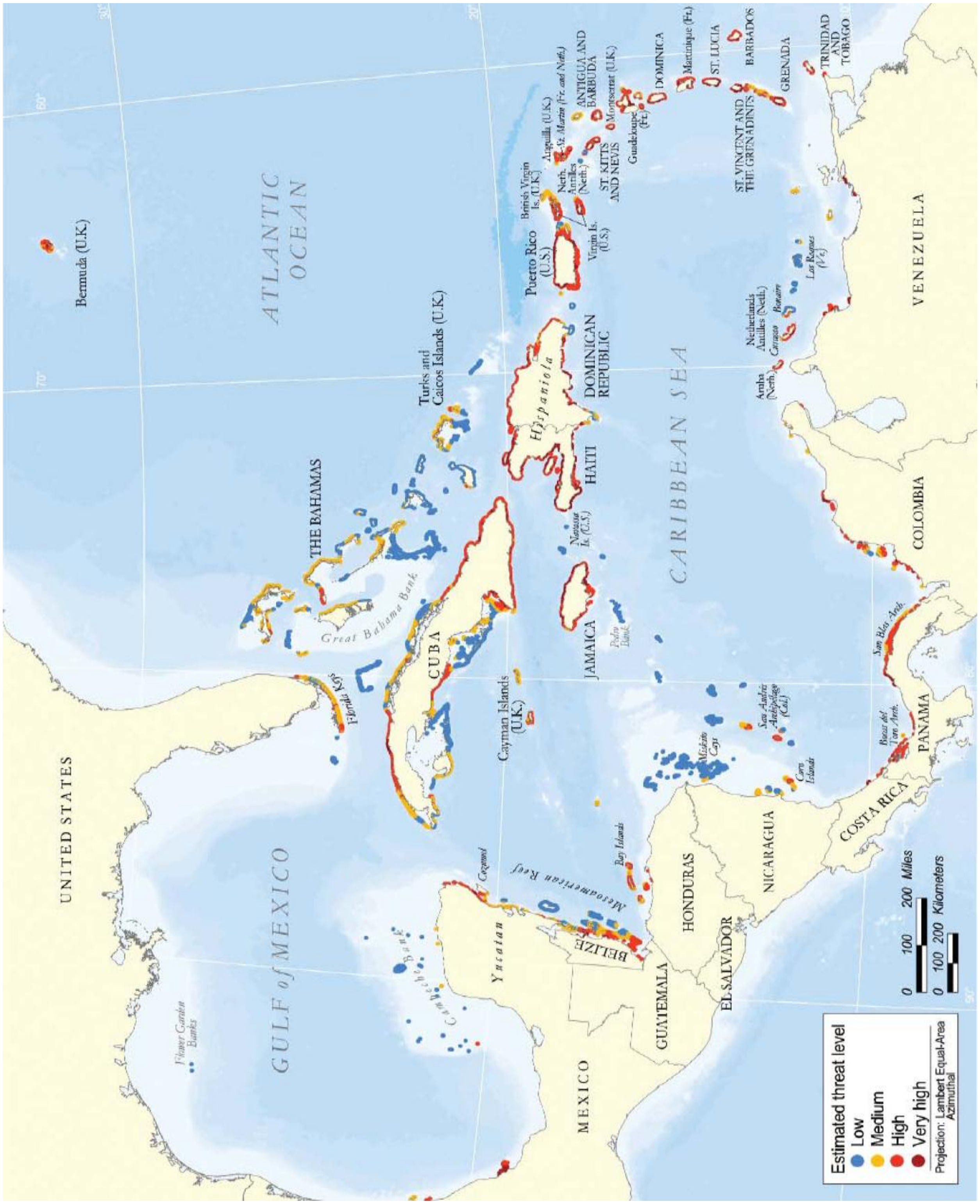
The Western Caribbean sub-region includes one of the longest reef systems in the region. The Mesoamerican Reef stretches from the Mexican Caribbean coast of the Yucatan Peninsula to the Bay Islands off the coast of Honduras. This reef system includes a near continuous barrier reef, which runs for 220 km off the coast of Belize. Overfishing is the most pervasive threat to reefs in the Mesoamerican reef. Off Mexico's Yucatan Peninsula, the Caribbean reefs have been subject to intense artisanal fishing since the 1960s, when this formerly underdeveloped and isolated coast was opened to the pressures of modern development. In Belize, there is evidence of overfishing by small-scale local fishers and industrial fishing fleets. Intensive fishing in Honduras has affected the reef populations around the Bay Islands, and fishers also travel to remote offshore banks instead of fishing the heavily exploited fringing reefs. Coastal development is rapid, with tourism burgeoning in many coastal areas. The Mexican state of Quintana Roo has become a very successful resort area and is now the main tourist destination within the country. Coastal development is spreading quickly southward along the coast, and the government plans to build a huge, high-density tourist resort complex extending down to the Belizean border. In Belize, larger cayes and tourist centers, like Ambergis Caye and San Pedro Town, are growing rapidly as a result of tourist-based economic activity. Sedimentation is a problem for reefs near the coasts, particularly off southern Belize and continental Honduras, where the intensification of agriculture and logging over the last few decades has resulted in increased erosion. Nutrient pollution is also a problem due to runoff of fertilizer from banana and citrus plantations, from southern Belize down through Guatemala and Honduras. However, standards for minimizing the environmental impact of banana cultivation are being encouraged through initiatives such as the Better Banana Project.[150] Reefs in the Mesoamerican reef, particularly near Belize, were severely damaged by two large-scale, natural disturbances in 1998. A bleaching event, coinciding with high sea-surface temperatures, was followed by Hurricane Mitch, a Category 5 storm. Bleaching caused catastrophic coral loss in the lagoonal reefs of Belize, while the hurricane caused widespread coral destruction in fore reefs and outer atoll reefs. The full consequences of these events will take years to emerge. The Belize Coastal Zone Management Authority and Institute is a model of integrated coastal management for the region. The country's system of 13 MPAs is well-established, with most under active co-management with local NGOs. Monitoring across the whole sub-region was expected to increase under the World Bank/GEF Mesoamerican Barrier Reef System project, which has now expired.

Key Findings

- The Reefs at Risk Threat Index indicates that nearly two-thirds of coral reefs in the Caribbean are threatened by human activities.
- An estimated one-third of Caribbean coral reefs are threatened by coastal development.
- Sediment and pollution from inland sources threaten about one-third of Caribbean coral reefs.
- Marine-based threats to coral reefs are widespread across the Caribbean.
- Overfishing threatens over 60 percent of Caribbean coral reefs.
- Diseases and rising sea temperatures threaten to damage coral reefs across the Caribbean region.
- Ineffective management of protected areas further threatens Caribbean coral reefs.

The level of risks to the Belize Barrier Reef is shown in figure below.

Figure 46 Integrated Threat - The Reefs at Risk Index



Source: WRI, Reef at Risk in the Caribbean, 2004.

6.2 FORMULATION OF INTEGRATED WILDLAND FIRE MANAGEMENT POLICY AND STRATEGY

Forest (wildlands) fires have increased both in frequency and intensity in many parts of the world in recent years resulting in major impacts on forests and wildlife, on rural and urban people and on the economies of the affected countries. The data indicated that over 90% of all forest fires are caused by human interventions, attributed to shifting cultivation, escaped fires for hunting, grazing, burning for agriculture and agribusiness activities (Avella, 2009).

It is not possible to prevent forest fires altogether, but proper management and control can reduce their occurrence and spread, or at least minimize the damage. Faced with increasing fire occurrences and decreasing fire suppression budgets, governments have to consider the full range of fire management options available, including decentralized and community-based management regimes. This paradigm shift recognizes that local people will make themselves become more involved in helping to prevent, suppress and manage forest fires when they are benefitting directly or indirectly from the forest resources that surround them.

Belize and Guatemala participated in the "Strengthening Public Policy Related to Forest Fire Management in Belize" Project over the period November 2008 to July 2009. The purpose/ short-term impact of the project was to develop "a policy and strategic framework for fire management in Guatemala and Belize, which is developed and endorsed by the stakeholders of civil society and by the Governments" (Avella, 2009).

The Project was funded by the Critical Ecosystem Partnership Fund (CEPF) and related to the CEPF's Strategic Direction to promote the participation of civil society in the regional decision making process on investments and policies selected to promote the conservation and sustainable development of corridors in the Selva Maya and Selva Zoque and Chiapas/Guatemalan highlands.

Although apparently not directly related, and not deliberately designed to achieve such an objective, the success of this project has implications for GHG emissions in the region. Belize's second GHG inventory indicated that the greatest proportion of the emissions of the study period was the result of land use change and agricultural activities. Both activities are frequently accomplished with the use of fires which sometimes escape to become wildlands or forest fires. Any effort to bring this situation under control will therefore mitigate the emissions from these sectors.

6.3 SUSTAINABLE LAND MANAGEMENT PROJECT

The Sustainable Land Management Project is a three-year medium-sized project funded by the Global Environment Facility through the United Nations Development Fund initiated in late 2008. It is being executed by the Ministry of Natural Resources through the Forest Department. A key objective of the Sustainable Land Management Project is to mainstream sustainable land management into national development plans by incorporating environment considerations, by improving inter-sectoral coordination, and by enhancing an enabling environment for land management. Clear policy direction was identified as a need, along with the need for review of the legislative framework, along with an improved and enabling institutional framework.

The SLM project seeks to incorporate natural resource management objectives in the poverty elimination strategy and into ongoing projects supporting enhanced policy and planning frameworks. It should complement the outputs of the project for Strengthening Capacity for Coordination of Conservation Management (SCCCM) and those of the sustainable livelihoods components of the Belize Rural Development Project (BRDP). The project aims to strengthen individual and institutional capacities for sustainable land management and for integrated and comprehensive development planning. It should also help to strengthen decentralized governance capacities for sustainable land management at the village council level.

6.4 GUIDES FOR SUSTAINABLE TOURISM

This Inter-American Development Bank funded project was designed and implemented as a facilitating tool for community businesses and for small and medium-sized entrepreneurs to adopt specific actions that would allow them to take the needed steps to carry out and manage sustainable development.

The World Tourism Organization had defined Sustainable Tourism as "satisfying current tourist and host community needs, while protecting and improving future opportunities. It is seen as a guide in managing all resources, in such a way that economic, social, and aesthetic needs may be met, while maintaining cultural integrity, essential ecological processes, biological diversity, and life support systems."

It requires the adoption of "best practices" in order to make sustainable tourism a reality. Corrective or improved measures must be implemented in every area of tourism business management and operation. The goal is to ensure that the least possible impact occurs, that tourist product quality and image are improved, that business development becomes more efficient, and therefore social and economic development also improve.

The project had the participation of about ninety percent of the hotels across Belize, as well as a major proportion of the related service providers.

6.5 REFERENCES

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Burke, Lauretta, Jonathan Maidens, 2004. *Reefs at Risk in the Caribbean*. World Resources Institute, Washington, D.C.

Avella, Evaristo, Carlos Santos, E. Green, 2009. *Diagnostic and Baseline for the Current Situation of Forest Fire Management in Belize.* Forest Department, Friends for Conservation and Development, Belmopan, Belize.

Rainforest Alliance, 2007. Guide for Sustainable Tourism Development Best Practices. Second Edition. 665 Broadway, Suite 500, New York, New York, USA.

CHAPTER 7 CONSTRAINTS AND GAPS

The National Capacity Self Assessment conducted in 2004/2005 identified some gaps and constraints that affected Belize's ability to properly implement the Convention. That exercise enabled a better understanding of capacity needs, constraints, and opportunities. .

The priority needs identified through that assessment included:-

- Formulation and implementation of a national climate change programme which would be developed with national stakeholder participation;
- Reduction of information gaps through research and systematic observation, and increased availability and accessibility to reliable data and information; and
- Establishment of a National System for the management of green house gas inventories.

The NCSA further analyzed the Root Causes of the gaps and constraints in reference to certain articles of the Convention. Some activities or requirements not addressed at that time included:-

- *Article 4.1(b)*: The formulation, publication, implementation and regular update of National Programmes to Mitigate and Adapt to Climate Change.
- *Article 4.1(c)*: To promote and cooperate in the development, application, diffusion, and transfer of technologies that control, reduce or prevent emissions of greenhouse gases (GHGs).
- *Article 4.1(e):* To cooperate in preparing for adaptation to the impacts of climate change, develop integrated plans for coastal zone management, water resources and agriculture, and for the protection and rehabilitation of areas affected by drought and floods.
- *Art 4.1(g):* To promote and cooperate in scientific, technological, technical, socio-economic and other research, systematic observation and development of data archives related to the climate system and intended to further the understanding and reduce or eliminate the remaining uncertainties related to climate change and the economic and social consequences of response strategies.
- *Art 5(b):* To support international and intergovernmental efforts to strengthen systematic observation and national scientific and technical research capacities and capabilities and to promote access to and exchange of data and analyses obtained from areas beyond national jurisdiction.
- *Article 6*: To promote and facilitate at the national, sub-regional and regional levels public access to information on climate change and its effects.
- *Article 6(a)(iii)*: To promote and facilitate at the national, sub-regional and regional levels public participation in addressing climate change and its effects and developing adequate responses.

- *Article 6(a)(iv)*: To promote and facilitate at the national, sub-regional and regional levels training of scientific, technical and managerial personnel.
- *Article 6(b)(i)*: To cooperate in and promote at the international level the development and exchange of educational and public awareness material on climate change and its effects.
- *Article 6(a)(i):* To promote and facilitate at the national, sub-regional and regional levels the development and implementation of educational and public awareness programmes on climate change and its effects.
- *Articles 7.6; 9.1; and 10.1:* Effective participation in the Conference of the Parties, sessions of the Subsidiary Body for Scientific and Technological Advise, and sessions of the Subsidiary Body for Implementation
- *Article 12.4*: To propose projects for financing, including specific technologies, materials, equipment or practices that would be needed to implement such projects along with an estimate of incremental costs for mitigating climate change as well as an estimate of the consequent benefits
- *Other requirements*: The Parties establish and maintain a National System for the Inventories of the Greenhouse Gas Emissions and Removals.

Articles 4.1 (b) and (c) have not yet been addressed since the National Adaptation Policy has not yet been finalized and adopted. In relation to Article 4.1(e), legislation has been enacted for integrated water resources management; the Coastal Zone Management Authority and Institute has been reactivated and is revising the Coastal Zone Management Plan; an agricultural policy has been formulated; and Sustainable Land Use Management Plan is being introduced by the Forest Department in order to address the issues of land degradation and deforestation.

Various strategic alliances among government and non-state stakeholders have been formed to facilitate research in sectors including climate change (eg.WWF research in climate change impacts on the Belize barrier reef, rehabilitation of mangrove ecosystems, etc). The establishment of the Caribbean Community Climate Change Centre, headquartered in Belize, is a regional initiative to conduct research, formulate strategies and plans, and generally address climate change issues for the CARICOM member states. This Centre operates in collaboration and partnership with other countries and institutions around the world. This would enable implementation of Article 4.1(g); Article 5(b); Article 6; Article 6(a)(iii; Article 6(a)(iv); Article 6(b)(i); Article 7.6; Articles 9.1; and 10.1 at both regional and international levels. Some other constraints have also been mitigated through measures applied and are mentioned elsewhere under capacity building.

Other gaps and constraints remain until the National Climate Change Committee is institutionalized and provided with the necessary resources to make it effectively operational. This would set the stage for the formulation and implementation of a national climate change adaptation strategy; with complementary execution of programmes/projects under the various flexible mechanisms.

CHAPTER 8 TECHNOLOGY NEEDS ASSESSMENT

8.1 INTRODUCTION AND BACKGROUND

Belize submitted its Initial National Communication (INC) in July 2002, pursuant to its obligations under the United Nations Framework Convention on Climate Change (UNFCCC). That report addressed various aspects of the national circumstances of the country including a greenhouse gas emissions inventory by sector as well as assessments of vulnerability to climate change. The INC did not address issues related to technology needs in respect of mitigating greenhouse gas emissions nor adapting to climate change. During the preparation of the Second National Communication a technology needs assessment to address climate change in Belize was undertaken. That report is published separately.

8.2 METHODOLOGY AND APPROACH

The methodology used in conducting the TNA followed that described in the UNDP handbook[126] on conducting technology needs assessments for climate change as far as was possible. Sectors addressed were guided by sectoral reports on greenhouse gas emissions and sectoral vulnerability assessments, where available, as well as stakeholder consultations. Additionally, issues and recommendations identified during stakeholder consultations were taken into consideration when identifying technologies (See Appendices I and II). Generally, activities focused on:

- Identification of vulnerable sectors;
- Identification of greenhouse gas emitting sectors;
- Identification of applicable technologies;
- Screening of suitability of technologies based on criteria outlined in the UNDP handbook;
- Identification of possible barriers to transfer and implementation of identified technologies.

8.2.1 OBJECTIVES AND SCOPE OF STUDY

The Technology Needs Assessment (TNA) undertaken was an important outcome of the SNC exercise as it allows developing nations such as Belize to capitalize on one of the more important recommendations of the convention, "the development and transfer of technology". This outcome is particularly important in helping Belize to cope with an ever evolving climate system. The TNA followed the advice of the Subsidiary Body on Science and Technology Advice (SBSTA) as a guide to its preparation. TNA preparation was undertaken through a three step approach including preliminary sector overviews intended to identify major emitting sectors as well as vulnerable sectors, establishment of national criteria for identification, assessment and selection of appropriate technologies/ best practices, prioritization of sectors and selection of key technologies, and the identification of national barriers and policy needs as they related to implementation of selected criteria. The process was consultative in nature involving a broad cross section of governmental and

126 Gross, R., Dougherty, W. And Kumarsingh, K. (2004) Conducting Technology Needs Assessments for Climate Change. UNDP, New York, Us, 26pp.

private sector entities. The TNA synthesis report was complemented by a report on the implementation mechanism which identified actions and opportunities for implementation.

It should be noted that the recommendations for technology needs made in the report were based on issues related to climate change mitigation and adaptation as identified in various national reports, stakeholder consultations and possible applicability and adaptability of technologies as well as a consideration of proposed developmental plans and policies in the various sectors, where they existed. Policy recommendations were made only in so far as they may have relevant technology implications. The report did not constitute an endorsement of one type of technology over another nor did it base its recommendations on any technology that has been tried and tested in Belize. Any choice of a particular technology would require further analysis based on cost-benefit and policy considerations as well as environmental impact of the technology, which are outside the scope of this study. Although some general assessment of impacts was presented, detailed environmental impact assessment would need to be done based on the peculiarities of the receiving environment.

8.3 Technologies for Mitigation of GHG Emissions

The study evaluated the available technologies suitable for application to mitigate greenhouse gases emissions from the identified key sources within the context of national development objectives and policies. Key sources of GHG in Belize were the LULUCF Sector, and the Road Transport, national navigation, and power generation sub-sectors of the Energy Sector. Possible barriers to applying the technologies were considered, and possible approaches to removing such barriers were recommended.

Conclusions

Any consideration of mitigation technologies cannot be done in isolation of the cross-cutting linkages. Therefore, before any definite choice can be made on the technology, consideration would have to be given to cost-benefit analyses, environmental impacts, trade and other possible market-based barriers and possibly funding sources. These considerations were outside the scope of the TNA study.

8.4 Technologies for Adaptation

The study utilized the same approach to evaluate available technologies suitable for application in adaptation measures for the vulnerable sectors; i.e. within the context of national development objectives and policies. Possible barriers to applying the technologies were identified and considered; and possible approaches to removing such barriers were recommended. The identification of potential technologies for adaptation is a function of the extent of vulnerability of the particular sector for which the technology is potentially applicable. Accordingly, the assessment of technologies for adaptation was carried out taking into consideration the vulnerable sectors identified in the various sectoral vulnerability reports and the Initial National Communication (INC). For this particular assessment, consideration was given to:

- Extent of vulnerability
- Scale
- Economic importance of the sector
- Applicability (if the technology can be applied to reduce the identified vulnerability)
- Adoptability (if the technology can be applied in its original form)
- Adaptability (if the technology can be modified to conform to the specific needs, taking into consideration scale, circumstances, receiving environment).

The sectors identified as vulnerable in the National Communications were:-forestry and terrestrial ecosystems, coastal ecosystems, water resources, agriculture, human settlements, human health, and tourism.

The identification of potential technologies for adaptation is a function of the extent of vulnerability of the particular sector for which the technology is potentially applicable. Accordingly, the assessment of technologies for adaptation was carried out taking into consideration the vulnerable sectors identified in the various sectoral vulnerability reports and the Initial National Communication (INC). For this particular assessment, consideration was given to:

- Extent of vulnerability
- Scale
- Economic importance of the sector
- Applicability (if the technology can be applied to reduce the identified vulnerability)
- Adoptability (if the technology can be applied in its original form)
- Adaptability (if the technology can be modified to conform to the specific needs, taking into consideration scale, circumstances, receiving environment).

8.5 SECTOR NEXUS AND TECHNOLOGY SYNERGY AND SELECTION

The TNA study revealed cross-sector linkages, nexuses and the potential for technology synergy. The table below provides a matrix that attempts to illustrate the possible synergy and inter-linkages. The table should be read across only to avoid confusion among the relationships between the sectors. The purpose of the table is to aid in prioritising technologies that can have multiple or collateral benefits in other sectors. It should be noted that the identified inter-linkages is based on the possible applicable technologies only.

8.6 CONCLUSIONS & RECOMMENDATIONS

Further analysis should be done to prioritise technology applications, including cost-benefit analyses, more detailed environmental impact assessments based on the receiving environment, and most critically, an analysis of the enabling environment to receive the technology. Follow-up to the initial study would include a comprehensive overview of the institutional, policy and legislative barriers in the context of the identified technology. The initial study sought to identify technology needs that can address climate change issues which were identified and evaluated in preparation of the Second National Communication.

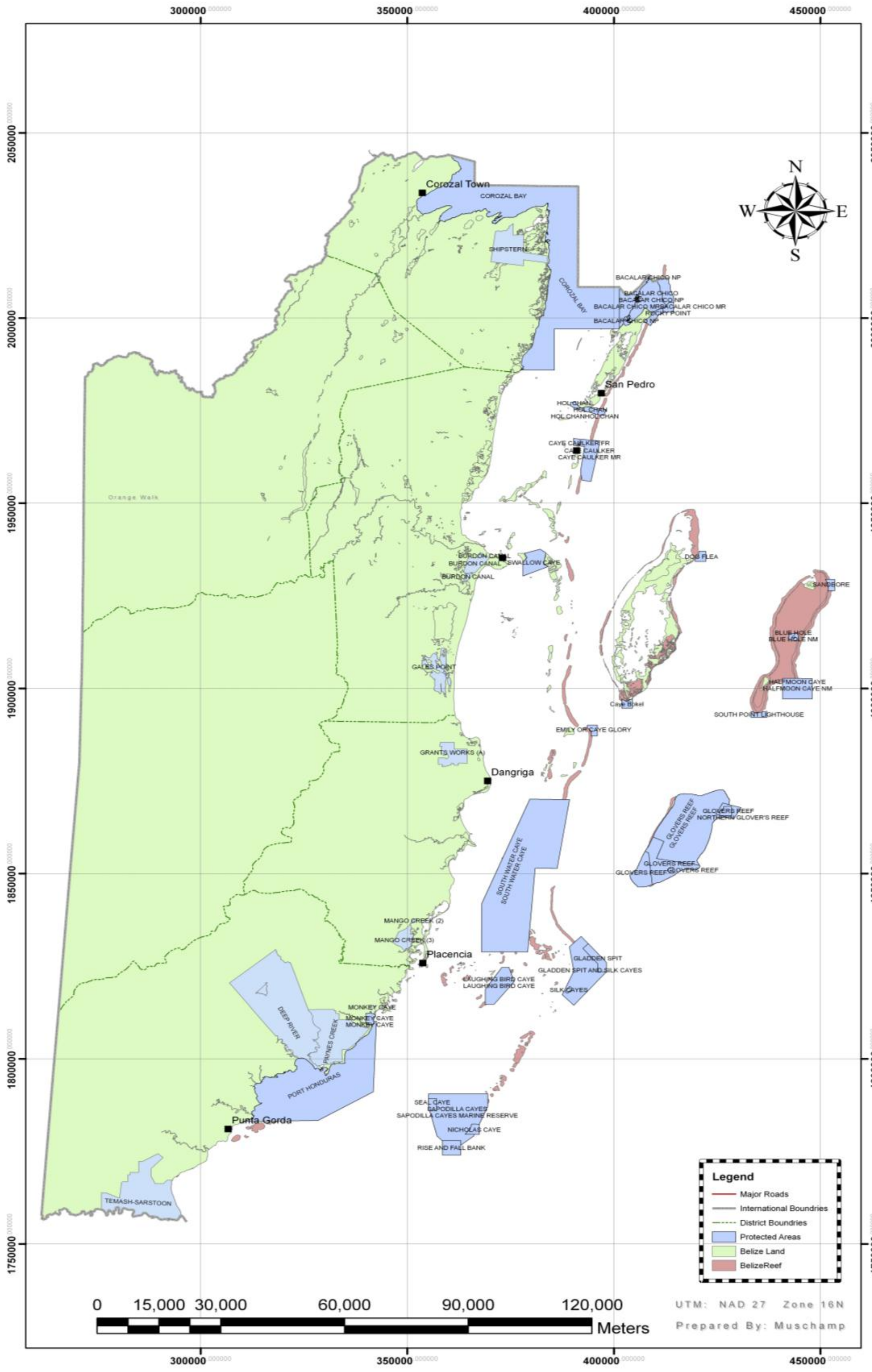
Technology requirements can be expected to change with changes in policy, development objectives and changes in the technologies themselves. It should therefore be cautioned that the technology needs identified may only have a limited timeframe of application. Any choice of technology should at least satisfy a set of basic requirements and criteria which are determined at the national level, including consideration of sustainable development criteria. However, as a general requirement the following should be taken into account:

- Longevity of the technology;
- Technical support requirements of the technology at the time of availability;
- Cost;
- Social acceptance/environmental impact;
- Contribution to sustainable development objectives as identified.

Table 28 Inter-Sectoral Linkages and Synergy

Sector	Energy	Road Transport	Forestry & Terrestrial Ecosystems	Coastal Ecosystems	Water Resources	Agriculture & Aquaculture	Human Settlements	Human Health	Tourism
Energy		♦				♦	♦		♦
Road Transport	♦							♦	
Forestry & Terrestrial Ecosystems				♦	♦	♦			♦
Coastal Ecosystems			♦		♦	♦	♦		♦
Water Resources			♦	♦		♦		♦	♦
Agriculture	♦		♦	♦	♦			♦	♦
Human Settlements	♦			♦				♦	♦
Human Health		♦			♦	♦			♦
Tourism	♦		♦	♦	♦	♦	♦	♦	

APPENDIX 1: Protected Areas of Belize - 2007



"Belizeans changing behaviours to adapt to Climate Change"

ALL Primary Schools

ow express what they've learnt through art by participating in a countrywide "On- the-Spot Painting Competition" using the theme: ***"Belizeans changing behaviours to adapt to Climate Change"***

- ★ **How can I enter this competition?**
- The competition is open to all primary school students countrywide, between ages 8 to 14 years.
- Ensure that you and your parent/guardian fill out the entry form.
- Each entry form should be certified by the school's Principal or Class Teacher as you will also be representing your school. ***Up to 5 students can represent the school***.
- ★ **What must I bring?**
- You must bring all your painting materials such as colourings/pencils/crayons, etc.
- A standard white bristol board will be provided by the organizers.
- ★ **How could I win?**
- Learn what you can about what is Climate Change; ask your teacher and classmates to help.
- You will need to base your paintings/ drawings on the theme, drawing one or many things that we can do to adapt to climate change.
- You will do the drawing/painting within two hours, hence the name "On-the-Spot Painting". This ensures an original and unaided work.
- More importantly, you will need to be present at the opening of the protected areas exhibition in your area, where the competition will take place. Date and place is listed below:

Special Protected Areas Exhibition

Date	Time	Place	Area
23rd April 2007	9:00-11:00 a.m. & 1:00-4:00 p.m.	Holy Redeemer Parish Hall	Belize City
25th April 2007	9:00-11:00 a.m. & 1:00-4:00 p.m.	Cascada Maya	Corozal Town
26th April 2007	9:00-11:00 a.m. & 1:00-4:00 p.m.	La Inmaculada Auditorium	Orange Walk Town
3rd May 2007	9:00-11:00 a.m. & 1:00-4:00 p.m.	Father Ring Parish Hall	Punta Gorda Town
4th May 2007	9:00-11:00 a.m. & 1:00-4:00 p.m.	Sacred Heart Parish Hall	Dangriga Town
7th May 2007	9:00-11:00 a.m. & 1:00-4:00 p.m.	Belmopan City Centre	Belmopan City
9th May 2007	9:00-11:00 a.m. & 1:00-4:00 p.m.	San Ignacio Hotel	San Ignacio Town

1st, 2nd, 3rd PRIZES: A Computer for your school, Environmental/Education tour for your entire class (35 pax), Personal Bank Savings certificate, Educational Package, SMART Phone, Digital Camera, Bicycle, Awards and other great prizes.

The prizes will be presented at a ceremony to be held on 22nd May, 2007 at the Guanacaste Park at 9:30 a.m., in celebration of Natural Resources and Environment Week 2007

PLEASE SEE REVERSE SIDE

Belizeans Changing Behaviour To Adapt To Climate Change

Climate Change is more than changes in our weather patterns caused by global warming. Climate change affects the way we live, our economy, environment and our communities.

We now know that global warming is happening. Global warming is the earth getting hotter because of our harmful human activities. These activities include burning of fossil fuels for electricity and transportation. The cutting down of trees also contributes to the increase of carbon dioxide in our air. The amount of garbage we produce at home, the unsafe way we get rid of garbage and other actions we do contribute to global warming, which results in climate change.

Some of the likely effects of Climate Change are:

- more intense hurricanes in our region,
- sea-level rise
- warmer sea surface temperatures
- salt water intrusion
- many dry spells or droughts
- an increase in temperatures and
- increase in heavy or extreme rainfall events.

As a result, it could affect our health, biodiversity, agriculture, coral reefs and marine ecosystems, water resources, coastal areas and infrastructure and our tourism industry.

Belize joined many other countries in an effort to achieve eight Millennium Development Goals. Goal seven (7) of the Millennium Goals calls for a global effort to ensure Environmental Sustainability. This includes minimizing the effects of Climate Change. Additionally, Belize signed the United Nations Framework Convention on Climate Change in 1992. The Convention calls on everyone to work towards environmentally friendly development.

Everybody has a role to play in dealing with climate change, whether it is the government, businesses, communities, or you. We have two main things to do to address Climate Change. We can firstly, reduce the amount of greenhouse gases we emit in the air and secondly, we can adapt or adjust to our changing climate. Taking action will require changing the way we live, which might be easier than we think. It doesn't mean sacrificing our living standards, but just doing things smartly.

Here are a few smart things to help us reduce greenhouse gases which cause global warming and a few things to help us adapt to Climate Change:

1. Learn how to ***reduce, reuse, recycle***
   a. Learn to reuse all your household goods, clothing, envelopes, jars, paper bags, scrap paper, and appliances. Carry your own bags to the grocery store.
   b. Urge our communities and government to begin to recycle paper, plastics and aluminium
   c. Start doing your own recycling at home or school by separating garbage.
   d. Buy recycled paper, plastics and other recycled products.
   e. Reduce your amount of garbage. Try buying more vegetables instead of can foods
2. Use energy-efficient appliances and use energy-saving light bulbs
3. Turn off all lights that don't need to be on.
4. Walk or use a bicycle whenever possible. Enjoy sports and recreational activities that use your muscles rather than gasoline and electricity.
5. Urge farmers not to slash and burn, use harmful pesticides or other improper farming practices. Burning garbage is also harmful. These are forms of persistent organic pollutants, which affect human health and our environment.
6. Don't buy aerosols or other products containing CFCs. It is harmful to our ozone layer.
7. Support programs that aim to save our rainforest. Don't cut down our trees, it also increases erosion and land degradation.
8. Stay informed about our weather and state of our environment.
9. Talk to friends, relatives, and co-workers about preventing global warming and climate change.
10. Plant trees and a garden that shelter our homes from the sun. The more trees we plant helps our air.
11. Start investing in stronger homes that can resist natural disasters such as storms and hurricanes
12. Know what to do in cases of natural disasters.
13. Start rotating crops and planting crops that are more resistant to climate changes
14. Support solar and renewable energy development.
15. Conserve water. Work to protect our local watershed areas. Water is a source of life and development. Using it sparingly helps prevent water scarcity and preserves healthy environments.
    a. Spare water while showering or brushing teeth.
    b. Collect rainwater for household activities such as washing clothes and use the graywater for gardening use.
16. Think often about the kind of Earth you would like to see for your grandchildren's children.

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For more entry forms or more information, please contact Mr. Juan Rancharan or Ms. Violet Yorke at the Ministry of Natural Resources & the Environment at:

Tel: 822-2082, Fax: 822-2333, Email: info@mnrei.gov.bz or visit our website at www.mnrei.gov.bz