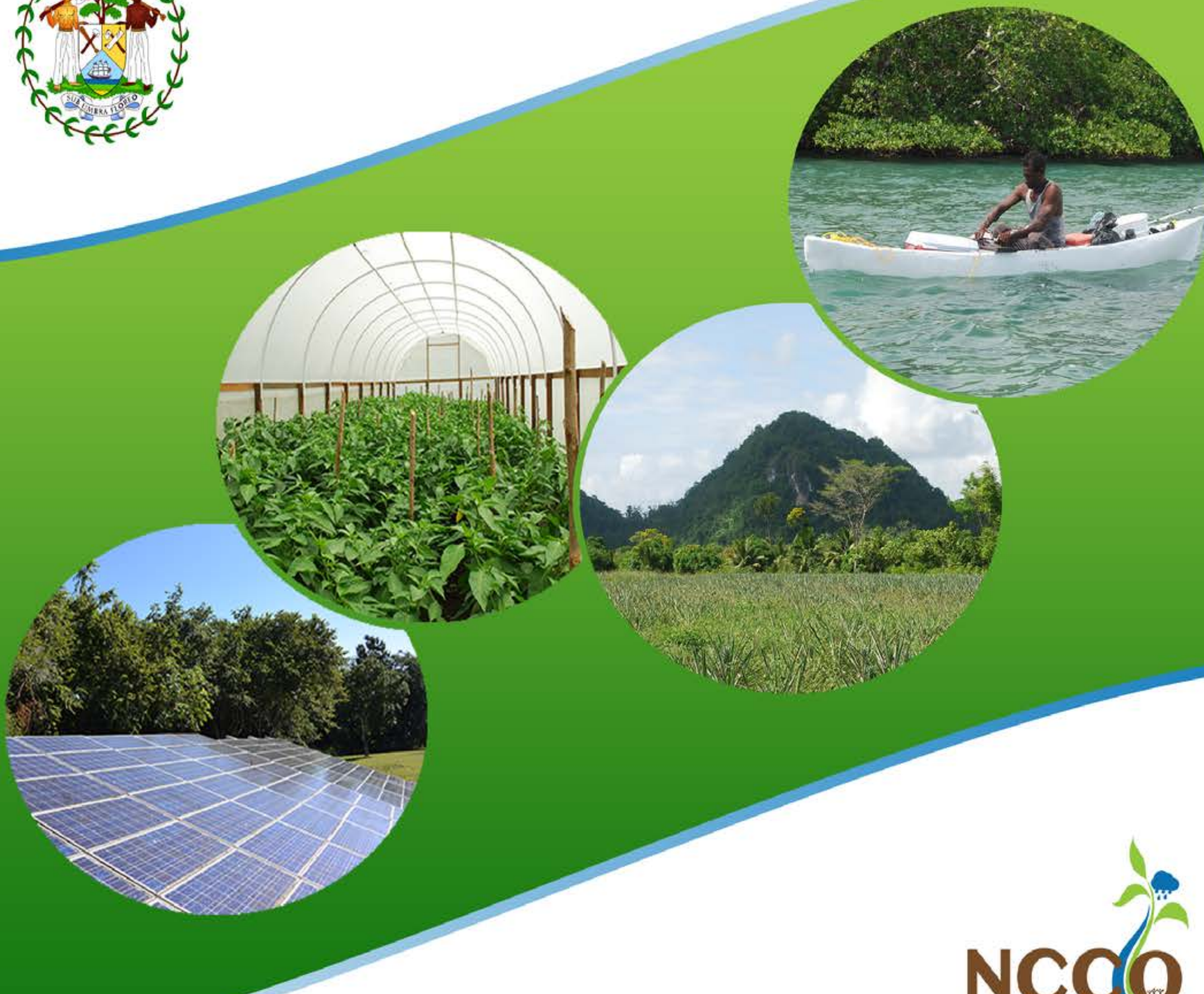
BELIZE'S THIRD NATIONAL COMMUNICATION TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE



National Climate Change Office, 2016

Ministry of Agriculture, Fisheries, Forestry, the Environment and Sustainable Development

Belize's Third National Communication to the United Nations Framework Convention on Climate Change
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FOREWARD

Statement from the Minister of State, Ministry of Agriculture, Fisheries, Forestry, the Environment and Sustainable Development

Dear Stakeholders,

Global Climate Change is one of the most serious threats to sustainable development in Belize. For us, we have already been experiencing the negative effects of climate change. We see and experience these impacts every day; whether it is sustained droughts, floods, increase coastal erosion and changing precipitation patterns. Combined, these climate changes related phenomena are having significant impacts on many environmental, physical, social and economic systems within the country. In the future, these effects are expected to increase, thereby threatening the physical and social infrastructure in Belize. Recognizing the need to address this challenge at national and local levels, the Ministry of Agriculture, Fisheries, Forestry, the Environment and Sustainable Development, that also has responsibility for Climate Change, is pleased to present Belize's Third National Communication (TNC) to the United Nations Framework Convention on Climate Change (UNFCCC) and the people of Belize.

Belize's Third National Communication provides a set of robust recommendations that are relevant to facilitate more effective coordination and planning for Climate Change mitigation and adaptation at the national and local level, in addition to the development of permanent institutional capacities and processes relating to Climate Change.

The development of the TNC on Climate Change was made possible through the collaborative efforts of a broad cross-section of stakeholders, including state and non-state actors and technical experts. Financial support was provided by the Global Environmental Facility (GEF), through the United Nations Development Program (UNDP). We also wish to acknowledge the contributions of the Caribbean Community Climate Change Centre in this regard.

Belize places great importance in meeting its commitments to the United Nations Framework Convention on Climate Change. To this end, the comprehensive national greenhouse gas inventory outlined in the TNC is critical in addressing Climate Change and the associated environmental challenges confronting us. The integrated vulnerability assessment undertaken identified actions that will reduce vulnerability within priority development sectors, namely coastal development, water, agriculture, tourism, human health and fisheries by mitigating the impacts of Climate Change on these sectors and enhancing adaptive capacity.

To this end, the information from the TNC was critical in the formulation of the National Climate Change Policy, Strategy and Action Plan and for the mainstreaming of Climate Change in the national development planning agenda. Most recently, my government approved the National Climate Change Policy, Strategy and Action Plan which sets out the policy direction to strategically transition Belize's economy to one that is characteristic of low-carbon development while strengthening our resilience to the effects of Climate Change.

It is our intent that the TNC will be used as the national document to address critical Climate Change issues at national, local and sectoral levels in order to incorporate Climate Change into these plans. Furthermore, it is our hope that this TNC will set the stage for us to develop projects and programmes that will attract financial resources to support the implementation of the necessary climate change activities throughout Belize.

Our unique circumstances and small size make us particularly vulnerable to climate change and its negative impacts. As such, it behoves all of us to ensure that we are coordinated in our responses necessary to build and improve our resilience to climate change. It is also our intention to address issues, problems, gaps and constraints identified in this publication when developing the Fourth National Communication, thus ensuring that improvements are carried out in an efficient and effective manner.

Finally, we are grateful for the assistance given by the Belize National Climate Change Committee to the National Climate Change Office for the development of this document and other efforts aimed at implementing the UNFCCC.

Honourable Omar Figueroa
Minister of State
Ministry of Agriculture, Fisheries, Forestry, the Environment and Sustainable Development

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LIST OF ABBREVIATIONS AND ACRONYMS

A1B- Medium Emissions Scenario
A2 – High Emissions Scenario
ACP- Africa, Caribbean & Pacific -
AF- Adaptation Fund
A-OGCM-Atmosphere-Ocean General Circulation Model
APAMO – Association of Protected Areas Management Organization
AOI- Area of Interest
ASO- August –September-October
B1- Low Emissions Scenario
BAL- Belize Aquaculture Limited
BECOL- Belize Electric Company Limited
BEL- Belize Electricity Limited
BELCOGEN-Belize Co-generation Energy Limited
Bel-Car- Belize-Caribbean Export and Import Company Limited
BEST-Belize Enterprise for Sustainable Technology
BNCCC- Belize National Climate Change Committee
BNE- Belize Natural Energy
BOD- Biological Oxygen Demand
BSI- Belize Sugar Industry
BST- British Summer Time
BTB -Belize Tourism Board
BTL- Belize Telemedia Limited
BWS- Belize Water Services
BZE- Belize
^{O}C- Degree Celsius
CAHSU- Central American Health Sciences University
CARIBSAVE- a Caribbean regional not-for-profit organisation that innovates connects and implements practical solutions for sustainable development and Climate Change.
CARICOM-Caribbean Community
CaO – Calcium Oxide
CBA - Central Building Authority
CCCCC - Caribbean Community Climate Change Centre
CCORAL- Caribbean Climate Online Risk and Adaptation Tool
CCTF- Climate Change Trust Fund
CDM - Clean Development Mechanism
CDMA- Code Division Multiple Access
CFE- Comisión Federal de Electricidad
CH_4- Methane
CM1P3- Phase 3 of the Coupled Modelled Inter-comparison Project
CO- Carbon Monoxide
CO_2 – Carbon Dioxide
CO_2eq – Carbon Dioxide equivalent
CPE- Customer Premises Equipment
CRU- Climate Research Unit
DEM- Digital Elevation Model
DF- Dengue Fever
DJF-December-January-February
DO- Dissolved Oxygen
DOC- Degradable Organic Carbon
DSL- Digital Subscriber Line
DSM-Digital Simulation Models
DSSAT-Decision Support System for Agro-technology Transfer
DoE - Department of the Environment
DTM- Digital Terrain Model
E- Evaporation
ECHAM4- European/German General Circulation Model (version 4)
ECHAM5- European/German General Circulation Model (version 5)
ECV- Essential Climate Variables
EE - Energy Efficiency
EF- Emission Factor
EIA- Environmental Impact Assessment
EPA- Economic Partnership Agreement
EPZ- Export Processing Zone
EU - European Union
FADE- Focus Analysis Develop Execute-Evaluate
FAO- Food and Agriculture Organization (of the United Nations)
FMA- February-March-April
FSTV- Fourth Street Tourism Village

FracNPR- Fraction of Nitrogen in Protein
ft- foot/feet
GCCA - Global Climate Change Alliance
GCOS- Global Climate Observing System
GDP - Gross Domestic Product
GEF - Global Environment Facility/Grid Emission Factor
GEO- Group on Earth Observation
GEO Belize-Belize environmental Outlook
GFCS- Global Framework for Climate
Gg- Gigagrams
GHG- Green House Gas
GHGI- Green House Gas Inventory
GIZ- Gesellschaft für Internationale Zusammenarbeit (German Dev. Agency)
GoB - Government of Belize
GSDS- Growth and Sustainable Development Strategy
GSM- Global System for Mobile
GUAN- GCOS Upper Air Network
GWh- giga watt hour
GWP- Global Warming Potential
HadCM3Q11- Hadley Centre General Circulation Model (QUMP)
HML- Hydro Maya Limited
ICT- Information and Communication Technology
ICZM- Integrated Coastal Zone Management
IDB - Inter-American Development Bank
IICA- Inter-American Institute for Cooperation on Agriculture
INSMET- Instituto de Meteorologia de Cuba
INC – Initial/First National Communication
INDC - Intended Nationally Determined Contributions
IPCC - Intergovernmental Panel on Climate Change
IPM- Integrated Pest Management
IWRM- Integrated Water Resource Management
kg- Kilogram
km- Kilometres
km^2- square kilometres
kW – kilowatts
JJA-June- July-August
JSDF- Japan Social Development Fund
lbs.- pounds
LIC- Land Information Centre
LFG- Landfill Gas
LPG- Liquefied Petroleum Gas
LULUCF - Land Use, Land Use Change and Forestry
m- metres
m^3- cubic metres
MAM-March-April-May
max- maximum
MCF- Methane Correction Factor
MESTPU - Ministry of Energy, Science and Technology and Public Utilities
MFED-Ministry of Finance and Economic Development
MFFSD - Ministry of Fisheries, Forestry and Sustainable Development of Belize
MHz- megahertz
MIE- Multilateral Implementing Entity
min- minimum
MJJ- May – June-July
mm- millimetres
MNRA - Ministry of Natural Resources and the Agriculture
MNRE- Ministry of Natural Resources and the Environment
MNREI- Ministry of Natural Resources, the Environment and Immigration
MPAs- Marine Protected Areas
MRV – Measuring, Reporting and Verification
MSW- Municipal Waste
MW- megawatts
N- Nitrogen
N_2O- Nitrous Oxide
NAMA(s) - Nationally Appropriate Mitigation Action(s)
NCCO - National Climate Change Office
NCCPSAP – National Climate Change Policy, Strategy and Action Plan
NDJ- November-December-January
NFert- Nitrogen Fertilizer
NGO – Non-Governmental Organisation
NO_x- Oxides of Nitrogen (generic term)

NPAPSP - National Protected Areas Policy and System Plan
NEMO - National Emergency Management Organization
NMS - National Meteorological Service
NMVOC - Non Methane Volatile Organic Compound(s)
NO_2 - Nitrogen dioxide
NOAA- National Oceanic and Atmospheric Administration
NWS- United States Weather Service
OECD - Organisation for Economic Co-operation and Development
OFID- OPEC Fund for International Development
OPEC- Organisation of the Petroleum Exporting Countries
P- Precipitation
PACT- Protected Areas Conservation Trust
PCMDI-Program for Climate Model Diagnosis and Inter-comparison
PGIA-Philip Goldson International Airport
pH- the measure of how acidic/basic something is
PMU- Project Management Unit
ppm- parts per million
PRECIS-Providing Regional Climates for Impacts Studies
PUC - Public Utilities Commission
PV- photovoltaic
RBCMA - Rio Bravo Conservation and Management Area
RE - Renewable Energy/Energies
REDD+ - Reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries
RK- Red Kidney
SACD- Sarteneja Alliance for Conservation and Development
SAP- Strategic Action Plan
SCCF- Special Climate Change Fund
SEA-Southern Environmental Association
SIB- Statistical Institute of Belize
SICA- Sistema de la Integración Centroamericana
SIDS- Small Island Developing State
SIRDI- Sugar Industry Research and Development Institute
SMART- Speednet Communications
SNRL- Sustainable Natural Resource-based Livelihoods
SON- September-October- November
***spp.* –** species
sq- square
SRES- Special Report Emissions Scenarios
SWDS- Solid Waste Disposal Systems
t/ha- tonnes per hectare
TIDE- Toledo Institute for Development and Environment
UB - University of Belize
ULV- Ultra low volume
UK- United Kingdom
UNCSD- United Nations Conference on Sustainable Development
UNDP - United Nations Development Programme
UNFCCC - United Nations Framework Convention on Climate Change
US- United States
USA- United States of America
UTC- Coordinated Universal Time
V&A- Vulnerability and Adaptation
WB- World Bank
WCRP-World Climate Research Programme
WHO-World Health Organization

EXECUTIVE SUMMARY

National Circumstance

Geography

Belize is a relatively small independent country situated on the east coast of Central America and bounded on the north by Mexico, on the south and west by Guatemala and on the East by the Caribbean Sea. The national territory covers a total area of 46,620 sq km (18,000 sq miles) with a land area of approximately 22,967 sq km (8,867 sq miles), including 280km of coastland. The mainland makes up 95% of the territory and 5% is represented by more than 1,060 small islands or Cayes.

There are six administrative districts in Belize: Belize, Cayo, Corozal, Orange Walk, Stann Creek and Toledo. The capital of the country is the City of Belmopan, situated in the central part of the country, but Belize City is the largest urban agglomeration with approximately 66,000 inhabitants. The Belize District, where Belize City is located, is the most urban area in the country; whereas the Toledo District located deep within the southern portion of Belize is the most rural area.

Climate

Belize is characterised as having a sub-tropical climate with two (2) distinct wet and dry seasons. The rainy season occurs in the period from June to November and brings approximately 60 inches (1524mm) of rain in the north to 160 inches (4064mm) of rain in the south. Rainfall varies from year to year in many areas, except in the Southern parts of the country where annual rainfall average is consistent. The heaviest amount of rainfall is usually expected in June or early July and is punctuated by a break in late July or August while the dry season occurs from November to May. The process of changing from dry to wet seasons can be considered as being gradual with a cool transition from November to February and a warm transition from March to May.

The mean temperature in Belize ranges from 27°C (max - 30.1°C, min- 22.6°C) along the coast to 21°C (max - 25.3°C, min - 17.7°C) in the hills, with the coldest month being January and the warmest temperatures experienced in May. The winds blow at an average of five (5) knots and travel in the direction of east to southeast all year long. The country is also affected by tropical storms, tropical waves and hurricanes that move westward through the Caribbean from the months of June to November.

Population profile

Population estimates by the Statistical Institute of Belize revealed that by mid-2014, there were approximately 358,899 persons living within Belize. There was a steady growth in the population from 315,082 persons in 2009 to a total of 358,899 persons in 2014 with growth rates ranging from 2.5% to 2.63%.

Economy

The Statistical Institute of Belize puts the value of the country’s GDP at BZE $2,635.6 million dollars based on 2014 data. Tertiary industries, which include the tourism and services sector, have contributed to 60.29% of the GDP with a total of BZE $1,589.1 million dollars in 2013. This includes wholesale and retail trade and repairs (15.36%), hotels and restaurants (4.72%), transport and communications (11.01%), financial intermediation (6.65%), real estate (10.15%) and community services (4.72%).

Secondary industries such as manufacturing (9.90%), construction (2.81%)and electricity and water supply (3.33%) are the second highest income earners; contributing to 16.03% of the GDP with a total of BZE $407.2 million. The primary industries which include agriculture and forestry (10.15%), fishing (3.08%) and mining and quarrying (0.46%) gave the smallest contribution of 13.70% and a total of BZE $381 million dollars.

National Greenhouse Gas Inventory

This chapter communicates Belize's national inventory of anthropogenic emissions by sources and removals by sinks. Key source assessments for reference years 2003, 2006 and 2009 were conducted and sought to capture new sources and sinks in addition to those described in the Initial and Second National Communications that might have arisen because of recent developments in the country.

Trends in Belize's Greenhouse Gas Emissions and Sinks

Over the entire study period, Belize continued to be a net emitter of greenhouse gases. It was also noted, when using the 2000 Reference Year, that the trend in emissions of all the greenhouse gases was upward until the 2003 period. Furthermore, a comparison of the carbon dioxide emissions and removals for the reference revealed a decreasing ratio.

In 2000, the ratio of CO_2 removals to CO_2 emissions was approximately 1:3.3; by 2003 the ratio of removals/emissions was observed at 1:1.88. This narrowing of the ratio between removals and emissions of CO_2 was again displayed in 2006 and 2009. A comparison of the results over the study period showed a general decline in CO_2 emissions from 2003 to 2009, with a similar decline in removals from 2003 to 2009. Methane, carbon monoxide, and nitrogen dioxide levels remained almost constant for the same period.

Table 1: Summary Estimates of Emissions and Sinks by Gas

Reference Years	CO_2 Emissions (Gg)	CO_2 Removals (Gg)	CH_4 (Gg)	N_2O (Gg)	NOx (Gg)	CO (Gg)	Total Emissions (Gg)
2000	11,950	3,862	40	0	10	349	8,487
2003	18,168	9,666	43	0	11	376	8,932
2006	17,375	9,208	41	0	10	361	8,579
2009	13,449	8,778	40	0	10	346	5,067

Source: GHGI, 2015

Emissions by Economic Sector

The estimates for the ***Energy Sector*** show an overall decrease in emissions of carbon dioxide for the reference period under review, 2003 to 2009. Noteworthy are the contributions of the sources which showed a decline from liquid fuels resulting from an increase in biomass use and the supplies of hydroelectricity. In the case of emissions due to biomass, the two main contributors are fuel wood and bagasse. This production/consumption increased dramatically with the co-generation project of BELCOGEN beginning operations within the study period.

The amount of GHG emissions within the Energy Sector in Belize declined from the previous period reported in the Second National Communication. The Energy Sector accounted for a considerable proportion of the decline due to the shift from using fossil fuels to renewable sources of energy.

The results obtained for the study period indicated that there was some increase in activity within the ***Industrial Processes (and Other Product Use) Sector*** for the reference year 2006 (an average of the 2005 to 2007 economic period). It is noted that the CO_2 emissions were impacted by increased lime production over that period then declined for the following three-year period (reference year 2009: 2008-2010). CO_2 emissions appeared to remain constant from beer and spirits production during the entire nine year period (2002-2010) under study. Non-methane volatile organic compound (NMVOC) emissions were apparently similarly affected by increased production occurring within that same period.

The estimates of emissions from the Agricultural Sector also showed a decrease since discussions about the "prescribed burning of savannahs" resulted in a conclusion that this is not an agricultural practice. This may cause the emissions from the Agriculture sector to vary depending on the annual crop and livestock production. Furthermore, the trends in production which responds to the global markets for these commodities should be noted.

The trend in the net emissions and removals of the GHGs within the Land Use, Land Use Change and Forestry Sector over the reference years 2000 to 2009 indicates that after the 2000 reference year, there was an increase in the emissions and in the CO_2 removals. This was followed by a decline in emissions from the sector, with the removals displaying the same trend. The emissions were mainly from forest and grassland conversions and emissions from soils. Estimates of the emissions of methane, carbon monoxide, and oxides of nitrogen from this sector showed insignificant changes over the study period.

Further trend analyses are offered within each sector in the full report of the Third National Communication.

Table 2: Total GHG Emissions by Sector (Gg) 2003, 2006 & 2009

Sector	2003	2006	2009
Land Use, Land-Use Change & Forestry	14,378.5500	13,076.0068	12,461.8961
Energy	483.6668	447.3982	445.3748
Waste	1.9300	2.5600	3.5700
Agriculture	6.1015	7.0551	7.8654
Industrial Processes & Solvents	4.0028	4.7925	2.4307
Total	**14,874.2511**	**13,537.8126**	**12,921.1370**

Source: GHGI, 2015

Table 3: Total GHG Emissions by Sector in percentages – 2003, 2006, 2009

Sector	2003 % of Total	2006 % of Total	2009 % of Total
Land Use, Land-Use Change & Forestry	96.67	96.59	96.45
Energy	3.25	3.30	3.45
Waste	0.01	0.02	0.03
Agriculture	0.04	0.05	0.06
Industrial Processes & Solvents	0.03	0.04	0.02
Total	100.00	100.00	100.00

Source: GHGI, 2015

Climate Change Impacts: Vulnerability Assessments and Adaptation Measures

The Vulnerability and Adaptation (V&A) component aims to support more detailed assessments within priority development sectors, namely, water, agriculture, tourism, human health, fisheries and the coastal zone with emphasis on coastal development.

According to the UNDP Country Profiles, an increase in air temperature ranging from 2° C to 4°C is projected by 2100 for Belize. Similarly, a general decrease in annual rainfall of about 10 % is projected by 2100. As for the Climate Change scenarios, both the ECHAM5 and HadCM3Q11 climate models consistently project an increase in temperature ranging from 2 to 4°C for all Districts of Belize and for all seasons in the future (2060-2069) compared to the present (1961-1990).

Coastal Zone

Climate Change and climate-driven sea level rise impose additional threats to coastal systems already under pressure from population concentration and increasing population growth in the future. Human presence, including infrastructure facilities, is having a significant direct and indirect impact on coastal ecosystem functions and coastal processes. Increased coastal erosion and more extensive inundation are expected from rising sea levels; storm surges may flood greater areas than now, thereby impacting primary production, and may cause saline intrusion up estuaries and into groundwater aquifers. These biophysical impacts may cause loss of coastal habitats, property damage, flooding and loss of life, as well as having economic consequences for rural production and urban lifestyles. In many cases the effect of a change in climate and sea level are going to exacerbate problems that already exist.

Adaptation measures for the coastal zone include the formulation and implementation of land-use planning policies to address people and settlements and agricultural lands at risk to inundation deriving from sea level rise and storm surges; the fortification of sea and river defences in accordance with sea level rise and storm surges in vulnerable areas; further implementation of early warning systems in the event of storm surges; and the building of more shelters on higher ground either near the coast or inland to house people in the event of inundation due to storm surges.

Water Sector

Climate Change is very likely to have a significant impact on the water sector of Belize. Rainfall is projected to decrease slightly and become more variable leading to intense rains and flooding while also worsening drought conditions (McSweeney et al., 2008, 2009; IPCC, 2007; 2013). Variability in rainfall will result in risks of flooding from excessive rainfall in the low-lying coastlands; and decreases in water supply with lower levels of rainfall. Agricultural production would be negatively affected due to projected alternating conditions of excessive rainfall and flooding on the one hand and drought on the other.

Sea level rise and storm surges will also affect the water sector through saline intrusions into coastal aquifers and soils as well as flooding of coastal lowlands and towns; where the bulk of the population of Belize is located (Singh and El Fouladi, 2007). Other related sectors, especially human health, will be directly affected through loss of life due to flooding or indirectly through the impacts on food supply and the proliferation of disease-spreading vectors. Adaptation measures for the sector include the enhancement of mechanisms for the protection and restoration of ecosystems, increased water harvesting, raising awareness to promote the effective and efficient use of water, protecting the water environment, preventing and controlling water pollution and efficient use of water in agriculture.

Agriculture Sector

The agricultural sector of Belize would suffer mainly negative impacts from future (2060-2069) climate change. Yields of the major crops, namely sugarcane, rice, bananas, citrus and red kidney beans, are all expected to decrease. These decreases in crop yields would result from an increase in air temperature accompanied by higher evaporation rates, variable rainfall and increases or decreases in rainfall, depending upon the location in Belize.

Agricultural adaptation options are grouped according to four main categories that are not mutually exclusive: (1) technological developments such as the development of new crop varieties including types, cultivars and hybrids, (2) government programs such as the use of crop insurance and agricultural subsidies, (3) farm production practices including changes in farm operational practices, and (4) farm-level responses using farm income strategies, both government supported and private, to reduce the risk of climate-related income loss (Smith and Skinner, 2002).

Fisheries Sector

In view of the projected changes in air temperature especially, and changes in sea level and ocean acidity, one can expect mostly negative impacts on the fisheries sector of Belize. The effect of Climate Change and sea level rise on the fisheries sector of Belize will be mostly indirect. Fisheries require healthy habitats to survive and reproduce. Rising sea levels could lead to partial or complete disappearance of these habitats through inundation. On the other hand, rising near-surface water temperature and increasing acidification may cause massive bleaching and dieback of corals.

Additionally, as long as there are still viable fisheries stocks, people will continue to fish legally or illegally. As such, employment, income and foreign exchange generation through capture fishing will continue to decline if an adequate fisheries management regime is not implemented. Adaptive responses to Climate Change in fisheries could include the implementation of management approaches and policies that further strengthen the livelihood asset base, monitoring of the biophysical, social and economic indicators linked to management and policy responses and adoption of multi-sector adaptive strategies to minimize negative impacts such as instituting Government regulations on fishing seasons.

Tourism

Climate Change and climate-driven sea level rise will most likely have important and severe impacts on the tourism industry of Belize. Increases in air temperature (2°C to 4°C) towards the end of the century may make conditions unbearable, especially for the elderly retired tourist population, the major age group of tourists. The projected variability in precipitation will very likely lead to extreme conditions, namely increasing drought in the dry season, torrential rains and flooding in the rainy season and water and food shortages or higher prices of imported food. Tropical storms and hurricanes, compounded by sea level rise, are also likely to increase in numbers and intensity, and apart from flooding and erosion of recreational beaches, they will also very likely cause flooding and damage to transport and other infrastructure. Moreover, these projected changes in climate will have indirect secondary and tertiary effects including the loss of beaches, loss of coral reefs due to temperature-induced bleaching, loss of food supply chains and loss of coastal infrastructure.

It is important for the managers of the tourism industry in Belize to begin to shape policies and integrate them into Government plans to adapt to the negative impacts of Climate Change. Adaptation planning should incorporate the expansion and diversification of tourism activities; for example, the construction of marinas in the lagoon near Placencia for sailing boats used by tourists. Additionally, there should be comprehensive short-term, medium-term and long-term adaptation plans integrating vulnerabilities of the tourism industry of Belize to Climate Change and sea level rise.

Human Health Sector

Climate Change will lead to higher levels of some air pollutants; an increasing number of extreme weather events, increasing outbreaks and transmission of diseases through unclean water and contaminated food, and will threaten agricultural production in some of the poorest countries such as Belize. Furthermore, Climate Change will also bring new challenges to the control of infectious diseases. Certain vector- borne diseases such as dengue and malaria, respiratory diseases such as asthma and water borne diseases such as cholera and dysentery may become more acute and prevalent in the future with Climate Change.

Adaptation options for the health sector in Belize include both climate and non-climatic factors. These adaptation measures are likely to include: a greater understanding of current and future incidence of diseases, control of vectors (mosquitoes) for diseases (malaria, dengue), stagnant water control measures and sanitation improvements in areas where houses are built in swampy locations, caring for the most vulnerable population at risk such as the elderly, infants and young children and the economically disadvantaged groups, lifestyle changes such as eating healthier foods to maintain good health, improved health care and access such as health alerts including more ambulances with more rapid response times, and more health care centres and hospitals with professional staff.

Policies and Measures Promoting Greenhouse Gas Emissions Reduction and Climate Change adaptation

Belize has made significant efforts to fulfil the objectives of the Convention, despite not being required to take on quantitative commitments for reducing GHG emissions as a Non- Annex 1 Party to the UNFCCC. These efforts have been seen in the form of appropriating and creating new policies, designing projects and programmes geared towards GHG emissions abatement and adapting to the negative impacts of Climate Change to bolster a low carbon development, climate resilient pathway.

Other key policy initiatives undertaken include the development and implementation of an Integrated Coastal Zone Management Plan (2013), the Ministry of Energy, Science & Technology and Public Utilities (MESTPU) Strategic Plan 2012-2017, the Sustainable Energy Action Plan for Belize, the National Sustainable Tourism Master Plan of Belize (2010), Growth and Sustainable Development Strategy (GSDS) 2014 – 2017, the National Agenda for Sustainable Development (2013),and the National Climate Resilience Investment Plan (2013).

National Climate Change Policy, Strategy and Action Plan

The goal of the National Climate Change Policy is to guide the short, medium and long-term processes of adaptation and mitigation of Climate Change in accordance with national prospects for sustainable development in addition to regional and international commitments. The policy ensures an integrated and well-coordinated approach to Climate Change adaptation and mitigation by fostering the development of appropriate administrative and legislative mechanisms in alignment with national sectoral policies and adaptation plans.

The strategy is consistent with the overall goal of the GSDS 2014-2017 and encourages the use of new economic and financial mechanisms including National Appropriate Mitigation Actions (NAMAs) and markets. It also encourages the development of instruments to facilitate public-private sector partnership, research, innovation, development and adjustment to climate technologies and strengthening of capacities, as well as ensuring that policy makers, negotiators and civil society have access to relevant and best available scientific information for decision-making.

The Climate Change Action Plan is a five-year programme (2015-2020) to build the capacity and resilience of the country to meet the challenges of climate change. The Action Plan is divided into two thematic areas namely adaptation and mitigation. The choice of these two thematic areas is based on the fact that the country has, in its First and Second National Communication report to the UNFCCC, identified a number of sectors, namely, coastal zone, human settlement, fisheries and aquaculture, agriculture, forestry, tourism, water, energy and health as national priorities for Climate Change mitigation and adaptation efforts.

Low Carbon Development Roadmap

The development of the national roadmap for Belize to achieve a low carbon development strategy will create a platform for low carbon growth in new areas while still attaining the national development targets. The roadmap will be implemented in 2 phases:

Phase I: (short-term, horizon 2015). This phase will focus on urgent needs at the technical, policy, and institutional levels, namely updating the GHG inventory and setting GHG emission reduction targets, and reforming/building capacity for key institutions to reinforce Climate Change management.

Phase II: (medium-term, horizon 2020). This phase will focus on policies, building technical capacity, strengthening institutions, facilitating public-private partnerships and engaging stakeholders to adopt sustainable practices. In addition there will be provision for designing technical tools such as Baseline Scenarios, and Mitigation Abatement Curves (MAC), along with developing and operating policy instruments tailor-made for the identified priority sectors, while implementing current.

Other Information for Achieving Convention Goals

Other initiatives that were implemented to achieve the objectives of the convention include climate research and systematic observation and education and public awareness. Meteorological observations in Belize date back to 1887. Observations at that time were recorded by a number of individuals and organizations such as the Agriculture, Forestry and later Civil Aviation Departments. With the establishment of the Belize Weather Bureau in the early 1970’s, weather observations were officially assumed by the newly formed department. In 1978, under a cooperative agreement between the United States of America and the Belize and British governments, the Upper Air and Marine Forecasting Centre in Swan Island were transferred to the National Meteorological Service (NMS) of Belize. The NMS also maintains a data archive of Essential Climate Variables (ECVs) assembled as part of a larger data collection process.

In terms of education and public awareness, a National Climate Change Symposium was held in

October, 2014 under the title 'Building Climate Resilient Municipalities'. The Symposium contained sessions focusing on climate change, vulnerability, resilience, early warning systems, greening our landscapes, clean energy and the diversification of the tourism industry. Through partnership with other agencies such as the Caribbean Community Climate Change Centre, the Toledo Institute for Development and the Environment (TIDE), Programme for Belize and the World Wildlife Fund (WWF), the NCCO implemented programmes such as the 1.5 Stay Alive: an "Educational Initiative Teacher's Continuous Professional Development workshop" and other initiatives covering various climate related concepts including mainstreaming of climate change, climate variability, impacts and adaptation.

Gaps, constraints and related financial, technical and capacity needs for achieving the convention implementation

The Government of Belize has made great strides to integrate Climate Change into its national development processes and mechanisms. Nevertheless, various gaps and constraints and the related financial, technical and capacity needs were identified during the process of preparing its Third National Communication. These gaps and constraints were in the areas of GHG inventory, vulnerability and adaptation assessment, research and systematic observation, in addition to the country's financial and capacity building needs.

Greenhouse Gas Inventory

Coordination among data providers needs to be strengthened to ensure that collection and reporting of data are done at a regular basis to support reporting responsibilities such as the National Communication process, Biennial Update Report and institutional needs. Additionally, opportunities should be identified to link data collection needs with other data collection programmes such as REDD+ initiatives, "waste to energy" which has the potential to create renewable energy from waste matter, including solid waste, industrial waste, agricultural waste, and waste by-products. Institutionalizing linkages between GHG inventory estimation with broader Climate Change research is very much needed.

Capacity building and training will be an on-going effort at the institutional and technical level. Institutions generating the activity data will need to be trained in GHG inventory and data formats.

Vulnerability and Adaptation Assessment

The major gaps identified during this exercise included financial, technical and capacity needs to sustain infrastructure for implementation of climate actions. Other gaps pertained to inadequate capacity at district and community level on Climate Change impacts, insufficient use of economic instruments and lack of input data for some sectors and inadequate capacity for modelling. Therefore, the next steps for the Fourth National Communication should include information relating to cumulative impacts of Climate Change and sea level rise and its associated costs.

Research and Systematic Observation

Much effort is being put into searching archives of data stored by other organizations and digitizing those historical paper records. The addition of these records will increase both the spatial and temporal coverage of data under the NMS stewardship. To enhance the completion of this process further support is needed.

Also key to note is that staff members of the NMS who have the capacity to undertake research studies are used to fulfil the operational demands of the Department such as maintaining operational forecasting and climate services. In order to effect a significantly larger and more active participation in research, the NMS should acquire a greater cadre of appropriately qualified individuals.

Public Education and Awareness

Education, training and public awareness will facilitate capacity building to participate and implement effectively the commitments to the Convention. Despite moderate progress in this area, there is a need to improve the provision of public education and awareness at the community and local levels. This should also involve high-level policy makers to ensure the integration of Climate Change considerations into national development policies.

Proposed Projects for Funding

There are a number of projects being proposed in various sectors that will require funding. Areas of focus for these projects include, but not limited to:

1. **Agriculture-** Increasing access to drought resistant crops and livestock feeds, adopt better soil management practices and provide early warning/meteorological forecasts and related information to be competitive in the region.
2. **Forestry-**Systematically assess the potential impacts of Climate Change on Belize's forests, develop a comprehensive monitoring system to evaluate changes in the forest cover and maintain and restore healthy forest ecosystems by sustainable forest management.
3. **Fisheries and Aquaculture-** The sustainable management of the fisheries resources, conservation and preservation of fisheries resources and marine habitats in promoting reef ecosystem resilience.
4. **Coastal and Marine resources-** Increase and strengthen the capacity of the Coastal Zone Management Authority, develop a programme and acquire equipment to monitor and provide early warning in respect of storm surges and implement mangrove restoration or sea and river defence structures to prevent coastal erosion.
5. **Water Resources-** Design and implement an IWRM programme in watersheds to reduce the impacts of Climate Change.
6. **Land Use and Human Settlements**- Undertake a comprehensive assessment of human settlements and related infrastructure at risk from the effects of Climate Change.
7. **Tourism-** Undertake a sea level rise vulnerability mapping exercise as part of a revision of the Tourism Master Plans and Land Use Plans.
8. **Human health-** Assessment of impacts of Climate Change on human health and well-

being.

9. **Transportation-**Comprehensive assessment of transportation/communications infrastructure and their vulnerability to storm surges, floods and other forms of natural disasters.
10. **Solid Waste-**Develop and implement a National (country-wide) Integrated Solid Waste Management Programme for Belize.
11. **Energy-**Improve energy efficiency to dramatically lower energy intensities across key economic sectors such as Transport, Industry and Buildings.

1 NATIONAL CIRCUMSTANCES

This section provides a detailed description of Belize's current environmental and economic sectoral state. The country's geography, climate and economy are assessed in the context of addressing mitigation and adaptation, the impacts of Climate Change and climate variability.

1.1 Geography

Belize is a relatively small independent country situated on the east coast of Central America and bounded on the north by Mexico, on the south and west by Guatemala and on the East by the Caribbean Sea. The country is located on a portion of the Yucatan Peninsula and lies between 15°45'and 18°30'north latitude, and 87°30' and 89°15' west longitude. The national territory covers a total area of 46,620 sq km (18,000 sq miles) with a land area of approximately 22,967 sq km (8,867 sq miles), including 280km of coastland. The mainland makes up 95 % of the territory and 5% is represented by more than 1,060 small islands or Cayes.

The Maya Mountains found in Belize cover the lower half of the country, surging across the country into neighbouring Guatemala with a height of 1,124 m above sea level (3688 ft) at its highest point. Other natural features such as basins and plateaus also dominate much of the country, except for the areas where the coastal plains are located. Much of Belize (69%) remains under natural vegetation while 39.1% of the terrestrial area is made up of protected forests (UNCSD, 2012).

There are six administrative districts in Belize: Belize, Cayo, Corozal, Orange Walk, Stann Creek and Toledo. The capital of the country is the City of Belmopan, situated in the central part of the country, but Belize City is the largest urban agglomeration with approximately 66,000 inhabitants. The Belize District, where Belize City is located, is the most urban area in the country, whereas the Toledo District located deep within the southern portion of Belize has the most rural areas.

1.2 Climate

Belize is characterised as having a sub-tropical climate with two (2) distinct wet and dry seasons. The rainy season occurs in the period from June to November and brings approximately 60 inches (1524mm) of rain in the north to 160 inches (4064mm) of rain in the south. Rainfall varies from year to year in many areas, except in the Southern parts of the country where annual rainfall average is consistent. The heaviest amount of rainfall is usually expected in June or early July and is punctuated by a break in late July or August while the dry season occurs from November to May (Figure 1). The process of changing from dry to wet seasons can be considered as being gradual with a cool transition from November to February and a warm transition from March to May.

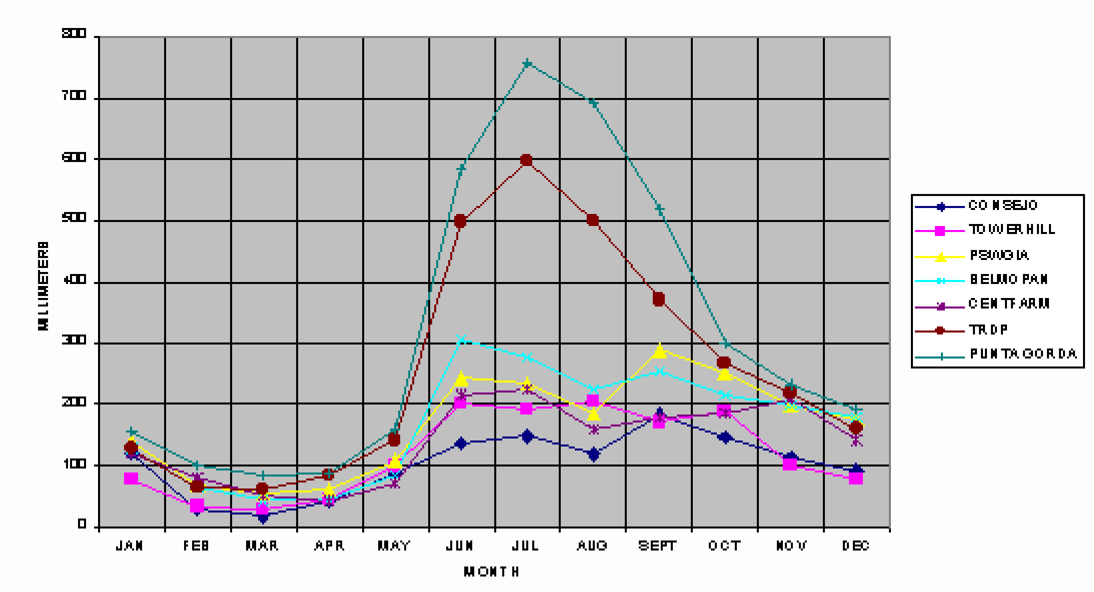

Figure 1: The average monthly rainfall in Belize

Source: National Meteorological Service of Belize, 2015

The mean temperature in Belize ranges from 27°C (max - 30.1°C, min 22.6°C) along the coast to 21°C (max - 25.3°C, min - 17.7°C) in the hills, with the coldest month being January and the warmest temperatures experienced in May. Inland areas are more inclined to have higher temperatures than coastal areas with the temperature in the latter being influenced by sea breeze which reduces the temperature. Other features of Belize's climate are cold fronts which move south-eastward from North America into the Northwest Caribbean. This phenomenon affects Belize every ten (10) days and is occasionally accompanied by an enhancement of precipitation (National Meteorological Service of Belize, 2015).

The winds blow at an average of five (5) knots and travel in the direction of east to southeast all year long. The country is also affected by tropical storms, tropical waves and hurricanes that move westward through the Caribbean from the months of June to November. Belize is affected by a major hurricane or storm every three (3) years with damages usually predominant in the northern portion of the country. Hurricanes are usually expected during the months of September to October and vary in number from year to year. Major hurricanes that have recently affected Belize, causing major damage are but not limited to; Hurricane Mitch (1998), Hurricane Keith (2000), Hurricane Iris (2001), Hurricane Dean (2007) and Hurricane Richard (2010) (MNREI, 2011).

1.3 Environmental Profile

Belize is divided into the following six (6) water basin regions: the Northern Watershed Region, the North-eastern, the Central, the South-eastern, the South-western and the Southern Watershed Region. The country is known to have sixteen (16) major watersheds that were grouped into six main watershed regions based on general characteristics of topography, geology, soils, rainfall and land use (BEST, 2009) (Figure 2).

The Belize River watershed is the largest in the country, occupying more of Belize's land mass than the others and dominating the central portion of the country. Nevertheless, groundwater is an important source of freshwater for the Belizean population, providing 95% of the total. Additionally, the inland areas of Belize are comprised of many rivers, waterways, lagoons and swamps (BEST, 2014).

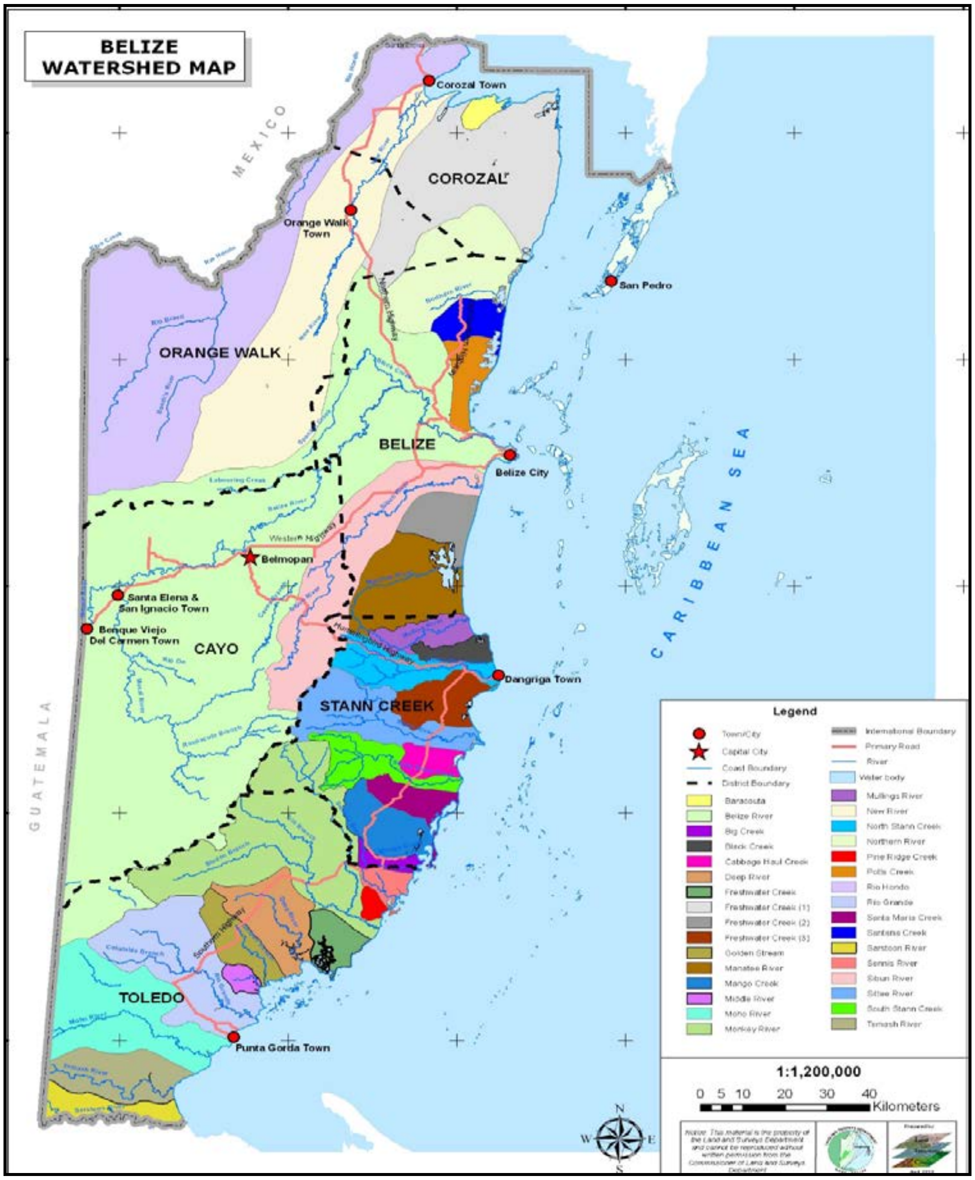

Figure 2: Watershed map of Belize

Source: Unknown

Belize also has many wetlands which are mostly found in the Northern parts of the country. The most notable of these is the Crooked Tree Lagoon; a 165-km^2wetland complex connected to the Belize River via two streams. Other substantial wetlands include New River Lagoon, Progresso Lagoon, Cox Lagoon, and Pulltrouser Swamp.

1.3.1 Biodiversity and Ecosystems

Belize is located in the Mesoamerican biodiversity hotspot and is characterized as having a variety of terrestrial, marine, and freshwater ecosystems. More specifically, eighty-five (85) terrestrial ecosystems, fifteen (15) marine ecosystems, and forty-three (43) different riverine ecosystems have been classified in the country. In the coastal zone, habitats are characterized by numerous fringing reefs, patched reefs, faros, mangroves, littoral forests, broadleaf forests, pine forests, savannahs, sea grass habitats, deep water systems, sand and silt-bottom habitats, and Cayes, inter alia. These habitats are particularly important because of their high levels of biodiversity and the tourism and fisheries economies that they support (Figure 3) (Meerman, 2005).

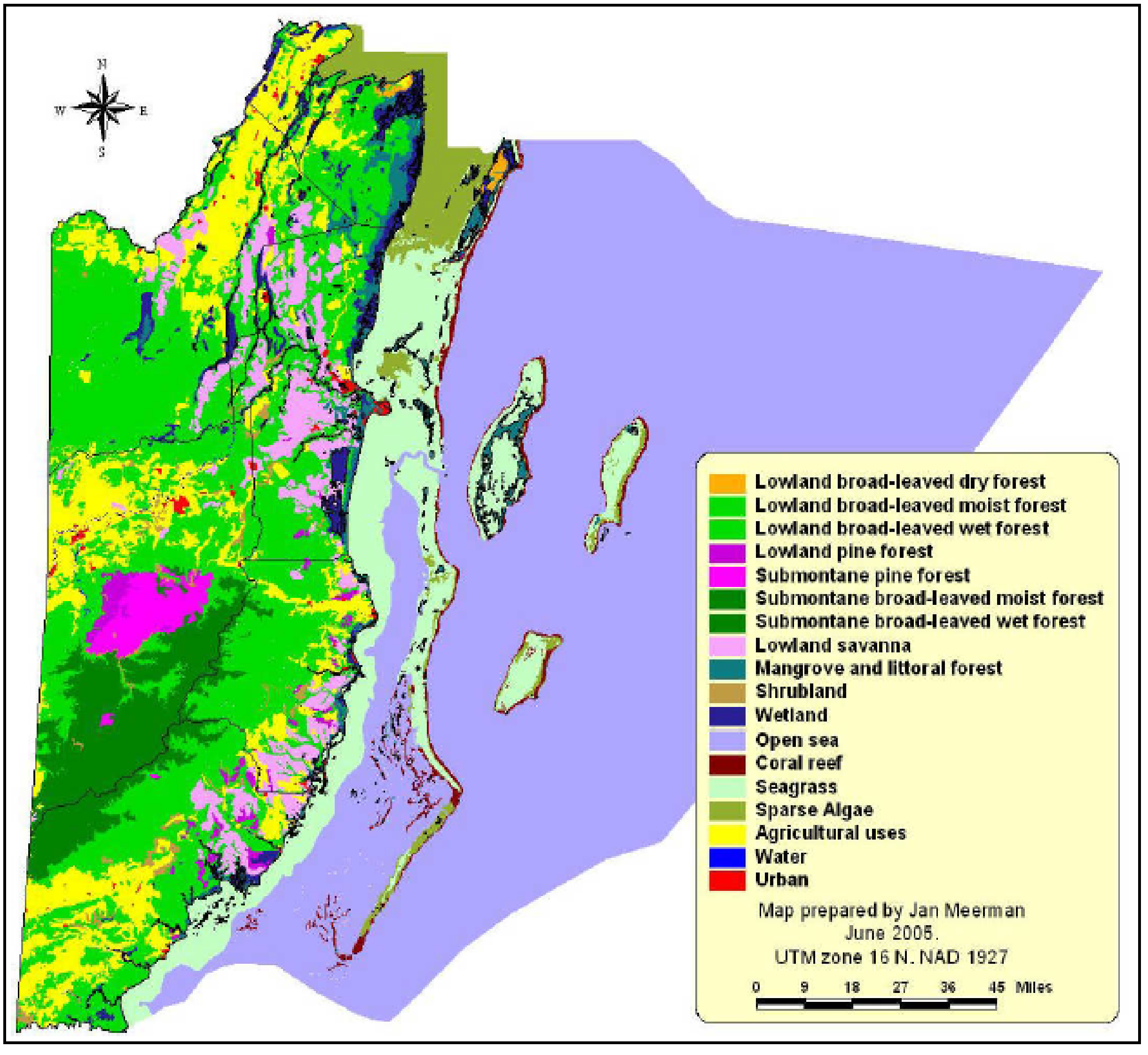

Figure 3: The ecosystem map of Belize

Source: Meerman, 2005

The wide array of biodiversity in Belize includes forty three (43) species of freshwater fish, three hundred species of marine fish (300), one hundred and fifty eight (158) species of molluscs, one hundred and twenty two (122) species of reptiles, five hundred and seventy six (576) species of birds, one hundred and sixty three (163) species of mammals, forty two (42) species of amphibians and forty (40) species of corals. The country is also estimated to have four thousand (4,000) species of flowering plants; many of which are of medicinal value. Most of these species, which are considered to be under pressure in Central America, are being protected (Gillett and Myvette, 2008).

1.3.2 Protected Areas

There are one hundred and three (103) protected areas in Belize and these include all the statutory sites, private protected areas and archaeological reserves that are recognised as being part of the national system. Of the one hundred and three (103) legally recognised protected areas, seventeen (17) had been designated as forest reserves, four (4) as nature reserves, eighteen (18) as national parks, eight (8) as private reserves, eight (8) as wildlife sanctuaries, nine (9) as marine reserves, five (5) as natural monuments, fifteen (15) as archaeological reserves, seven (7) as bird sanctuaries and twelve (12) as spawning aggregation reserves (Salas and Shal, 2015).

The protected areas system includes:

- Maya Mountains Massif and part of the Selva Maya Node; two (2) areas that are very important for biodiversity conservation.
- Crooked Tree Wildlife Sanctuary
- Belize Barrier Reef; a globally important network of marine protected areas and seven (7) marine protected areas which is inscribed as a world heritage site.

The forest department and the fisheries department, which are part of the Ministry of Forestry, Fisheries and Sustainable Development, play a very important role in the management of various protected areas sites. Currently, fifty-two (52) protected areas are managed by the forest department while nine (9) Marine Reserves and twelve (12) spawning aggregation sites (many of which overlap existing Marine Reserves) are managed by the Fisheries Department (Salas and Shal, 2015).

In Belize, communities and non-government organizations play an important role in working with the government for the protection and conservation of the environment and biodiversity in protected areas. This situation has occurred because of the limitations being faced by the government relating to insufficient human and financial resources for the management of terrestrial and marine protected areas. Some notable protected areas co-managers are: the Belize Audubon Society, the Bladen Consortium, the Toledo Institute for Development and Environment (TIDE), Rancho Dolores Environment and Development Group and Programme for Belize.

1.4 Population Profile

Population estimates by the Statistical Institute of Belize revealed that by mid-2014, there were approximately 358,899 persons living within Belize (Figure 4). There was a steady growth in the population from 315,082 persons in 2009 to a total of 358,899 persons in 2014 with growth rates ranging from 2.5% to 2.63%.

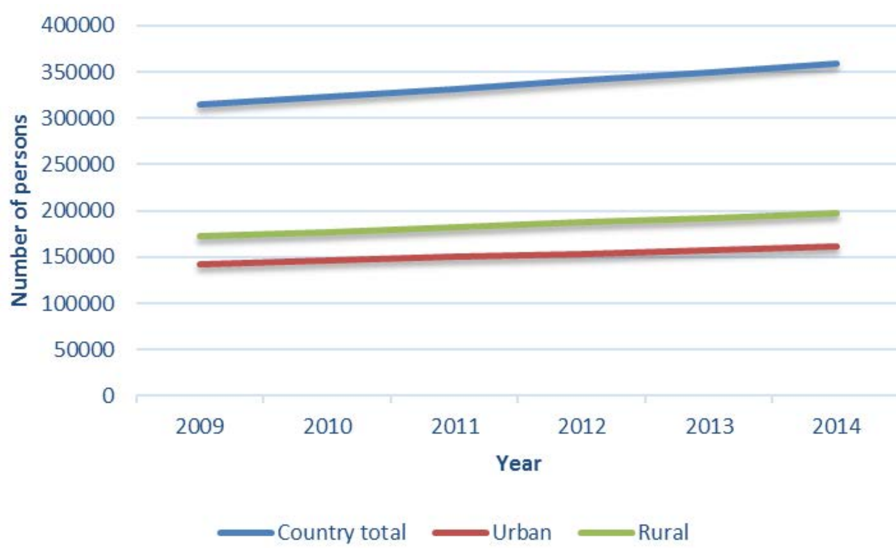

Figure 4: Estimated mid-year population for Belize

Source: Statistical Institute of Belize, 2014

Belize continues to be among the minority of countries that have a predominantly rural population. From the period of 2009 to 2014, there was a steady increase in population for both rural and urban areas. The population grew by 11.7% and 12.5% for urban and rural areas respectively between mid-2009 and mid-2014.

From the year 1946, the population grew at an annual average rate of 2.65%, with the highest growth rate being experienced in the period of 1960-1970. In the last 3 decades, the population in Belize has more than doubled (Figure 5). The Statistical Institute of Belize predicts that, if Belize's population continues to grow at a similar rate, the population will double again by the year 2036 (Statistics Institute of Belize, 2010). Such growth can have implications for Climate Change management and sustainable development in Belize.

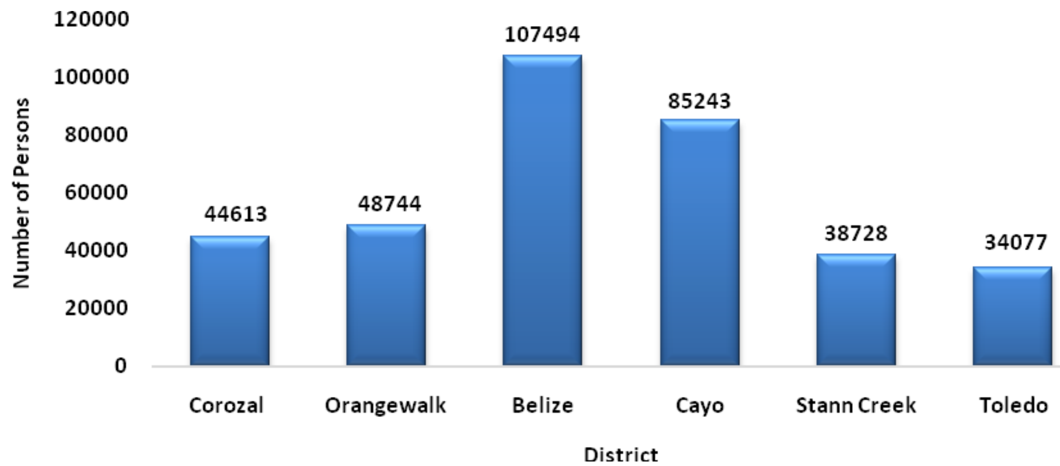

Figure 5: Midyear population by districts 2014

Source: Statistical Institute of Belize, 2014

1.4.1 Education and Labour Force

School attendance in Belize continues to be among the lowest in the Latin American and Caribbean region. Only one-third (101,655) of the population two (2) years and older was enrolled in the formal education system in 2010. Among children of primary school age (5 to 12 years), 95.9 percent were attending formal school in 2010. On the other hand, about three quarters (75.9 percent) of secondary school-aged (13 to 16 years) persons were attending formal school, up from just over two-thirds (68.0 percent) of them in 2000 (Statistics Institute of Belize, 2010).

The additional members of the population attend vocational schools which are scattered throughout the country and which are equipped to provide the necessary skills and practical experience needed for productivity in the main sectors of the Belizean economy. Tertiary educational institutions available include the University of Belize (UB), Central America Health Sciences University (CAHSU), Belize Medical College and Galen University which offer Associates, Bachelors, Masters, and Doctoral degrees.

Approximately 152,893 persons of working age in Belize are in the labour force. These persons either have a job or are available if one was offered to them. The Corozal District has the highest proportion of working age persons in the labour force (at 71.0% of the total) while the Toledo District has the lowest (at 53.2% of the total).

Belize has a young labour force with 75% of them being below the age of forty-four (44). This age group makes up most of the labour force. The second largest group of persons in the labour force is found between the ages of 14-24 with a total of 36,642 persons (24% of the workforce). The third largest group, 35,020 persons (23% of the total), are found between the ages of 35-44. Local educational policies and programmes have been aimed at enriching the workforce with the skills and abilities to serve in areas such as telesales, customer service, professionalism and communication and other areas of the natural and physical sciences.

1.5 Economy

Belize has a small open economy that is primarily dependent on its natural resource endowments. The economy is diversified with various primary, secondary and tertiary industries playing a major role in economic development. Historically, the country has always been dependent on the agriculture and forestry industries for economic development. Production of sugar, citrus, banana exports and forestry (logwood, mahogany and chicle) contributed greatly to the country's economic growth. Reforms of revenue collection, expenditure controls and budgeting and planning processes, which were carried out in 1998, have led to the rise-increased public spending on infrastructure as well as increased tourism and foreign investment.

The Statistical Institute of Belize puts the value of the country's GDP at BZE $2,635.6 million dollars based on 2014 data. Tertiary industries, which include the tourism and services sector, have contributed to 60.29% of the GDP with a total of BZE $1,589.1 million dollars in 2013 This includes wholesale and retail trade and repairs (15.36%), hotels and restaurants (4.72%), transport and communications (11.01%), financial intermediation (6.65%), real estate (10.15%) and community services (4.72%) inter alia.

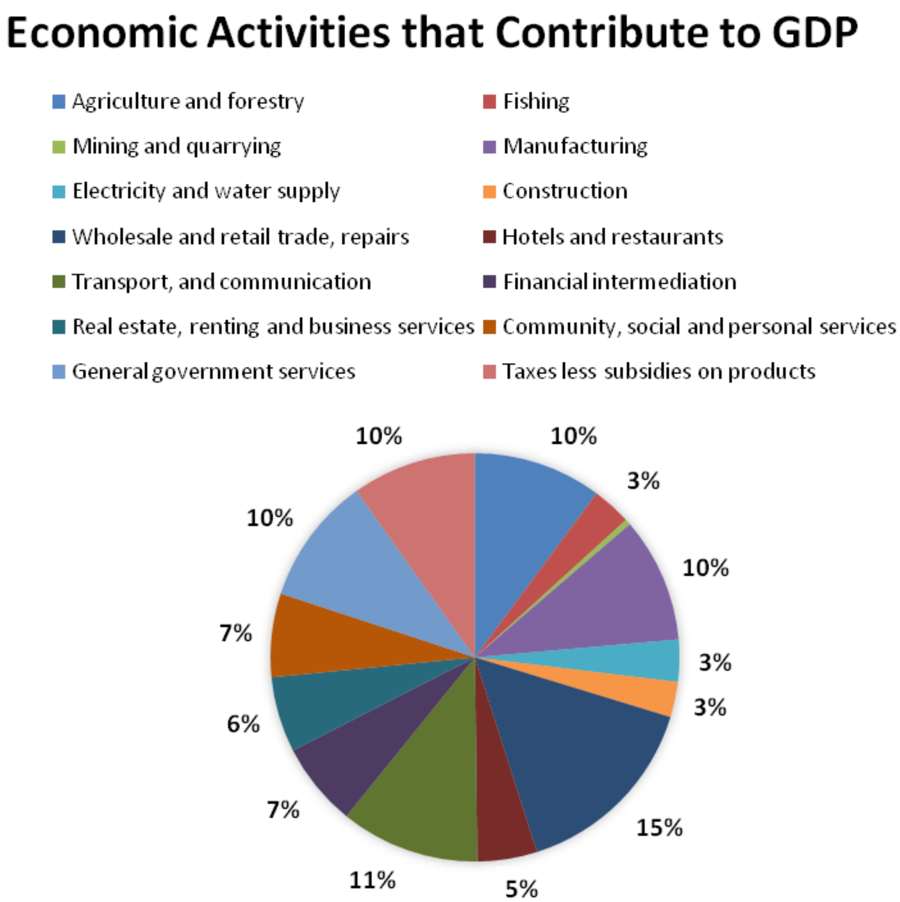

Figure 6: Economic activities that contribute to GDP in 2013

Source: Statistical Institute of Belize, 2014

Secondary industries such as manufacturing (9.90%), construction (2.81%)and electricity and water supply (3.33%) are the second highest income earners; contributing to 16.03% of the GDP with a total of BZE $407.2 million . The primary industries which include agriculture and forestry (10.15%), fishing (3.08%), and mining and quarrying (0.46%) gave the smallest contribution of 13.70% and a total of BZE $381 million dollars (Figure 6).

Belize's GDP has been growing steadily at an average of 4% per year for the past two (2) decades. Growth during the 90's averaged 4.6% and notwithstanding three natural disasters and the September 9/11 attack on the U.S., growth between 2000 and 2006 averaged 6.5% (MNRE, 2011). In 2009 growth slowed to just 0.3%, before recovering in 2010, when it accelerated to 3.1%. The economy then grew by 2.1% in 2011, 4% in 2012 and an estimated 0.7% in 2013.

Belize had a sharp rise in GDP from BZE $1,159.7 million in 1992 to BZE $2,635.6 million dollars in 2013. Future increases in GDP are predicted to result from further diversification of the Belizean economy, which includes the expansion of the tourism, agriculture and oil industries. Specifically, the oil industry had given the economy a boost in 2005/06. Studies show 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.

1.6 Energy

Energy production in Belize comes from sources such as wood (10.09%), petroleum gas (0.86%), hydro (10.10%), biomass (35.36%) and crude oil (43.56%) (Figure 7). Belize Natural Energy (BNE) is currently the only agency that produces oil (about 1,760 barrels a day) within the country with an estimated 20 million barrels of recoverable oil reserves in its portfolio. Currently, no refining of oil is done locally and most of it is exported.

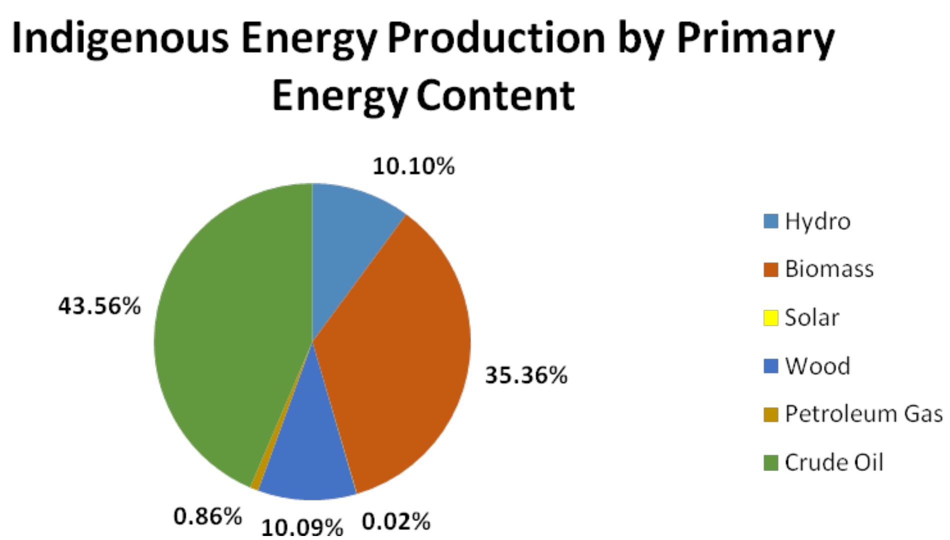

Figure 7: Showing supply by primary energy content in 2014

Source: Energy Report, 2014

Four (4) hydro power plants, three (3) on the Macal River and one on the Columbia River, supply power to the local electricity sector. These are the Mollejon Hydroelectric Plant, Chalillo Hydro Dam and Plant, Vaca Hydroelectric Plant and Hydro Maya Limited (HML), respectively. Sugar cane processing by the BELCOGEN helps to produce electricity from biomass while wood is used by local entities to produce charcoal for consumption by households and small scale commercial and industrial entities (Tillett et al., 2012). Thirty seven percent (37%) of energy supplied in 2014 was from the above-mentioned domestic energy sources.

In addition to its domestic fossil fuel sources, Belize imports a significant amount of its energy supply in the form of petroleum products and as electricity (56.37% in 2014). Products such as liquefied petroleum gas (LPG), gasoline, kerosene, light fuel oils and diesel oil make up 88.52% of the imports in 2014, while electricity made up 11.48% (Energy Report, 2014). Most of the oil products are imported from Venezuela under the Petro-Caribe Agreement and transported to Belize via ocean tankers. In 2014, 36.82% of the electricity generation output was sourced from Comisión Federal de Energía in Mexico while 63.18% was sourced from the aforementioned local providers.

The transport sector is the biggest consumer of energy in Belize, accounting for 46.8% of total consumption in 2010. This is followed by the industrial sector (27.43%), and the residential and commercial services sectors (25.77%).

It is expected that the demand for electricity will grow in Belize but that energy efficiency can reduce that demand while the use of renewable energy can increase supply. Belize is said to have unrealized sustainable energy potential worth approximately BZE $524 million which can last up to 2033. To make this a reality, it is envisaged that renewable sources could represent 89% of the supply, with a 24% decrease in electricity use resulting from energy efficiency. In the report for the development of Belize’s renewable energy and energy efficiency strategy, Castalia Limited (2014) recommends the increased use of methods such as the biomass, solar and hydropower and a broad range of energy efficiency methods by businesses, citizens and government agencies in order to achieve efficient and reliable energy supply for the future (Castalia, 2014).

1.7 Agriculture

The agriculture industry is considered the mainstay of the Belizean economy; employing about 12,000 farmers, earning a significant amount of foreign change and contributing to the nation’s food and nutrition security (FAO, 2011). The sector is characterized by three main sub-sectors which are as follows:

- An organized traditional export sector for sugar, banana, citrus, and marine products
- A traditional, small-scale farm sector, producing food mainly for local consumption
- A well-integrated large-scale commercial sector

Approximately, 800,000 hectares or about 38% of Belize’s total land area is considered suitable for agriculture but only 15% of this is currently used for crop and livestock production (BEST, 2014). Twenty four percent (24%) of these farms are less than 5 acres, 33% of them are between 5 and 20 acres and 74% of them are below 50 acres. A quarter of all farms are located in the Toledo district with 77% of them being small farms. Orange Walk has approximately 22% of farms while Corozal has 21%. An estimated 60,000 acres of land are under sugar production, 46,000 acres are used for citrus production and 38,000 acres are used for corn production, while 150,000 acres are used as pastures for grazing cattle (FAO, 2011).

Crops such as corn, beans, sugarcane, citrus and bananas, cattle and aquaculture products contribute significantly to foreign exchange earnings. High foreign exchange earnings from these commodities result from organized marketing and excellent production systems. Crops such as rice, corn, beans and livestock (beef cattle, dairy cattle, poultry, and pigs) are considered staples in Belize. Together with root crops, fish and seasonally available vegetables and fruits, these staples contribute significantly to food and nutrition security in Belize.

Production systems can range from shifting cultivation practices to fully mechanized operations. Shifting cultivation practices are used by small famers to produce vegetables for the domestic market. Crops such as sugarcane citrus, banana, beans and vegetables are cultivated using semi-mechanized practices in districts such as Corozal, Orange Walk, Stann Creek, Cayo and Belize. Corn and rice are grown under mechanized practices in the Cayo, Orange Walk, Corozal and Toledo districts. Most of the agricultural land is cultivated using rain-fed irrigation practices (90%) while only 10% is irrigated (FAO, 2011).

In terms of marketing, sugar cane is produced and sold to the Belize Sugar Industries Limited (a subsidiary of American sugar refining), for processing. Most of the raw processed sugar is exported to the European Union (EU) under the EU-ACP Economic Partnership Agreement (EPA). Citrus (mainly oranges and grapefruits) is sold to the Citrus Products of Belize Limited. The citrus products (frozen concentrate) are then exported to the United States of America (USA), Japan, Latin America, the Caribbean and the European Union. Banana produce is primarily exported to the EU and the surplus is consumed by the local market. Rice, corn and beans are produced for local use but are also sold to the Bel-Car Export and Import Company Limited, a private company which is owned by the Belize Grain Growers Association and other farmers, for export to the Caribbean and other parts of the world (BEST, 2014). Cattle are sold locally but are also exported to Mexico.

1.8 Fisheries and Aquaculture

The Fisheries sector is considered one of the most productive sectors in the Belizean economy and directly influences the livelihoods of more than 15,000 coastal inhabitants as fish products are the main source of protein and income generation. The industry operates at a small-scale artisanal level and provides employment for approximately 2,459 fisher folk with a fishing fleet of 560 artisanal boats. The sector also has four (4) fishermen cooperatives that are considered significant actors in the Fishing Industry, especially in providing access to international markets (Belize Fisheries Department, 2014). These establishments include the Northern Fishermen Cooperative Society, the National Fishermen Producers Cooperative, the Rio Grande Fishermen Cooperative and the Placencia Fishermen Co-op.

The harvesting of wild stocks in Belize swirls around two (2) main species: Spiny lobster (*Panulirusargus*) and Queen Conch (*Stombusgigas*) along various species such as finfish, crab, sea cucumber and octopus, which have high market value. Figures for the year 2014show that lobster and conch were the highest commodities produced in 2014 (Figure 8) in the fishing industry, earning a total of $24,151,423 in export earnings. Exports of whole fish such as grouper, snappers, hog fish, king mackerel, barracuda and jacks also earned a total of $825,669 in 2014. Overall production of fisheries commodities within the sector reached 2,017,242 pounds. Of the total, 1,691,647 pounds were exported to trading partners, especially to the USA and Mexico. These overall exports earned a total value of $27,676,211.64, making the industry a significant contributor to the country's GDP.

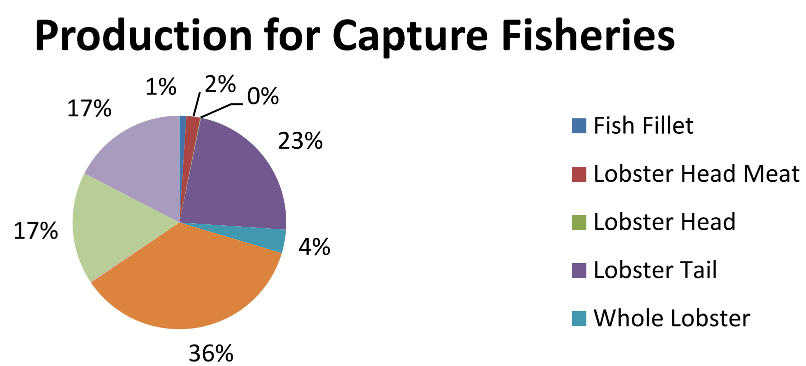

Figure 8: Production for capture fisheries in 2014

Source: Statistical Institute of Belize, 2014

Fishing within freshwater bodies also occurs but is less documented. These activities occur mainly in the brackish water marshes, swamps, and lagoons of the north, such as the New River the Rio Hondo, the Belize River and their tributaries. The most important fresh water species targeted are the Blue Catfish or "Baca", the Characins which includes the Billums, and the South American Catfishes which includes the Gafftopsail Catfish or "Old Guy" and the "Catto" (Gillett and Myvette, 2008). More recently, the Black Nile Tilapia has become popular since its introduction into Belizean waters.

1.8.1 Aquaculture

The two main important species that are produced in the aquaculture sector are shrimp and tilapia. Shrimp production dominates the sector to a large degree with approximately 6 shown farms producing the commodity in the Stann Creek district. On the other hand, tilapia is produced mainly at the subsistence level with only one (1) farm currently in operation (FAO, 2015).

Shrimp can be considered as the largest and most economically important fisheries export. Production of shrimp within the sector is considered as being semi-intensive, intensive and super intensive with farms ranging from 100 to 15,000 acres. Most farms are stocked at 60,000 to 100,000 shrimp per acre and can produce approximately 1,500 – 2,000 lbs of shrimp per acre at a survival rate of 70% - 80% (BEST, 2014).

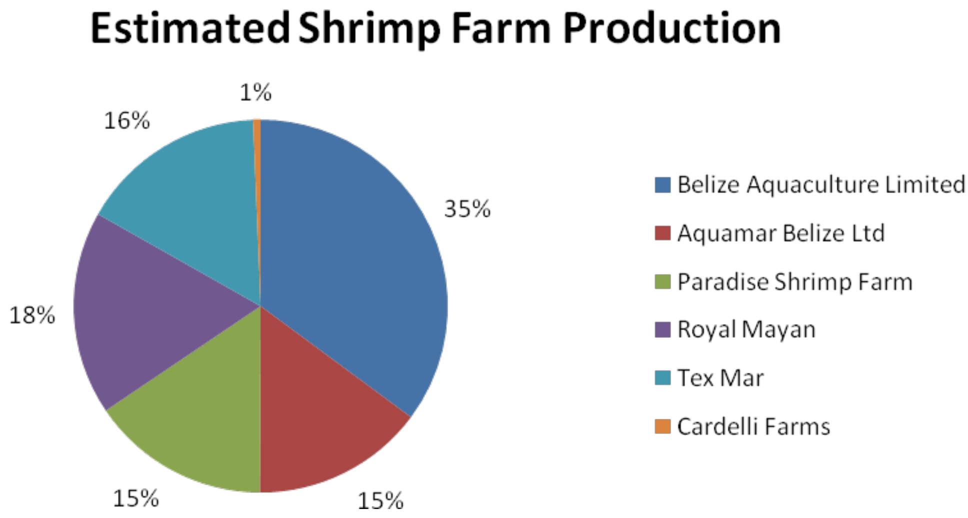

Figure 9: Shrimp production in percentages by farms for 2013

Source: Statistical Institute of Belize, 2014

The most recent data released from the Statistical Institute of Belize shows that a total of 15,067,059 pounds of shrimp were produced in 2013. This led to the earning of BZE $81,736,042 from shrimp exports from this commodity alone. The Belize Aquaculture Limited is the largest producer of shrimp with a total of 5,292,270 pounds of shrimp, followed by Royal Mayan (2,657,469 pounds), Tex Mar (2,433,063 pounds), Paradise Shrimp farm (2,332,400 pounds), Aquamar Belize Limited (2,252,831 pounds) and Cardelli Farms (99,026 pounds). Produce from the sector are exported to Mexico, the Caribbean, Europe and North America (Figure 9) (FAO, 2015).

In addition to its national economic contribution, the sector contributes greatly to the economic well-being of Belizeans in districts such as Toledo and Stann Creek (districts with high rates of poverty). Approximately, 1500 workers are employed in skilled or semi-skilled positions for the production and processing of shrimp (BEST, 2014).

1.9 Tourism

The tourism industry is the largest contributing sector to the GDP in Belize. The sector is considered to be the largest earner of foreign exchange and is very important for the sustained wealth of the country (Centre on Ecotourism and Sustainable Development, 2006).The sector itself was said to contribute to BZE $432.5 million (13.5% of GDP) to the GDP in 2013 and approximately BZE $450.3 million in 2014 (rising by 4.1%). Foreign exchange is generated by hotels, travel agents, airlines and other passenger transportation services and the activities of the restaurant and leisure industries (Turner, 2014).

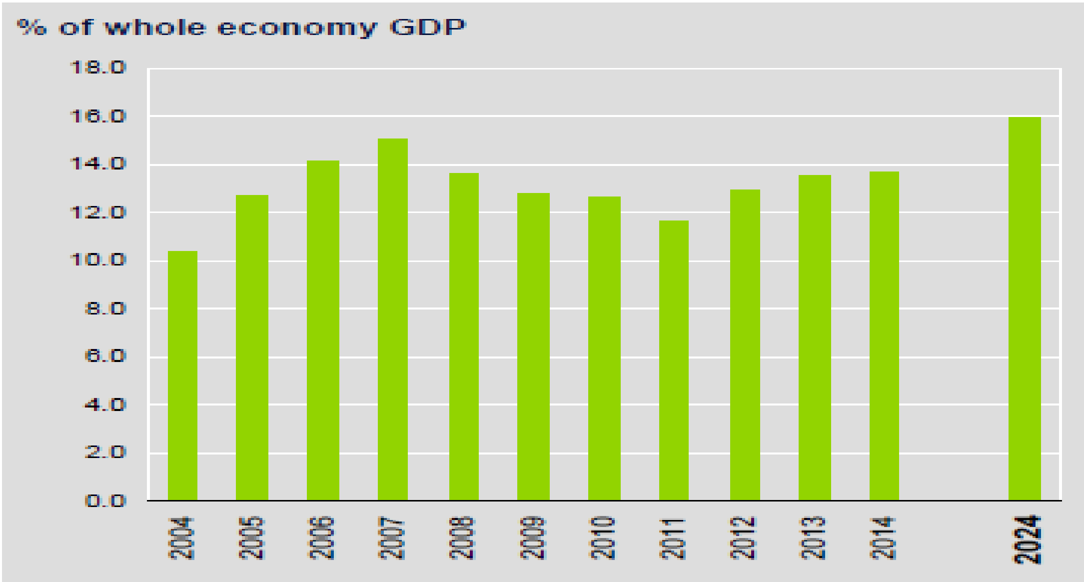

Figure 10: The contribution of the tourism industry to GDP

Source: Turner, 2014

The tourism industry has contributed significantly to Belize's GDP from 2004 to 2014 with contributions ranging from 10% to 15% between the years 2004 to 2014 (Figure 10). According to Turner (2014), contributions to GDP by the sector could reach 16% by the year 2024. It is estimated that the sector catered for 33% of total employment in 2013 which translates to approximately 47,000 jobs. The World Travel and Tourism Council had estimated that this figure would rise by 5.1% in 2014 and 4.1% by 2024, providing a total of 49,000 and 73,000 jobs, respectively (Turner, 2014).

The sector caters for overnight or stay-over visitors and cruise ship passengers. The sector records over 245,000 overnight visitors per year which is about 29% of all arrivals to the country. Citizens of the USA and Canada usually account for 60.7% and 6.6% of overnight arrivals, respectively. Approximately 75% of these overnight visitors stay in the Belize District while the remaining 25% of visitors stayed in places like Placencia in the South Stann Creek area and the Cayo District. The facilities for the sector involve approximately 600 hotel and resort facilities with 6,075 rooms, most of which are Belizean owned (Martin and Manzano, 2010).

The number of cruise ship passengers has increased from about 49,411 arrivals in the year 2000 to nearly 610,000 in 2013 (Inter-American Development Bank, 2014). The main attractions are anchored in Belize City harbour. Consequently, cruise ship passengers are transported via prearranged water taxis to the Tourism Village. The main attractions such as the (Fort Street Tourism Village (FSTV) includes: gift shops, duty free stores, jewellery shops, and arts and craft.

1.10 Transport, Information and Communications Technologies

1.10.1 Transport

The Ministry of Works and Transport has responsibility for the oversight of the transport sector in Belize. The Ministry coordinates planning, construction and maintenance of roads, bridges, drains, waterways and district airfields. The actual maintenance work on infrastructure is done by force account and by private contractors, who perform approximately 65% of the maintenance work on the road networks (McNish and Granada, 2013).

The Belize Airport Authority regulates the country's airstrips with the use of the Civil Aviation Act of 2000. The Department of Civil Aviation provides civil aviation services, administers license, operates municipal airstrips and operates the control tower at the Philip S.W. Goldson International Airport.

Trade to and from Belize is facilitated through the Port of Belize and the Big Creek Port. The Big Creek Port usually facilitates the trade of fruits, vegetables and crude oil while all other items are passed through the Port of Belize. Nevertheless, ports face disadvantages due to the existence of the barrier reef, which limits the docking of ships, and the provision of cold storage.

The Belize road stock is considered low compared to its surface area with a network consisting of 3,281 km of roads. There is also low road utilization that is due to low population density and the dispersed nature of housing and economic activities. Nevertheless, traffic volumes are noted to be on the increase in Belize City, the country's former capital and the City of Belmopan. The rate of road fatalities (23 per 100,000 people) is one of the highest in the world and is said to result from the lack of proper traffic signs, pavement markings, limited enforcement of speed limits and lack of driver education (Martin and Manzano, 2010).

Belize's road network is made of primary, secondary and rural roads, 20% of which are paved to connect the major urban settlements and border areas. Secondary roads make up 23% of the road network and consists almost entirely of unpaved roads with either gravel or marl surfaces. These roads link areas of agricultural production with the main market areas around the country and also provide linkage to the primary road system (18% of road network). Rural roads make up the bulk of the network (59%) and were built specifically to facilitate agriculture production activities. Nevertheless, many of these roads are in need of being upgraded, since they are mostly unpaved and their conditions are affected by the elements of the weather (McNish and Granada, 2013).

The condition of the road system is said to be deteriorating with five 5% to 12% of roads being categorised as bad or poor between the periods of 2004/2005 and 2007/2008. Poor resource allocation by the Ministry of Works and Transport for maintenance is considered the main cause, in addition to the lack of logistical equipment and basic data (road inventory, roughness, deflections, traffic counting, and safety measures) which impacts the effectiveness of the Ministry's maintenance management system (Martin and Manzano, 2010).

In terms of air travel, Belize has an international airport and a network of domestic airstrips. The Phillip S. W. Goldson International Airport (PGIA) is privately owned by the Belize Airport Concession Company Limited and is currently Belize's biggest and only international airport.

Several government-owned municipal airstrips also exist in areas such as Belize City, San Pedro, Dangriga, Caye Caulker, Placencia, Corozal, and Punta Gorda. None of the municipal airstrips currently meet International Civil Aviation Organization requirements for operational safety since they have no rescue or fire fighting services available and are considered to have uncontrolled aerodromes (Martin and Manzano, 2010).

1.10.2 Information Communications Technologies

The Telecommunications sector in Belize is regulated by the Telecommunications Act 2003 which liberalised the market and gave the responsibility of its regulation to the Public Utilities Commission (PUC); an autonomous institution composed of seven (7) commissioners and a small professional staff, which also regulates water and electricity (Stern, 2006). The PUC is responsible for technical and economic regulation of the sector and for implementing policy which is set on behalf of the Government of Belize.

Current providers in the market are Belize Telemedia Limited (BTL) and Speednet Communications (locally known as SMART). Both entities operate under various interconnection agreements which allow uninterrupted services to customers of both companies. BTL was nationalised in 2009 and competes directly with “SMART”. These companies aim at providing national and international telecommunications services including the establishment and operation of all types of facilities as well as directory services and customer premises equipment (CPE).

Both telephone companies provide a broad range of services, including basic telephone services, national and international calls, prepaid services, cellular services via GSM 1900 megahertz (MHz) and 4G Code Division Multiple Access (CDMA) 2000, respectively, international cellular roaming, fixed wireless, dial-up and internet, high-speed DSL, internet service, and national and international data networks (Belize Trade and Investment Zone, 2015). These companies currently have approximately 189,600 customers in total, 25,400 of which use main line telephones while 164, 200 use mobile cellular phones.

Belize has three (3) Information and Communication Technology companies operating locally. Firstly, in 2007, the Government of Belize gave Infotel International Limited EPZ the license to establish an ICT business and call centre which would provide services including, telemarketing, customer support, direct marketing, and e-mail and website hosting (Rowland et al., 2010). Another company, named “Ready Call”, is located at the centre of Belize City. The operations of the company began in 2005 and employed approximately 500 persons during its first year of operation. “Ready Call” only has one client, a prepaid mobile service provider, named TracFone, which is the USA based subsidiary of the Mexican America Movíl (Stern, 2006). Another company, Pinnacle BST, which is an ICT application service, also operates in Belize.

1.11 Climate Change Management

Cabinet stands at the hierarchy of the local Climate Change governance structure to provide the necessary guidance and leadership at the political level, including the ratification of international agreements such as the United Nations Framework Convention on Climate Change and its Kyoto protocol. The Ministry of Forestry, Fisheries and Sustainable Development is the Government Agency responsible for Climate Change. The National Climate Change Office (NCCO) is located in the Ministry with the main task of coordinating the country's Climate Change program on behalf of the Government of Belize.

Belize has a National Climate Change Committee (BNCCC). This committee is comprised of eleven members from various government Ministries, non-government organisations and members of the private sector. Ministries represented include those in charge of Works and Transport, Economic Development, Forestry, Fisheries and Sustainable Development, Natural Resources and Agriculture, Health, Tourism and Culture, Local Government and Energy. The committee has one representative of the private sector and a recognised non-government organisation respectively. The University of Belize also sits on the committee (Figure 11).

The Chief Executive Officer of the Ministry of Forestry, Fisheries and Sustainable Development (MFFSD) sits as the chair of the committee, whereas the NCCO functions as the secretariat of the committee. The main task of the committee is to advise the government of its responsibilities under the UNFCCC and the implementation of appropriate policies and strategies to ensure continued sustainable development in Belize.

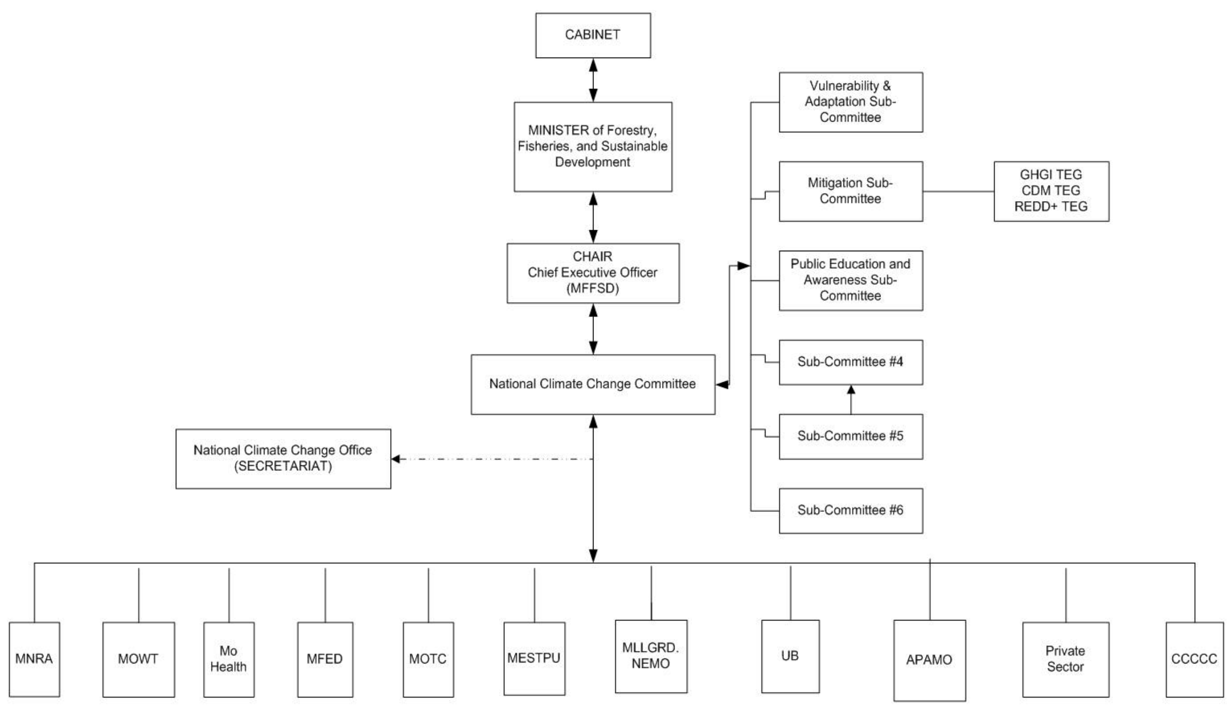

Figure 11: The current organizational structure for climate change

Source: NCCPSAP, 2015

The BNCCC has the authority to establish subcommittees to assist in the implementation of its terms of reference. Currently, there are three (3) sub-committees existing under the BNCCC. These are: the Mitigation Sub-Committee, the Vulnerability and Adaptation Sub-Committee and the Public Education and Awareness Sub-Committee. These sub-committees are made up of eight (8), eleven (11) and nine (9) members, respectively, including many government Ministries, the Caribbean Community Climate Change Centre (CCCCC), the University of Belize (UB), the United Nations Development Program (UNDP), the Southern Environmental Association of Belize (SEA) and the Association of Protected Areas Management Organisations (APAMO).

Belize also has a National Climate Change Policy, Strategy and Action Plan (NCCPSAP) which aim to guide the short, medium and long-term processes of adaptation and mitigation of Climate Change and to ensure the mainstreaming and integration of Climate Change considerations at all levels of the development planning and operational processes of governance (NCCPSAP, 2015). The NCCPSAP also prescribed specific actions to be executed by various Ministries and organisations to build capacity and to improve resilience so that Belize can meet the challenges of Climate Change.

In implementing the NCCPSAP, the Government of Belize will establish a Climate Change Department to replace the NCCO. The new department will play a key role in coordinating the implementation of the Climate Change programme with respect to Belize’s national, regional and international Climate Change obligations, including the implementation of the NCCPSAP. The NCCPSAP also proposed the establishment of a Climate Change Trust Fund (CCTF), which would be managed by the Protected Areas Conservation Trust (PACT), to provide finance for the implementation of the Climate Change adaptation and mitigation programmes identified in the NCCPSAP.

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2 NATIONAL GREENHOUSE GAS INVENTORY

In an effort to fulfil the requirements of article 4, paragraph 1(a) and article 12, paragraph 1(a) of the UNFCCC, this chapter seeks to communicate a national inventory of anthropogenic emissions by sources and removals by sinks throughout Belize. Key source assessments for reference years 2003, 2006 and 2009 were conducted and sought to capture new sources and sinks in addition to those described in the Initial and Second National Communications that might have arisen because of recent developments in the country.

2.1 Methodology

1. Establishment of a Project Management Unit (PMU) and Orientation Session Meeting with Government Officers and National counterparts involved in the Inventory Process

An inception meeting was held with the Project Management Unit in order to align the Work Plan expectations, finalize timelines, project activities, workshops, validation sessions and other issues. This resulted in the preparation of a detailed Work Plan focused on two components, and designed to achieve the project outputs within a proposed budget and timeframe.

2. Facilitate Greenhouse Gases Inventory (GHGI) Training based on an approved Curriculum

A GHGI training curriculum was initially designed and used to familiarise the team members with the GHGI process and reporting tools for each sector. Teams introduced to the various data types were taught how to treat data gaps and other constraints envisaged during the inventory process.

3. A draft summary of the National Green House Gas Inventory was prepared and submitted.

2.2 Energy

Focus Analyse Develop Execute-Evaluate (FADE) process, categorised the accounting and interpretation activities into four (4) phases. As a result of this quality assurance activity, sub-categories within the Energy sector, displaying GHG emissions, were identified as the following: Energy Industries, Transport (Domestic Aviation), Road Transport, National Navigation, Commercial, Residential, Agriculture, Forestry, Fisheries and International Bunkers.

There was a significant decrease in electrical energy generated from diesel fuel in Belize. This was primarily attributed to the import of electrical energy from Mexico, along with the increase of hydroelectric power output.

This generated a change in emissions due to the substitution of electrical energy generated from diesel fuel. The consumption of diesel generated electricity was reduced and largely substituted by hydroelectric energy and biomass. Furthermore, domestically produced crudes entered the supply chain with increasing contributions of emissions. In addition, the building of the reservoirs for the storage of water shifted the GHG’s emission from an anthropogenic source (hydrocarbon combustion) to emissions from natural decomposition.

2.2.1 Energy

A summary of the emission estimates for the Energy sector and sub-sector fuel use is presented in table 1.

Table 1: Energy Emissions by Sub-sector

Emissions in tonnes	**2003**				**2006**				**2009**			
	Gas	**Diesel**	**LPG**	**Crude**	**Gas**	**Diesel**	**LPG**	**Crude**	**Gas**	**Diesel**	**LPG**	**Crude**
Energy		26.18				13.37		1.55		5.66		5
Manufacture-autogen		1.2	0			1.18		1.85		1.7	0	3.44
Manufacture-process heat		11.9	1.6			11.82	2.05	1.85		6.41	1.76	9.64
Transport-aviation	2.43				2.3				2.44			
Road	47.47	36.12	1.06		35.9	37.4	1.25		39.6	33.53	1.18	
National marine	2.21				1.38				1.46			
Commercial autogen		0.8				0.79				0.57		
Commercial process heat		0.4	4.64			0.39	5.06			0.35		
Residential	0	0.3	5.3			0.63	5.87			0.28		
Agriculture	3.28	8.88	0.66		2.3	11.06	0.44	4.26	3.27	8.22	0.44	6.02
TOTALS	55.4	85.8	13.3	0	41.9	76.6	14.7	9.51	47.3	56.7	14.7	24.1

Source: Third National Greenhouse Gas Inventory Report, 2015

Diesel import was impacted by the increased consumption of crude, imports of electricity and increase hydropower generation (Figure 12) resulting in a change emission source.

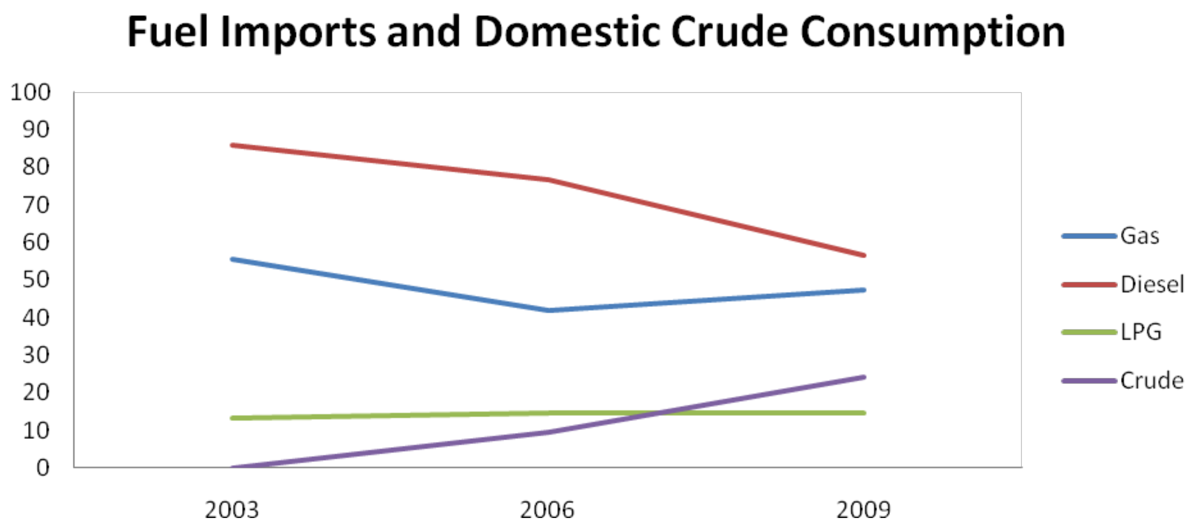


Figure 12: Comparison of Fuel Imports and Domestic Crude Consumption

Source: Third National Greenhouse Gas Inventory Report, 2015

There is no known standard or methodology used to estimate fuels illegally imported (contraband) from Mexico and Guatemala into Belize. No figure was assigned for contraband estimates from either country.

2.2.2 Domestic aviation

Domestic aviation emissions estimates include international flights to Mexico, Honduras and Guatemala that originated in Belize. However, the resulting emissions were considered to be of negligible amounts. The methodology uses average emission factors for each type of fuel irrespective of type of vehicle. Emissions for small aircraft were estimated using the corresponding emission factors for the type of fuel. There are two types of aviation fuels, kerosenes (Jet A, B, C) and Av-gas; individual factors are therefore assigned for each. Nevertheless, aviation fuels used could not be clearly deducted for international use by the domestic airlines.

2.2.3 Electricity

The shift of Belize Electricity Limited's (BEL) energy source contributed to the reduction of GHG's in the energy sector. Over the nine-year period, BEL continued to purchase electricity from alternative sources which led to a reduction in power generated from fossil fuel. The increase in hydro generated electricity was mainly responsible for the shift. In addition, electricity was imported from Mexico; therefore, these carbon emissions were not counted in those of Belize as they were produced in Mexico.

2.2.4 Biomass

Biomass use for industrial and domestic energy consumption occur in several process and productive sectors. The biomass is primarily used in the generation of energy for the sugar industry. Also, there are several other small users which include, bakeries, limekilns, and wood industries, most of which have or are undergoing a shift to liquid fuels.

GHG emissions within Belize's Energy Sector declined from the previous period reported in the Second National Communication. The Energy generation sub-sector accounted for a considerable proportion of the decline due to the shift from using fossil fuels to renewable sources of energy. Programmes geared toward GHG reduction are absent in the country. The incidental outfall that occurred during the review period is arguably a matter of economics or economic policy rather than by emissions reduction law and enforcement.

2.3 Industrial Processes and Product Use

There are limited industrial processes that produce GHGs in the country. There were only three categories of emission sources identified within this sector (fermentation, limekiln operations and road paving with asphalt). The fermentation processes, commonly used in the production of bread and alcoholic beverage and road paving, produce Non-methane Volatile Organic Compound (NMVOC). Limekilns produce quantities of CO_2 as the rock is burned and converted. Liming applications using crushed calcitic or dolomitic limestone do not produce measureable emissions when applied by spreading. Emissions in the industrial process and product use sectors remained negligible throughout the period under review despite the increases in sugar production.

In the case of fuel generated from the burning of wood, the bulk of the consumption is for small commercial operations and domestic use. The Statistical Institute of Belize 2010 census showed that13% of the population uses fuel wood as their energy source for cooking. The inventory results show that only two areas are sources of GHGs in the industrial sector in Belize. These are mineral production, food and drink manufacturing. Mineral production includes lime production and use of asphalt for paving. Food and drink manufacturing include the production of liquor, bread, processed meats, sugar and animal feeds.

2.3.1 Lime Production

The major purchasers of burnt lime (CaO) have been the shrimp farms, most notably Nova Limited which terminated operations during the review period. The entire aquaculture industry suffered major setbacks due to a combination of market prices and disease. This small industry continues to thrive and is found primarily within the Cayo District. A small number of producers have found a niche market for their product which is mostly used in the citrus orchards to change the pH of the soil.

2.3.2 Results

Tables 2, 3 and 4 below summarize the emissions from the activity areas for the reference years under study.

The results obtained for the study period indicated that there were some increases in industrial activity for the period 2005 to 2007. It is noted that the CO_2 emissions were impacted by increased lime production over that period then declined for the following three-year period. CO_2 emissions appeared to remain constant from beer and spirits production during the entire nine-year period under study. NMVOC emissions were similarly affected by increased production occurring within that same period.

Table 2: 2003 Industry Emissions by Source and Gas

Activity	**Quantity**	**Units**	**CO_2**		**NMVOC**	
			tonnes	**Gg**	**kg**	**Gg**
Lime production	5000	t	3925	3.93		
Road Paving	1439	t			23.02	
Beer production	50000	hl			17.50	0.00
Spirits production	500	hl			7500	0.01
Bread production	8568	t			68544	0.07
TOTALS			3925	3.93	76084.52	0.08

Source: Third National Greenhouse Gas Inventory Report, 2015

Table 3: 2006 Industry Emissions by Source and Gas

Activity	Quantity	Units	CO_2		NMVOC	
			tonnes	Gg	kg	Gg
Lime production	6000	t	4710	4.71		
Road Paving	837	t			13.38	0.02
Beer production	50000	hl			17.50	0.00
Spirits production	500	hl			7500	0.01
Bread production	9149	t			73192	0.07
TOTALS			4710	4,71	80722.88	0.10

Source: Third National Greenhouse Gas Inventory Report, 2015

Table 4: 2009 Industry Emissions by Source and Gas

Activity	Quantity	Units	CO_2		NMVOC	
			tonnes	Gg	kg	Gg
Lime production	3000	t	2355	2.36		
Road Paving	784	t			12.54	0.00
Beer production	50000	hl			17.50	0.00
Spirits production	500	hl			7500	0.01
Bread production	8304	t			66432	0.07
TOTALS			2355	2.36	73962.04	0.08

Source: Third National Greenhouse Gas Inventory Report, 2015

2.4 Agriculture

Two million acres of national land or 38% is considered suitable for agriculture 15% of which (about 300,000 acres) is under farming annually. A farm census carried out by the Ministry of Agriculture in 2003 indicated that 24% of farms have less than 5 acres, 33% between 5 and 20 acres, and 74% of farms below 50 acres. The Toledo District has one fourth of all farms in Belize and the highest concentration of small farms (77% below 20 acres) nationally. The Orange Walk District has 22% of farms while Corozal district has 21%. Total acres cultivated consist of 60,000 acres in sugar cane, 46,000 in citrus, 38,000 in corn, and 150,000 in pastures grazed by an estimated 80,000 head of cattle. The farming population of approximately 11,000 small farmers operates 5% of the agricultural land area; small farmers account for more than 75% of the farming population. A large percentage of agricultural farms produce crops such as sugar, bananas, and citrus, while others concentrate on domestic food crops such as rice, corn, beans, root crops and vegetables

2.4.1 Domestic Livestock: Enteric Fermentation and Manure Management

The domestic livestock sub-sector has grown in value and importance in the past ten years. A 2009 national livestock survey conducted by the Ministry of Natural Resource and Agriculture showed an overall growth in the livestock sector (table 5) from 2000 to 2009. There was substantial increase in pig and sheep production in 2009, with pig production increasing by 15.81% or from 14,712 in 2000 to 17,038 pigs in a ten-year period. Similarly, sheep production increased significantly by 225.45% or from 4000 in 2000 to 13,018 heads. Dairy cattle recorded an increase of 108.66%; 1,858 in 2000 to 3,877 heads indicating that dairy producers are still optimistic despite the challenges posed by milk imports and poor local marketing conditions. For beef cattle, population increased by 43.16% from a total of 63,655 in 2000 to 91,129 heads.

Table 5: Livestock Production 2000-2009

Livestock	2000	2003	2006	2009
Beef	63655	54250	67611	91,129
Dairy	1858	3550	7728	3,877
Swine	14712	21224	14533	17,038
Sheep	4000*	6265	7770	13,018
Goat		620	685	750
Buffalo		68	75	85
Poultry	1,000,000	11,061,544	11133634	12,140,498

Source: Third National Greenhouse Gas Inventory Report, 2015

2.4.2 Rice Cultivation: Flooded Rice Fields

Rice is grown under three systems in Belize, namely: Milpa or upland rice, mechanized and irrigated. Flood irrigation is only between 15-30 centimetres of water and only one crop harvested per annum (table 6).

Table 6: Rice production in acreage (2000 to 2009).

Treatment	2000	2003	2006	2009
Milpa	3500	1600	700	6170
Mechanized	2999	1627	738	1004
Irrigated	3589	7973	5757	4137
Total	10,088	11,200	7,195	11,311

Source: Third National Greenhouse Gas Inventory Report, 2015

2.4.3 Field Burning of Agricultural Residues

Field burning is a practice that is normally used in traditional milpa production systems and in sugarcane field prior to harvesting. However, in mechanized production systems, crop residues are burned and subsequently incorporated during field preparations as a soil amendment. This is especially done for the preparation of fields before planting leguminous crops, or cover crops that add nitrogen to the soil, especially where there are crop rotations with grain cereals.

Residue to crop ratio were obtained. Dry matter fraction for some crops is estimated at 0.4 and rice 0.83. Fraction burned in fields value is 0.4 as default figure for developing countries. The default fraction oxidized is 0.9 as presented in the IPCC manual. Sugarcane production, being the largest acreage crop in Belize whose residues are burnt in the field is the main contributor in the burning of crop residues. Belize has now developed its own conversion factors, as were applied for the second national GHG inventory. The residue to crop ratio is estimated at 0.25, the dry matter fraction for sugar cane 0.0562 and fraction burnt in the field is 0.1875.

2.4.4 Agricultural Soils

The total acreage under agriculture has increased from 274,278 acres in 2000 (with 55% under crop production and 45% in pastures development) to 338,718 acres in 2009 (with 65% under crop production and 35% under pasture development) as can be seen in table 7. This represents an expansion of approximately 24% over the decade. Many of the perennial crops and the grains require large amounts of agricultural inputs.

Table 7: Acreages under crop production and pasture development for 2000 - 2009

Land use	2000	2003	2006	2009
Crops	149,871	184,090	178,254	219,496
Natural Pastures	74,000	64,606	72,570	48,379
Improved Pastures	50,407	46,236	51,459	70,843
Total	274,278	294,932	307,283	338,718

Source: Third National Greenhouse Gas Inventory Report, 2015

2.4.5 Total Synthetic Fertilizers

The total synthetic fertilizer N applied to the soil (NFERT in kg N/year) was estimated from the importation Figure s for nitrogen-based fertilizers. These totals were then multiplied by their N content namely: Urea (46% N), Ammonium Nitrate (33% N) and Ammonium sulfate (21% N) plus all other mixed formulae containing N by 21% (tables 8 and 9).

Table 8 Total Nitrogen Fertilizers in kgs.

Fertilizer Type	2003	2006	2009
Urea	36020,700	2,066,209	9,105,733
Ammonium Sulphate	644,684	473,243	334,136
Ammonium Sulphate solution	531,854	360,504	405,222
Ammonium Nitrate	4,162,866	1,454,656	696,577
Diammonium phosphate	7,228,518	7,243,236	7,695,840
Nitrogenous Fertilizer	268,524	183,239	370,095
NPK Fertilizers	8,748,492	2,633,062	1,902,602
Fertilizer Mixes	9,497,189	2,071,549	1,812,897
Monoammonium phosphate	250		254
Ammonium carbonate	540	671	2131

Source: Third National Greenhouse Gas Inventory Report, 2015

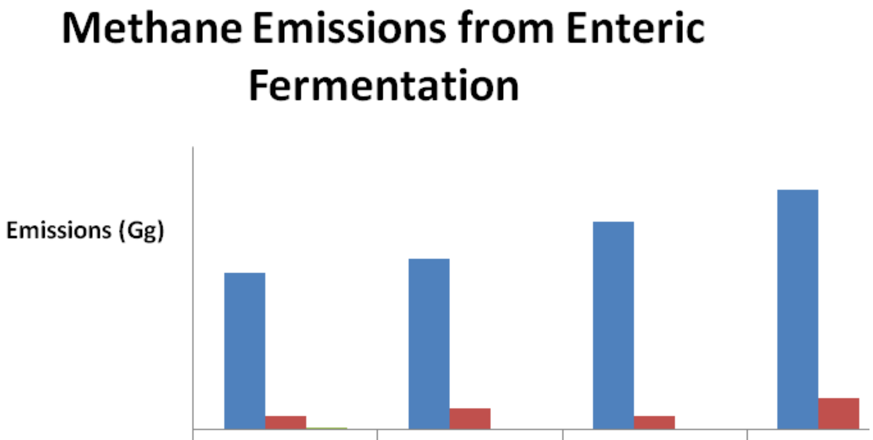
2.4.6 Results

Table 9: Summary of GHG Emissions (Gg) by Activity, Gas, and Source 2000 to 2009

Emission Source	2000	2003	2006	2009
Enteric Fermentation (CH_4)	2.73852	3.14	4.07	5.07
Manure Management (CH_4)	0.24882			
Manure Management NO_2		0.93	0.93	0.93
Flooded Rice Cultivation (CH_4)	0.2966	0.47	0.31	0.68
Agricultural Soils (N_2O)	37.51866	0.98	1.05	0.63
Agricultural Residue Burning CH_4-	0.052	0.02	0.03	0.02
N_2O	0.00158	0	0	0
NO_x	0.05725	0.03	0.03	0.03
CO	1.09209	0.52	0.64	0.5
Net Total per Year CH_4	3.33594	3.63	4.41	5.09
Net total per year N_2O	37.52023	1.91	1.98	1.56
Net Total per Year NOx	0.05725	0.03	0.03	0.03
Net Total per Year CO	1.09209	0.52	0.64	0.5
Total GWP per Year	16,980.0184	669.36	709.81	601.57

Source: Third National Greenhouse Gas Inventory Report, 2015

The cultivation of rice contributes to large percentage of methane emissions and more importantly is directly related to the area under production. In 2003, methane emission is estimated at 0.47 Gg while in 2006, it decreased and later increased three years later in 2009 to 0.68 Gg due to an increase in overall irrigated rice production. The methane emission from agriculture residue burning remained stable as only sugarcane crop production was accredited to agriculture crop residue burning (Figure 13). This practice is mostly realized in the preparation of compost and incorporated into the soil in most production systems.



	2000	2003	2006	2009
Enteric Fermentation	3.33594	3.63	4.41	5.09
Rice	0.2966	0.47	0.31	0.68
Agriculture Residue Burning	0.052	0.02	0.03	0.02

Figure 13: Methane Emissions from Enteric Fermentation, Rice cultivation and Agriculture Residue Burning (Gg CH_4)

Source: Third National Greenhouse Gas Inventory Report, 2015

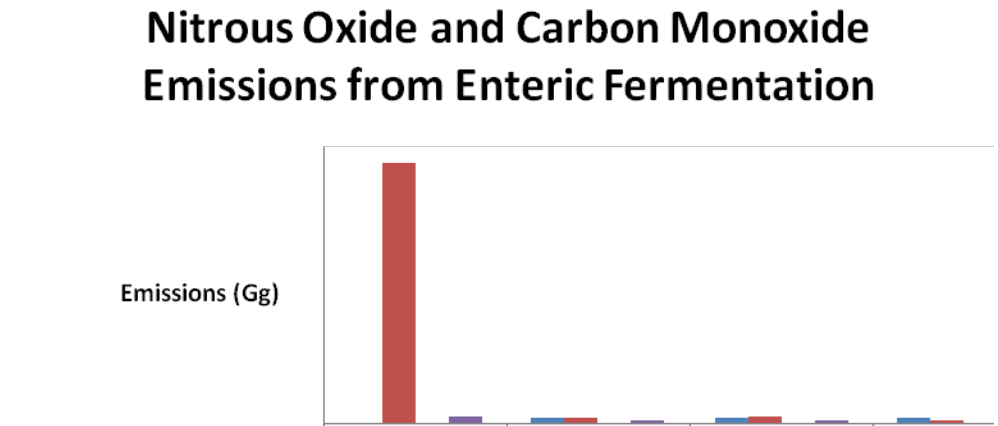
2.4.7 Nitrous Oxide Emissions:

Emissions increase is directly related to increase in livestock population and increase acreages under crop production. It should be noted that for 2000 the total N_2O was much larger than other reference years, this might be attributed to the prescribed burning of savannahs which is one of the largest contributors of the trace gases. As explained in the methodology, it was not calculated under agriculture mostly because the burning of savannahs is more suited to be calculated under the LULUCF sector (Figure 14).

Agricultural soils and agricultural residue burning followed similar trends with respect to nitrous oxide emissions as it is dependent on the changes of land area under agriculture production. Fluctuations depend therefore on the market conditions for agricultural commodities, this is expected to increase as more production of crops and livestock increases; Carbon Monoxide (CO) emissions, has remained constant (Figure 15).

2.4.8 Net emissions of the Agricultural Sector

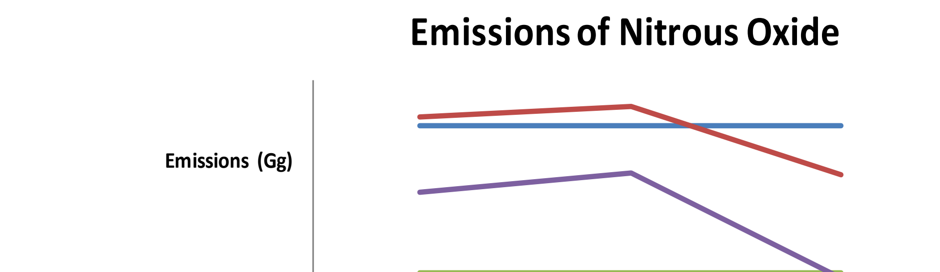
It can be observed that the emissions from the Agriculture Sector is considered one of the biggest contributors to the net total emissions, once the prescribed burning of savannahs is removed, this is no longer the case since the burning of savannahs is not considered as an agricultural practice (Figure 16).



	2000	2003	2006	2009
Enteric Fermentation	0.24882	0.93	0.93	0.93
Agricultural Soils	37.51866	0.98	1.05	0.63
Agricultural Residue Burning	0.00158	0.03	0.03	0.03
CO	1.09209	0.52	0.64	0.5

Figure 14: Nitrous Oxide and Carbon monoxide emissions from Enteric Fermentation, Agricultural soils, Agriculture Residue Burning

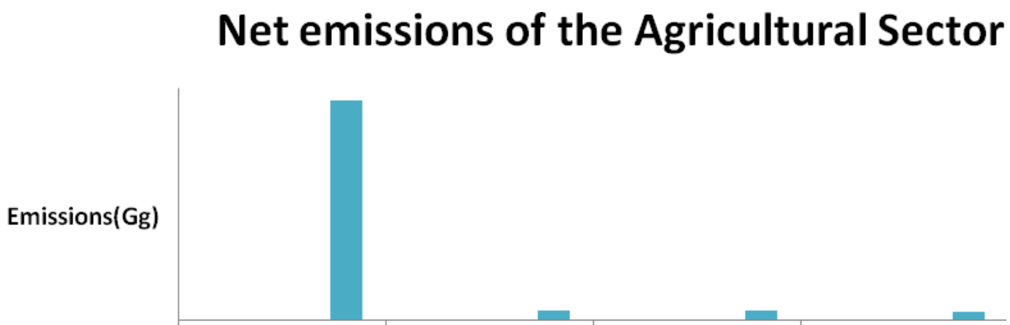
Source: Third National Greenhouse Gas Inventory Report, 2015



	2003	2006	2009
Enteric Fermentation	0.93	0.93	0.93
Agricultural Soils	0.98	1.05	0.63
Agricultural Residue Burning	0.03	0.03	0.03
CO	0.52	0.64	

Figure 15: Emissions of Nitrous Oxide in Gg.

Source: Third National Greenhouse Gas Inventory Report, 2015



	2000	2003	2006	2009
Methane	3.33594	3.63	4.41	5.09
Nitrous Oxide	37.5203	1.91	1.98	1.56
Nox	0.05725	0.03	0.03	0.03
CO	1.09209	0.52	0.64	0.5
GWP	16980.0184	669.36	709.81	601.57

Figure 16: Net emissions of the Agricultural Sector

Source: Third National Greenhouse Gas Inventory Report, 2015

2.4.9 Conclusions

The emissions from the agricultural sector decreased significantly since the prescribed burning of savannahs is not an agricultural practice but is rather captured within the LULUCF sector. This then shows that the emissions from the agriculture sector will vary depending on annual crop and livestock production it should also be noted that the trends in production also responds to the global markets for these commodities.

2.5 Land Use, Land Use Change and Forestry (LULUCF)

Tropical forests, such as those found in Belize, are among the most diverse and productive ecosystems on earth. They provide a wide range of economic and social benefits, and environmental services through their productivity and diversity. Economically, they contribute to formal and well-established industries such as timber and tourism, particularly ecotourism, and to newer industries based on trade of non-timber forest products. Forests also contribute to the informal economy in some countries through the provision of products that include fuel wood, game meat and non-timber forest products that are extracted and consumed by locals. For the purpose of this inventory, forests are classified as mature, natural and broadleaf forest.

2.5.1 Total Emission of CO_2 from LULUCF

Total emission of CO_2 from the LULUCF sector of 11,950 Gg were mainly because of deforestation and to a lesser extent from soil carbon in agriculturally impacted soils. Carbon sequestration from forest growth following logging and the re-growth of abandoned lands reduced this quantity by 3,862 Gg to a net emission value of 8,088 Gg (table 10).

Table 10: Emission per year 2000, 2003, 2006, and 2009

Sector Report on GHG Emissions – 2000 – 2009

2000 Reference Year	**CO2 Emissions (Gg)**	**CO2 Removals (Gg)**	**CH4 (Gg)**	**N2O (Gg)**	**NOx (Gg)**	**CO (Gg)**
Total Land Use Change and Forestry	8,088	0	40	0	10	349
Changes in Forestry and Other Woody Biomass	0	-3651				
Forest and Grassland Conversion	11,077	0	40	0	10	349
Abandonment of Managed Lands	0	-211				
CO_2 Emissions and Removals from Soils	873	0				
2003 Reference Year	**CO_2 Emissions (Gg)**	**CO_2 Removals (Gg)**	**CH_4 (Gg)**	**N_2O (Gg)**	**NOx (Gg)**	**CO (Gg)**
Total Land Use Change and Forestry	4,325	0	43	0	11	376
Changes in Forestry and Other Woody Biomass	0	-9,446				
Forest and Grassland Conversion	13,843	0	43	0.4	11	376

Abandonment of Managed Lands	0	-220				
CO_2 Emissions and Removals from Soils	106	0				
2006 Reference Year	**CO_2 Emissions (Gg)**	**CO_2 Removals (Gg)**	**CH_4 (Gg)**	**N_2O (Gg)**	**NOx (Gg)**	**CO (Gg)**
Total Land Use Change and Forestry	4,293	0	41	0	10	361
Changes in Forestry and Other Woody Biomass	0	-8,988				
Forest and Grassland Conversion	13,082	0	41	0	10	361
Abandonment of Managed Lands	0	-220				
CO_2 Emissions and Removals from Soils	-419	0				
2009 Reference Year	**CO_2 Emissions (Gg)**	**CO_2 Removals (Gg)**	**CH_4 (Gg)**	**N_2O (Gg)**	**NOx (Gg)**	**CO (Gg)**
Total Land Use Change and Forestry	4,671	0	40	0	10	346
Changes in Forestry and Other Woody Biomass	0	-8576				
Forest and Grassland Conversion	12,324	0	40	0	10	346
Abandonment of Managed Lands	0	-202				
CO2 Emissions and Removals from Soils	1,125	0				

Source: Third National Greenhouse Gas Inventory Report, 2015

There was a relatively large increase in the emissions from the LULUCF sector despite increases in CO_2 removals. There was a continuing decline in emissions from this sector with the removals displaying a similar trend. The emissions were mainly from forest and grassland conversion and emissions from soils. Indications are that the rate of forest and grassland conversion declines across the study period, while as expected, the rate of removal of carbon dioxide would decline because of the reducing growing biomass (forest cover) that was available to sustain the removals (Table 11).

Table 11: Summary Table of Net Emissions and Removals of LULUCF Sector – 2000-2009

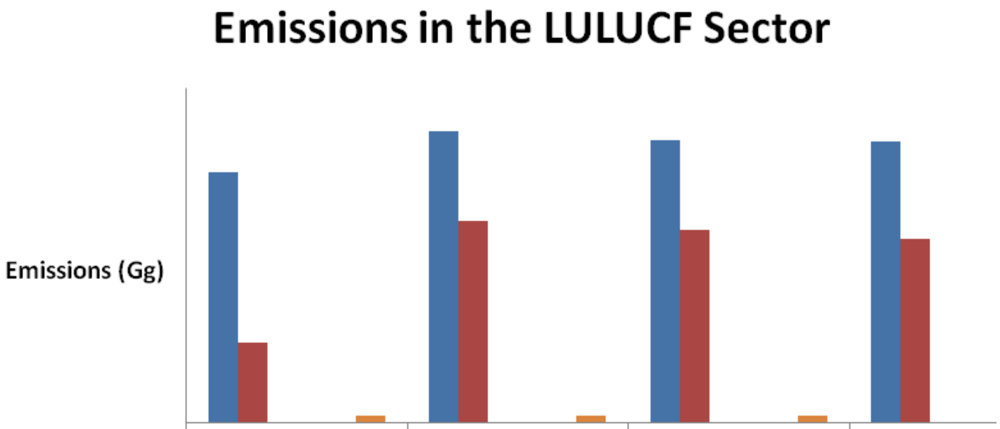
Reference Years	**CO_2 Emissions (Gg)**	**CO_2 Removals (Gg)**	**CH_4 (Gg)**	**N_2O (Gg)**	**NOx (Gg)**	**CO (Gg)**
2000	11,950	3,862	40	0	10	349
2003	18,168	9,666	43	0	11	376
2006	17,375	9,208	41	0	10	361
2009	13,449	8,778	40	0	10	346

Source: Third National Greenhouse Gas Inventory Report, 2015

There is a progressively small increase in net CO_2 emissions by the LULUCF sector in Belize. From the chart below, it is also apparent that this progressive increase in net CO_2 emissions by the LULUCF sector is linked to higher rates of deforestation and decreasing areas of forest being managed for long-term timber production (Figure 17).

2.5.2 Conclusions

Belize like most countries in the region shows that increase GHG emissions rates are related to deforestation activities. The continued reduction in areas under forest coverage will diminish the country’s capacity to offset emissions. Increases in land degradation and increased utilization of land with less productive potential, coupled with population increase, may very well contribute to greater non-sustainable forest conversion. The continuous monitoring of deforestation activities by incorporating updated data, improving data gathering mechanisms and relative statistics institutions are considered important for developing strategies and reducing the impacts.



	2000	2003	2006	2009
CO2 emissions	11950	13949	13501	13449
CO2 Removals	3862	9666	9208	8778
CH 4(Gg)	40	43	41	40
N2O (Gg)	0	0	0	0
Nox	10	11	10	10
Co (Gg)	349	376	361	346

Figure 17: Trends in Emissions in the LULUCF sector

Source: Third National Greenhouse Gas Inventory Report, 2015

2.6 Waste Sector

Belize faces challenges in the solid waste sector with respect to data collection and availability which is compounded by the tourism activities (cruise and overnight with respect to garbage generation) and by the large garbage masses that arrives across the sea from nearby countries or from the garbage dumped in the open seas. The country's main waste contributors are shown in Figure 18 which also shows that biodegradable organic material, plastics, paper, other organic materials, glass and metals are the largest contributors.

2.6.1 Industrial Waste

Agricultural activities in the citrus, sugar cane, banana and shrimp farming collectively account for one of the largest sector of Belize's economy. Apart from the waste generated by the production systems, these industries also produce their own solid waste. Available figures from the LIC (2006) show that the country's shrimp industry generated 3,835 tons of waste in 2003 to 5,781 tons in 2005 where approximately 35% of the total production is waste. The country's citrus, processor produced 139,083 metric tons of solid waste in 2000 which increased to 131,762 metric tons in 2007 in the form of peel from oranges and grapefruits (Table 12). Leaching from these solid wastes generated by the shrimp and citrus industries has been a cause for concern. Run-off from the composting citrus pulp results in high levels of biological oxygen demand (BOD) during decomposition. When the effluent enters sensitive areas such as water bodies in the Stann Creek District, this lowers the dissolved oxygen (DO) level in the water bodies. Another industry that also creates solid waste is the sugar industry. This industry generated a total of 407,065 tons of waste in 2001/2002 and up to 370,551 tons of waste in 2007/08. It should be noted that 69 to 82% of the total waste generated is used for energy production in a given crop year, 7 to 8% burnt and 10 to 13% discarded (LIC, 2006).

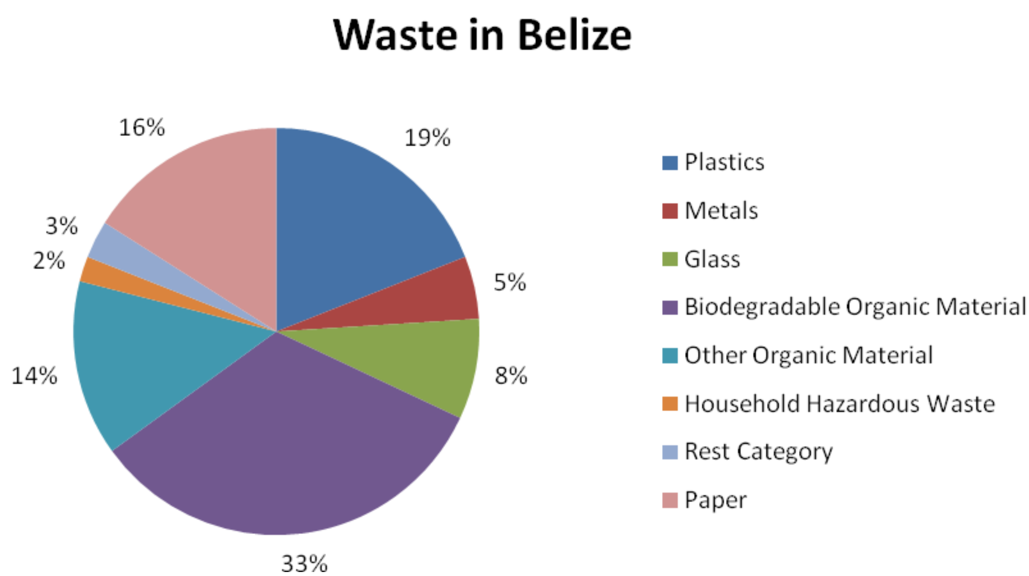


Figure 18: Composition of Total Waste in Belize

Source: Waste Generation and Composition Study, 2011

The steps in calculation of the GHG emissions from the waste sector utilized the Tier 1 approach as some reliable information existed, meanwhile for the calculations of the Methane Correction Factor (MCF) and other parameters, the default coefficients are utilized. The SIB also records estimates of the disposal rates for both urban and rural populations; and more recently, the Land Information Centre (LIC) of the Ministry of Natural Resources and Agriculture (MNRA). The rates utilized in the preparation of this inventory are based on literature reviews of various studies which have indicated an average of 88% urban population using the existing collection system, and 6% using "public dumps", which when combined amounted to 94% total disposal at existing dumpsites. For the solid waste disposal, 0.94 was used as the fraction of Municipal Solid Waste (MSW) disposed at solid waste disposal sites (SWDSs). This was utilized for the entire study period that was targeted as no change occurred.

The total urban population, based on the existing urban centres, was used to calculate solid waste generation rates while disposal rates are used to estimate GHG emissions since rural waste disposal is normally done by burning and other methods less conducive to emissions (IPCC Guidelines, 1996). Therefore, the fraction of MSW disposed to SWDSs for all years is 0.94, as is recorded in worksheets of the waste module.

The MCF was calculated by adding the total waste generated by Belize City, San Ignacio, Belmopan and Benque Viejo as their dump sites can be classified as “unmanaged - deep” (due to the amount of waste generation and garbage build-up) while the remaining municipal centres were classified as “unmanaged shallow” as defined by the IPCC Guidelines. The result is that the MCF for all years was 0.6; nothing had changed for the different years. Based on the above mentioned, all things being relatively constant, and the lack of real data, placed the default parameters as per IPCC Guidelines of Degradable Organic Carbon (DOC) as 0.13 and ratio of DOC that actually degrades as 0.77 while the released carbon as methane is 0.5.

These rates were applied in the worksheet along with the recommended default values for Methane Correction Factor (MCF), fraction of DOC in Municipal Solid Waste, fraction of DOC which actually degrades, and the fraction of carbon released as methane (CH_4) (table 13).

Table 12: Solid Waste Generated by the Citrus Companies (metric tons), 2000 - 2007

Year	**Rinds (solid waste)**			
	Orange	**Grapefruit**	**Total**	**Compost**
2000	113,083	26,000	139,083	
2001	100,980	23,830	124,810	
2002	83,867	22,247	106,114	
2003	70,315	32,011	102,326	
2004	101,320	39,221	140,541	56,216
2005	122,681	17,189	139,870	55,132
2006	98,491	32,900	131,391	52,556
2007	104,889	26,872	131,761	52,704

Source: Land Information Centre, 2010.

Table 13: Estimate of Total MSW and Default Values.

YEAR	Total Annual MSW Disposed to SWDSs (Gg MSW)	Methane Correction Factor (MCF)	Fraction of DOC in MSW	Fraction of DOC which Actually Degrades	Fraction of Carbon Released as Methane
2000	58.95	0.4	0.13	0.77	0.5
2003	80.94	0.6	0.13	0.77	0.5
2006	112.72	0.6	0.13	0.77	0.5
2009	165.15	0.6	0.13	0.77	0.5

Source: Third National Greenhouse Gas Inventory Report, 2015

2.6.2 Methane Emissions from the Industrial Waste Water

The industrial sector's wastewater data is not readily available. In the previous report of 2000, it was decided to report emissions from two industries: beer (including soft drinks) and sugar. Data for the sugar industry is available, and the tons of product produced and waste water treated are available from the SIB and the industry. Bananas and Shrimp wastewater were also calculated knowing the outputs and using the default factors from the IPCC guidelines. Citrus was not done as the default factors are not available at this time.

The calculation was based on readily available data on production as well as on the guidelines of the IPCC that provides default parameters for the selected industries. These values were then entered into the module 6 spreadsheet, applying recommended default values for the fraction of wastewater treated; the MCF was calculated depending on the type of wastewater management system. The fraction of wastewater treated and the MCF are two significant uncertainties for Belize since no data exists for these values for Belize's lagoon systems. Instead, the difference between those that are treated and that portion that is untreated is determined and the given figure is used to later arrive at the final MCF. These values recommended by the guidelines are for unspecified industrial treatment, and thus, the error may be significant.

2.6.3 Indirect Nitrous Oxide Emissions from Human Sewage

This was calculated by using the population data for 2003, 2006 and 2009 and using the default figures from the IPCC guidelines. The annual Per Capita Protein Consumption in Belize (Protein in kg/person/yr) is 71 g/person/day in 2003 and 72g/person/day in 2006 according to FAO 2010 Food Balance Sheets. The Fraction of Nitrogen in Protein (FracNPR) default value is 0.16 kg N/kg protein. The Emission Factor, EF6 default factor is 0.01kg N_2O-N/kg sewage-N produced.

2.6.4 Emissions from Solid Waste:

Emissions have increased as expected due to population growth (Figure 19), however, if the waste generated per capita is analysed it would appear higher than the average for similar countries in the region. The waste generated is added to the total municipal waste, increasing the total amount of waste generated which when calculated for the daily rates of waste generated per annum creates this distortion. This is especially evident in municipalities with high touristic activities.

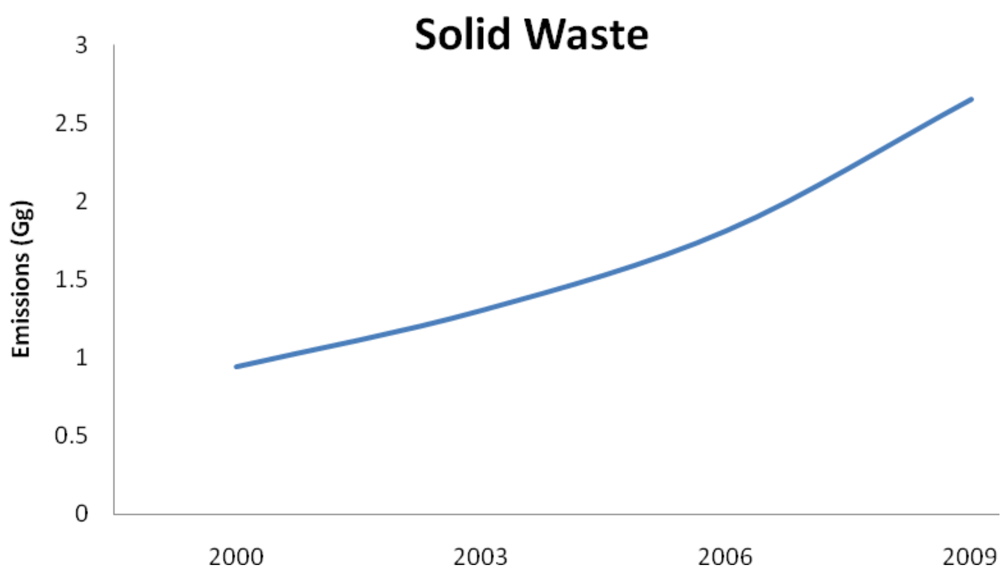


Figure 19: Solid Waste Emissions Gg (CH_4)

Source: Third National Greenhouse Gas Inventory Report, 2015

2.6.5 Emissions from Domestic and Commercial Wastewater Handling

Liquid waste and sewage pose a threat to the country's natural resources. Meanwhile individual efforts by the commercial and industrial sector to treat and manage liquid waste and effluents are slowly improving. For the purposes of this inventory and based on the IPCC Guidelines on calculation of this component, a Tier 1 approach was used to calculate the emissions on two basic types of wastewater handling.

As expected, the emissions from wastewater have increased mainly because of the population growth and due to an increase in tourism. The increase by 800% over little less than a decade should be noted for actions in this sector (Figure 20).

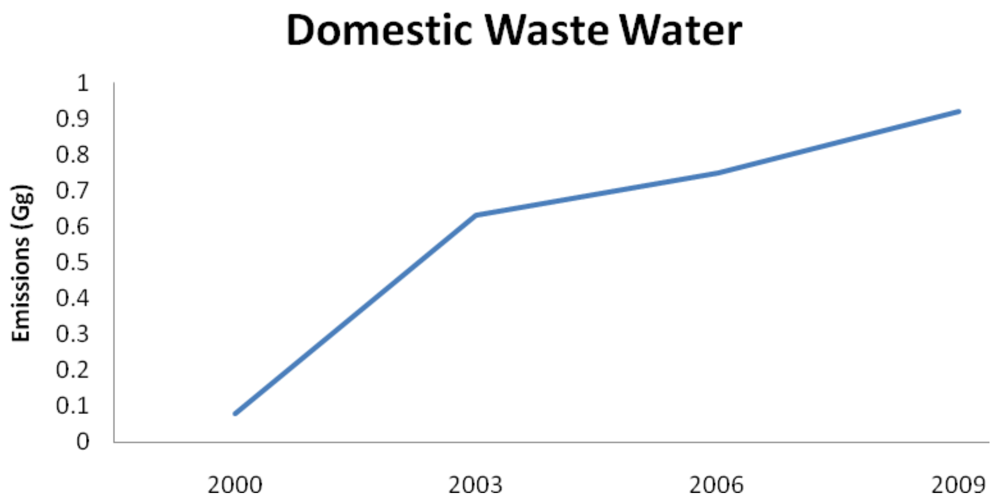


Figure 20: Methane Emissions from Domestic wastewater

Source: Third National Greenhouse Gas Inventory Report, 2015

2.6.6 Emissions from Industrial Waste Water Handling

The industrial sector for Belize uses aerobic systems primarily for manufacturing purposes, methane emissions are therefore negligible, and were not reported for most industry in 2000. However, on analysis of the existing available data and based on the IPCC Guidelines it was decided to focus on four industries, beer and soft drinks, shrimps, sugar and bananas. The methane emissions were estimated using the existing production data and the results presented as indicated in the IPCC guidelines. This however is considered a work in progress as there are still uncertainties in the default values used for these calculations.

The primary source of emissions is from domestic and commercial wastewater handling. Aerobic systems emit very little methane, while the main anaerobic system is septic tanks. The IPCC guidelines include the estimation from emissions from sludge, however, for purposes of this exercise it was noted that there is little or no sludge handling, and therefore, this was not estimated. Data to calculate GHG emission was done using the populations as per IPCC guidelines and from a number of literature review and sources.

It can be observed that overall emissions have increased however; in 2009, a drop can be observed (Figure 21). This drop in 2009 is a direct result of a fall in sugar and banana production. It should also be noted that the increase is because of production statistics for bananas and shrimps included in the calculations for the industrial wastewater emissions.

2.6.7 Net Emissions of the Waste Sector

It can be observed that the emissions from Industrial wastewater, remains the biggest contributor to the total net emissions of the Waste Sector (table 14). The net emissions have increased overall but had a minor drop in 2009 as a result in the fall in production of sugar and bananas.

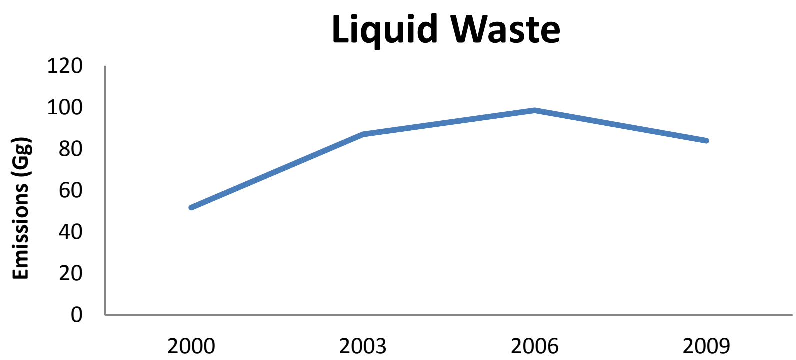


Figure 21: Liquid Waste emissions Gg (CH_4)

Source: Third National Greenhouse Gas Inventory Report, 2015

Table 14: Net CH_4 Emissions for 2000, 2003, 2006 and 2009

YEAR	Annual Methane Emissions (Gg CH_4) Solid Waste	Annual Methane Emissions (Gg CH_4) Waste Water Handling	Annual Methane Emissions (Gg CH_4) Industrial Waste Water Handling)	NET ANNUAL EMISSIONS (Gg CH_4)
2000	0.94	0.08	51.67	52.69
2003	1.3	0.63	87.08	89.01
2006	1.81	0.75	98.67	101.23
2009	2.65	0.92	83.98	87.55

Source: Third National Greenhouse Gas Inventory Report, 2015

2.6.8 Net Nitrous Oxide (N_2O) Emissions

The results of N_2O from human sewage is 0.02 Gg per year for all years as the protein intake is fairly constant as well as the population increase not too significant to affect the results (Figure 22). However, it should be noted that the amount of tourists visiting the country was not included in the calculation and should be noted that this figure is estimated to be three times the local population; the importance of this emission is the Global Warming Potential.

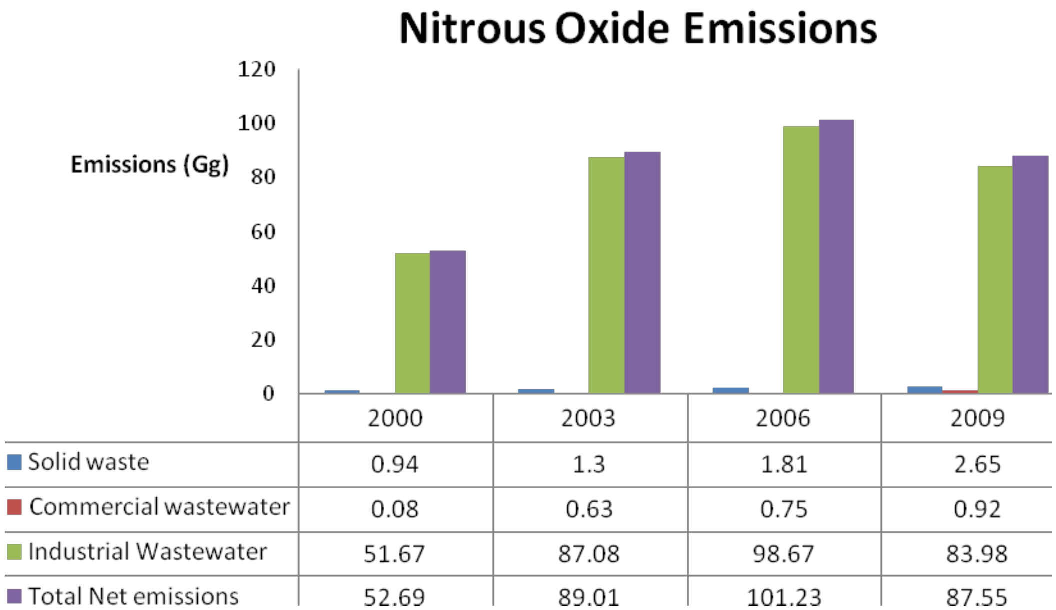


Figure 22: Net Nitrous Oxide Emissions

Source: Third National Greenhouse Gas Inventory Report, 2015

2.6.8.1 Global Warming Potential

This calculation shows the ability of each GHG to trap heat in the atmosphere relative to carbon dioxide (CO_2) over a specified time horizon. Often, GHG emissions are calculated in terms of how much CO_2 would be required to produce a similar warming effect oven the chosen time horizon. This is called the carbon dioxide equivalent (CO_2 eq) value and is calculated by multiplying the amount of gas by its associated global warming potential (GWP) (table 15).

Table 15: Net Emissions by Global Warming Potential

Year	**Net Methane Gg**	**GWP kts CO_2e**	**Net Nitrous oxide**	**GWP kts CO_2e**
2000	52.69	1,317.25	0.02	5.96
2003	89.01	2,225.25	0.02	5.96
2006	101.23	2,530.75	0.02	5.96
2009	87.55	2,188.75	0.02	5.96

Source: Third National Greenhouse Gas Inventory Report, 2015

2.6.9 Conclusion

The lack of capacity to properly dispose of solid waste is evident and readily observed by the overflowing landfills. At the time, the inventory was conducted, only the newly inaugurated engineered landfill located at Mile 23 on the George Price Highway was properly sealed to prevent the leaching of pollutants into ground water. A large proportion of industrial waste generated by large-scale industries (citrus, sugar, bananas, tilapia, and shrimp farms) also ends up in the country's dumpsites, which further compounds the problem. Solid wastes in dumpsites are frequently burned; a practice that is environmentally harmful with serious health implications, as well as added contributor to greenhouse gas contributions.

2.7 References

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3 CLIMATE CHANGE IMPACTS: VULNERABILITY ASSESSMENTS AND ADAPTATION MEASURES

The Vulnerability and Adaptation (V&A) component aims to support more detailed assessments within priority development sectors, namely, water, agriculture, tourism, human health and fisheries with emphasis on coastal development. These new assessments were analysed with increasing accuracy using scenarios, such as those of ECHAM5 and HadCM311 with assistance from Cuba's Institute of Meteorology (INSMET) via the Caribbean Community Climate Change Centre (CCCCC) and the Climate Research Unit (CRU)/Universities of East Anglia and Oxford, UK to support informed decisions on adaptation action by policy-makers, business, resource managers and the community at large.

This chapter presents future climate scenarios for Belize from two of the three sources of climate scenarios presented in the Final Report, namely the UNDP Country Profiles and the ECHAM5/A1B and HadCM3Q11/A1B PRECIS-downscaled seasonal data on mean temperature and rainfall. The scenarios of the National Meteorological and Hydrological Service of Belize on air temperature and precipitation (rainfall) were generated by the Cuban Meteorological Institute (INSMET) by downscaling the ECHAM4 global climate model (50 km resolution) and forced by the (SRES A2) socio-economic scenario using the British Meteorological Institute regional climate model PRECIS (Providing Regional Climates for Impact Studies) (Singh et al, 2014; Gonguez, 2012).

3.1 UNDP Country Profiles: A-OGCM Projections of Future Climate and Sea Level

The data sets and results reported in this section are extracted from the United Nations Development Programme (UNDP) Climate Change Country Profiles project (McSweeney *et al.*, 2009) that provides country-scale data files and easily accessible analyses of up-to-date observed data and multi-model scenario-based projections for several developing countries, including Belize. The project facilitates the use of observed and modelled climate data in climate impact assessment. In addition, observed data and future climate projections modelled using the Special Report on Emissions Scenarios (SRES) scenarios in the IPCC Fourth Assessment Report for each country. A standard format that is more manageable than the large global fields that are directly available from the Program for Climate Model Diagnosis and Inter-comparison (PCMDI) and the multi-model projections from the WCRP CMIP3 archive (McSweeney *et al.*, 2010).

The data used were current and future climatic scenarios (temperature and rainfall) together with time series climatology (1961-2100) extracted from ensemble coupled Atmosphere-Ocean General Circulation Models (A-OGCMs) forced by three of the SRES marker scenarios used in the IPCC Fourth Assessment Report (2007), namely a high (A2), a low (B1) and a medium (A1B) emissions scenario that produce high, low and medium climate forcing and changes.

3.1.1 Air Temperature

For Belize overall, the mean annual air temperature is projected to increase in the 2030s by 0.4 °C to 1.3 °C according to the B1 scenario, by 0.4 °C to 1.7 °C according to the A1B scenario and by 0.7 °C to 1.5 °C according to the A2 scenario (McSweeney *et al.*, 2010).

In the 2060s, the mean annual air temperature is projected to increase by 0.8 °C to 2.0 °C according to the B1 scenario, by 1.2 °C to 2.9 °C according to the A1B scenario and by 1.7 °C to 2.9 °C according to the A2 scenario (McSweeney *et al.*, 2010).

Finally, by the 2090s, the mean annual air temperature of Belize is projected to increase by 1.3 °C to 2.7 °C according to the B1 scenario, by 2.0 °C to 3.8 °C according to the A1B scenario and by 2.8 °C to 4.6 °C according to the A2 scenario (McSweeney *et al.*, 2010).

Furthermore, the projected rate of warming is similar in all seasons, but more rapid in the southern (ASO: August-September-October) and western interior regions (MJJ: May-June-July) of the country than in the northern, coastal regions (Figure 23) (McSweeney *et al.*, 2010).

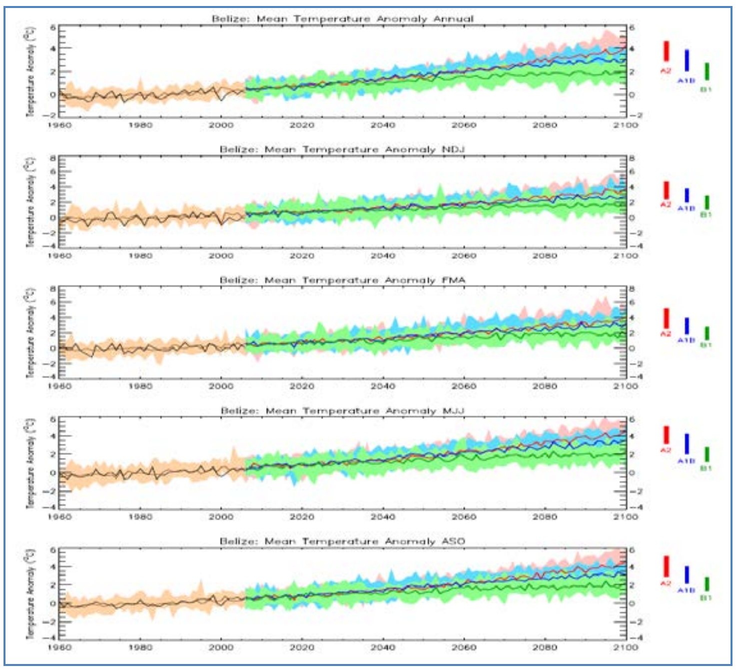

Figure 23 - Observed (1960-2006) and projected (to 2100) annual and seasonal air temperature anomalies for Belize (referenced to 1970-1999)

Source: Singh et al., 2014

3.1.2 Precipitation/Rainfall

A-OGCM projections of mean annual rainfall from different models in the ensemble project a wide range of changes in precipitation for Belize. Ensemble minimum and median values of rainfall changes (mm/month) by the 2030s, 2060s and 2090s, however, are generally and consistently negative for all seasons and emissions scenarios.

Overall, ensemble A-OGCM projections of mean annual rainfall decreases more and more from the 2030s to the 2090s. Furthermore, mean seasonal rainfall vary between a reduction of -26 % (A2: FMA- February March April) to an increase of +55 % (B1: ASO) by the 2090s, but with median values overall reductions of between -1 % (B1: NDJ) and -26 % (A2: FMA) (Figure 24) (McSweeney *et al*., 2010).

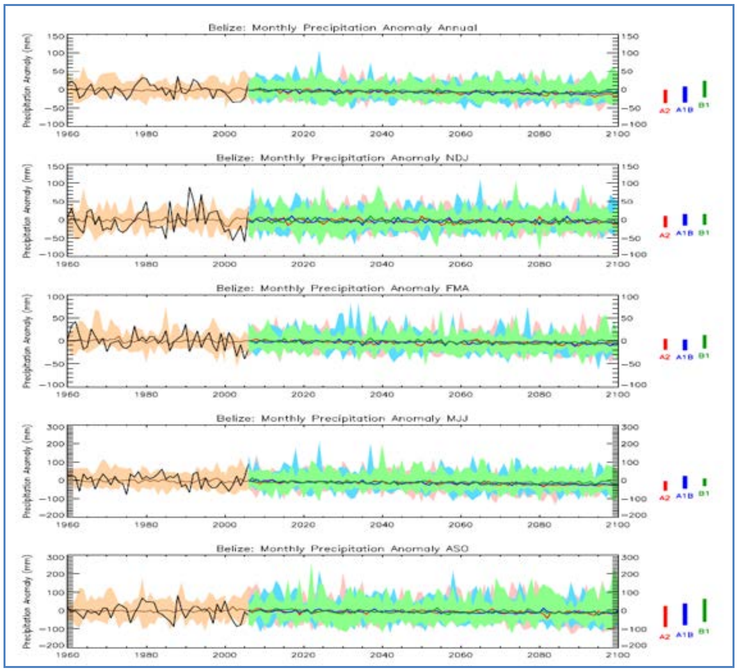

Figure 24 - Observed (1960-2006) and projected (to 2100) annual and seasonal air precipitation anomalies (mm) for Belize (referenced to 1970-1999)

Source: Singh et al., 2014

3.1.3 Sea level Rise

The coastal lowlands in northern Belize are vulnerable to sea-level rise. Sea-level in this region is projected by climate models to rise by the following levels by the 2090s, relative to1980-1999 sea-level (IPCC, 2007):

a) 0.18 to 0.43m under SRES B1;
b) 0.21 to 0.53m under SRES A1B;
c) 0.23 to 0.56m under SRES A2

But recent reports have claimed these sea level changes to be rather conservative. Regional variability in sea level change relative to the global average is projected to be higher in the North Atlantic in the region near Belize by the end of this century (Gregory *et al*., 2004). In fact, other recent semi-empirical models estimate that sea level will rise more than 1 meter by 2100, at least double the IPCC (2007) estimates and even more than previously thought, largely due to increased mass loss from the ice sheets mainly in the Arctic regions (Rahmstorf, 2007 and 2010; Horton et al., 2008; Vermeer and Rahmstorf, 2009; Grinsted et al., 2009). Low-lying coastal areas as the coastal zone of Belize would therefore be particularly at risk to these higher projections of sea level rise.

3.1.4 Downscaled ECHAM5 and HadCM3Q11 Scenarios

This section provides regional downscaled Climate Change scenarios data of several climate variables including air temperature, rainfall, solar radiation and evaporation, on an annual, monthly and daily basis for Belize for the period 1961 to 2100. The data provided by INSMET via the CCCCC are PRECIS-downscaled scenarios of the ECHAM5 and HadCM3Q11 climate models forced by the SRES A1B scenario and recast on a 25 x 25 km grid spacing.

3.1.5 Downscaled ECHAM5 Scenarios: Air Temperature (°C)

There is a significant change in mean seasonal air temperature (°C) for the future decadal period of 2060-2070, with temperatures exceeding 2°C for all of Belize and some of the larger Cayes except for the outer Turneffe Atoll. In fact, the temperature increases are ~ 2.4 °C for Corozal, Orange Walk, Cayo and most of Stann Creek Districts (Figure 25-A).

During the wet season, there is a more perceptible change in mean seasonal air temperature (°C) for the future decadal period of 2060-2070. Increases in mean temperature during these months now approach ~ 3°C. These future temperatures generally range from ~ 2.6 °C in Stann Creek and Corozal Districts to ~ 3°C in western Corozal Districts. It is only along the central coast of Belize District and the Ambergris, Caye Caulker and smaller Cayes that temperature increases are ~ 2.0 °C, most likely on account of marine influence (Figure 25-B).

The increases in mean seasonal air temperature (°C) for the future decadal period of 2060-2070 are of the order of 2.0 to 2.4 °C for all Districts of mainland Belize, except the northern Corozal and southern Toledo Districts where the temperature increases are > 2.4 °C. Also again, on account of the marine influence, the temperature increases are lower for the outer Cayes such as Ambergris Caye, where temperatures increase by < 2.0 °C (Figure 25-C).

Figure 25-D presents the changes in mean seasonal air temperature (2060-2070 vs. 1961-1990) according to the ECHAM5 climate model for the December-January-February season that currently (1961-1990) corresponds to the winter dry season in Belize. It shows that during this season there is an overall increase in seasonal temperature of ~ 2 °C for the future decadal period of 2060-2070 in the northern Belize, in the southern Orange Walk, the western Cayo and the southern Toledo Districts. But in the southern Belize, the Stann Creek and the northern Toledo Districts, the temperature increases are of ~ 1.8 °C. Again, on account of the marine influence, the temperature increases are lower for the outer Cayes such as Ambergris Caye, where temperatures increase by < 1.8 °C.

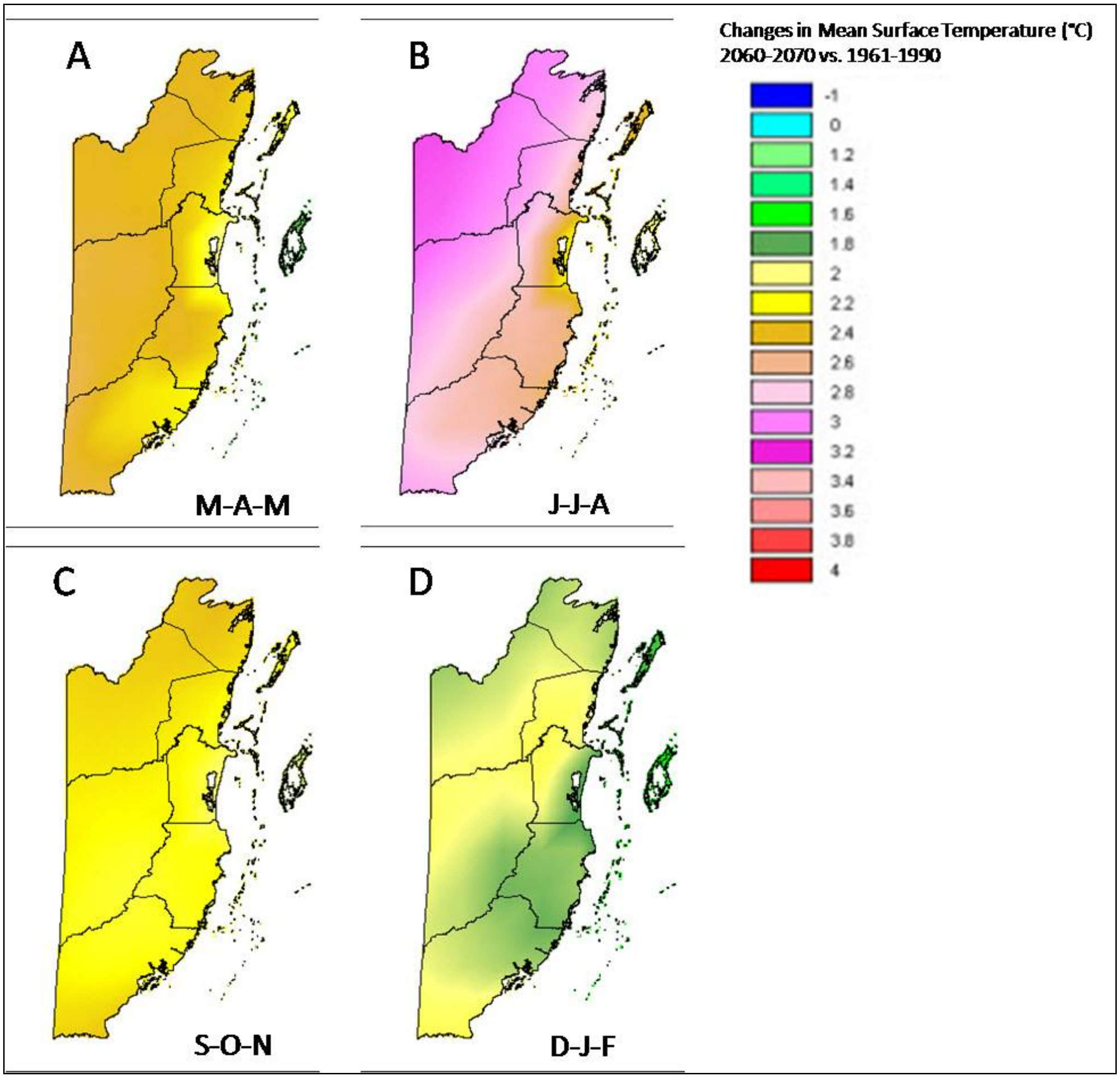

Figure 25 - Changes in mean seasonal air temperature (°C) (2060-2070 vs 1961-1990)) for the March-April-May (A), June-July-August (B), September-October-November (C), and December-January-February (D) season according to the ECHAM5 climate model

Source: Singh et al., 2014

3.1.6 Downscaled HadCM3Q11 Scenarios: Air Temperature (°C)

There is a significant change in mean seasonal air temperature (°C) for the future decadal period of 2060-2070, with average temperature increases exceeding ~ 2 to ~ 2.4 ^{0}C for all of Belize and even increasing by ~ 3.0 °C in some of the larger Cayes like Ambergris Caye and the coastal zone of southern Stann Creek and northern Toledo Districts. But in a small zone along the coast of southern Belize District and the outer Turneffe Atoll, a lower temperature increase of ~ 1.5 °C is projected, most likely due to oceanic influence (Figure 26-A).

It is seen that during this wet season there is a more perceptible change in mean seasonal air temperature (°C) for the future decadal period of 2060-2070. Increases in mean temperature during these months now generally range between ~ 2.6 and ~ 3°C for most of Belize. But in a central zone stretching from northern Belize district through eastern Cayo District to southern Stann Creek District and northern Toledo district increases in seasonal temperature are > 3°C. Also in northern Corozal district seasonal temperature increase, approaches ~ 4°C (Figure 26-B).

Similarly, Figure 26-C presents the changes in mean seasonal air temperature (°C) (2060-2070 vs 1961-1990) for the September-October-November season for Belize according to the HadCM3Q11 climate model. It shows that during this wet season there is again a very perceptible change in mean seasonal air temperature (°C) for the future decadal period of 2060-2070. Increases in mean temperature during these months again generally range between ~ 2.6 and ~ 3°C for most of Belize. Again, in a narrow zone along the east coast stretching from Corozal District through Belize District and eastern Cayo District to Stann Creek District increases in seasonal temperature are > 3°C.

Finally, Figure 26-D presents the changes in mean seasonal air temperature (°C) (2060-2070 vs 1961-1990) for the December-January-February dry season for Belize. It shows that during this cool dry season there is again a very perceptible change in mean seasonal air temperature (°C) for the future decadal period of 2060-2070. Increases in mean temperature during these months again generally range between ~ 2.8 and ~ 3.2 °C for most of Belize, except for parts of Belize district where the increase in temperature is ~ 2.6 °C. But in the extreme northern part of Belize, in most of Corozal District and the northern part of Orange Walk District, increases in seasonal temperature are ~ 4°C.

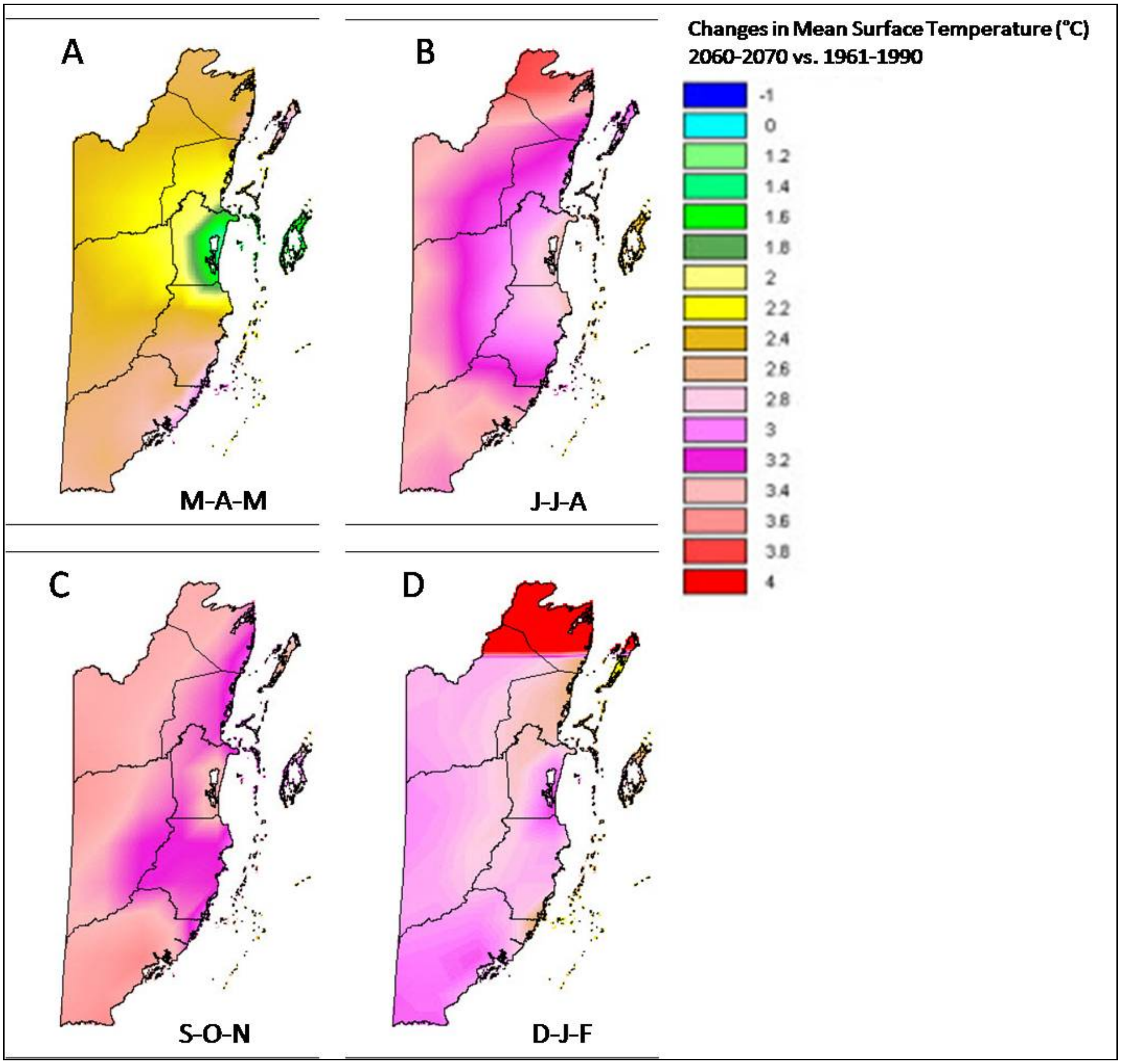

Figure 26 - Changes in mean seasonal air temperature (°C) (2060-2070 vs 1961-1990)) for the March-April-May (A), June-July-August (B), September-October-November (C), and December-January-February (D) season according to the HadCM3Q11 climate model

Source: Singh et al., 2014

3.1.7 Downscaled ECHAM5 Scenarios: Rainfall (mm/season)

Figure 27-A presents the changes in mean seasonal rainfall (mm/season) (2060-2070 vs. 1961-1990) for the March-April-May dry season for Belize according to the ECHAM5 climate model. It shows that during this season, generally, for most of Belize there is little or no change in rainfall or a decrease of ~ 100 mm/season, except for a small zone in southern Stann Creek District and northern Toledo District where a seasonal decrease of rainfall ~ 150 mm/season, with isolated pockets of decreases in rainfall of ~ 200 mm/season are projected.

On the other hand, Figure 27-B presents the changes in mean seasonal rainfall (mm/season) (2060-2070 vs. 1961-1990) for the June-July-August wet season for Belize according to the ECHAM5 climate model. It shows that during this season there is, generally, an overall decrease in rainfall over all of Belize. For most of the country the decrease in seasonal rainfall is ~ 200 to ~ 220 mm/season. But in a zone, south-western Cayo and north-western Toledo, the decrease in seasonal rainfall is lesser being ~ 160 mm/season. But in a zone covering northern Toledo District and southern Stann Creek District and some of the Cayes, the decrease in seasonal rainfall is greatest, being ~ 350 mm/season

As for Figure 27-C, it presents the changes in mean seasonal rainfall (mm/season) (2060-2070 vs. 1961-1990) for the September-October-November season for Belize according to the ECHAM5 climate model. It shows that during this season there is an overall decrease in rainfall over most of Belize of ~ 150 to ~ 160 mm/season. But, in a zone where the borders of Stann Creek District and Toledo District converge, and for some of the Cayes, the decrease in seasonal rainfall is ~ 220 mm/season, with isolated pockets of decreases in seasonal rainfall approaching ~ 350 mm/season.

Finally, Figure 27-D presents the changes in mean seasonal rainfall (mm/season) (2060-2070 vs 1961-1990) for the December-January-February dry season for Belize. It shows that during this season there is, generally, an overall decrease in rainfall of ~ 150 to ~ 160 mm/season for most of Belize. But in a zone covering northern Toledo District and most of Stann Creek District, and the Turneffe and nearby atolls, a decrease in seasonal rainfall of ~ 220 mm/season, with pockets of decreases in seasonal rainfall approaching ~ 350 mm/season are again projected.

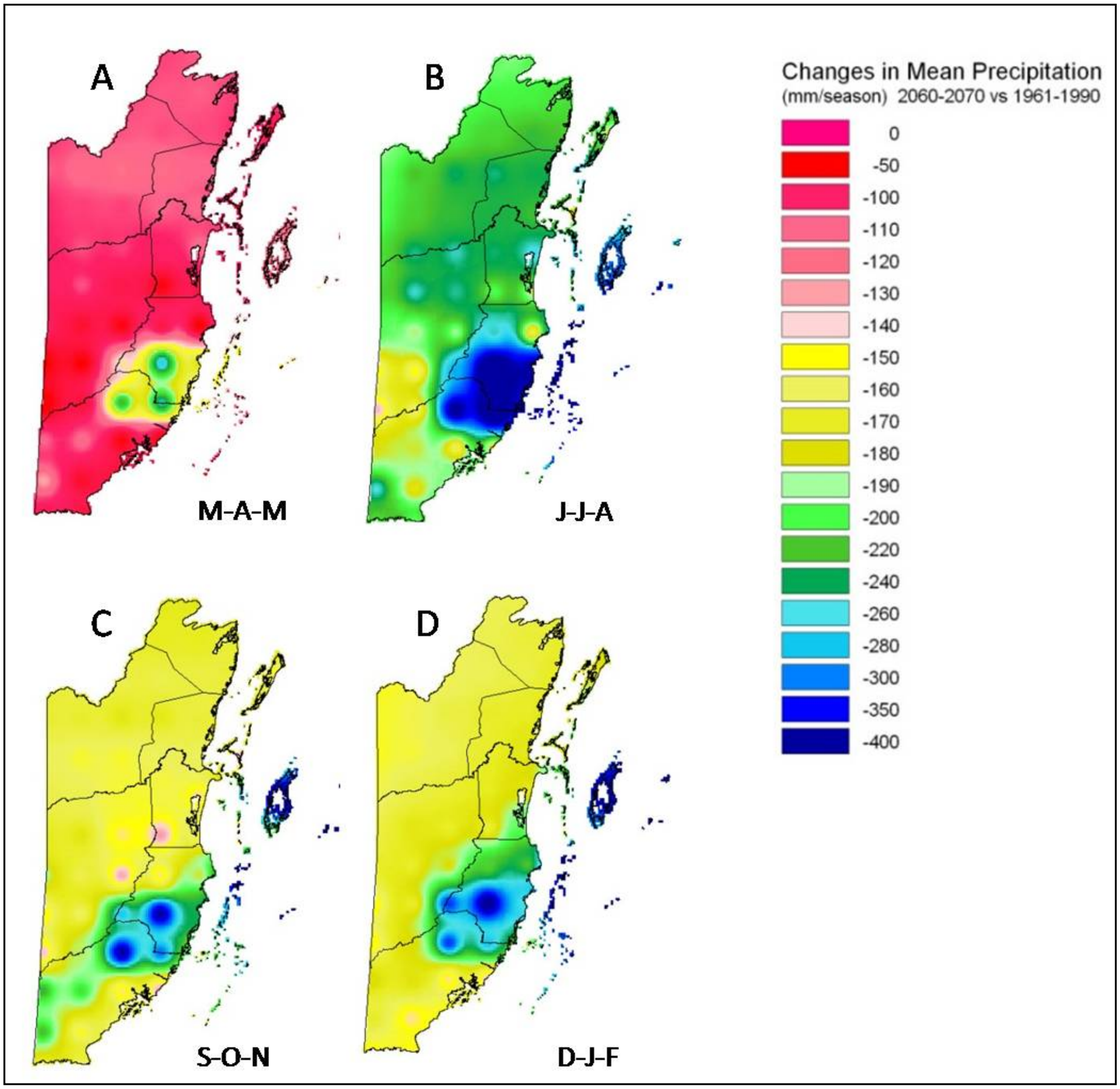

Figure 27 - Changes in mean seasonal rainfall (mm/season) (2060-2070 vs 1961-1990) for the March-April-May (A), June-July-August (B), September-October-November (C), and December-January-February (D) season according to the ECHAM5 climate model

Source: Singh et al., 2014

3.1.8 Downscaled HadCM3Q11 Scenarios: Rainfall (mm/season)

Figure 28-A presents the changes in mean seasonal rainfall (mm/season) (2060-2070 vs. 1961-1990) for the March-April-May dry season for Belize according to the HadCM3Q11climate model. It shows that, in general, during this season there is an overall decrease in rainfall over almost the entire country. In a zone covering western Cayo District, most of Orange Walk District and the northern tip of Corozal District the decrease in seasonal rainfall are ~ 160 mm/season. On the other hand, in a zone covering eastern Corozal District, most of Belize District and eastern Toledo District including most of the Cayes, the decrease in seasonal rainfall is ~ 190 to ~ 200 mm/season. But in a zone centred over all of Stann Creek District, the projected decrease in seasonal rainfall is even higher, namely ~ 240 mm/season with isolated pockets of decreases in seasonal rainfall approaching ~ 300 mm/season.

Figure 28-B, presents the changes in mean seasonal rainfall (mm/season) (2060-2070 vs. 1961-1990) for the June-July-August rainy season for Belize according to the HadCM3Q11 climate model. It shows that during this season there is an overall and significant decrease in seasonal rainfall over most of Belize. In a zone located in western Cayo District the decrease in seasonal rainfall is ~ 150 to ~ 160 mm/season. On the other hand, in a zone covering western Orange Walk District, the northern tip of Corozal District and parts of Toledo and Cayo Districts the decrease in seasonal rainfall is ~ 220 mm/season. But for most of Corozal and Belize Districts, the northern tip of Orange Walk District and parts of Toledo District and the offshore Cayes and atolls the decrease in seasonal rainfall is ~ 260 mm/seasons. In a zone centred over most of Stann Creek and southern Toledo Districts, the decrease in seasonal rainfall approaches ~ 300 mm/season.

As for Figure 28-C, it presents the changes in mean seasonal rainfall (mm/season) (2060-2070 vs. 1961-1990) for the September-October-November season for Belize according to the HadCM3Q11 climate model. It shows that during this season there is an overall decrease in rainfall of ~ 200 to ~ 220 mm/season for most of Belize. But in a zone centred over Stann Creek District and covering parts of Cayo and Belize Districts and the offshore Cayes and atolls, the changes in seasonal rainfall are ~ 260 mm/season with isolated pockets of seasonal rainfall decreases approaching ~350 mm/season.

Finally, Figure 28-D presents the changes in mean seasonal rainfall (mm/season) (2060-2070 vs. 1961-1990) for the December-January-February dry season for Belize according to the HadCM3Q11 climate model. It shows that during this season there is little change or an overall decrease in rainfall of ~ 100 mm/season for most of Belize. But in a zone centred over Stann Creek District and covering parts of Cayo, Toledo and Belize Districts and the offshore Cayes and atolls, the changes in seasonal rainfall are ~ 150 to ~ 200 mm/season.

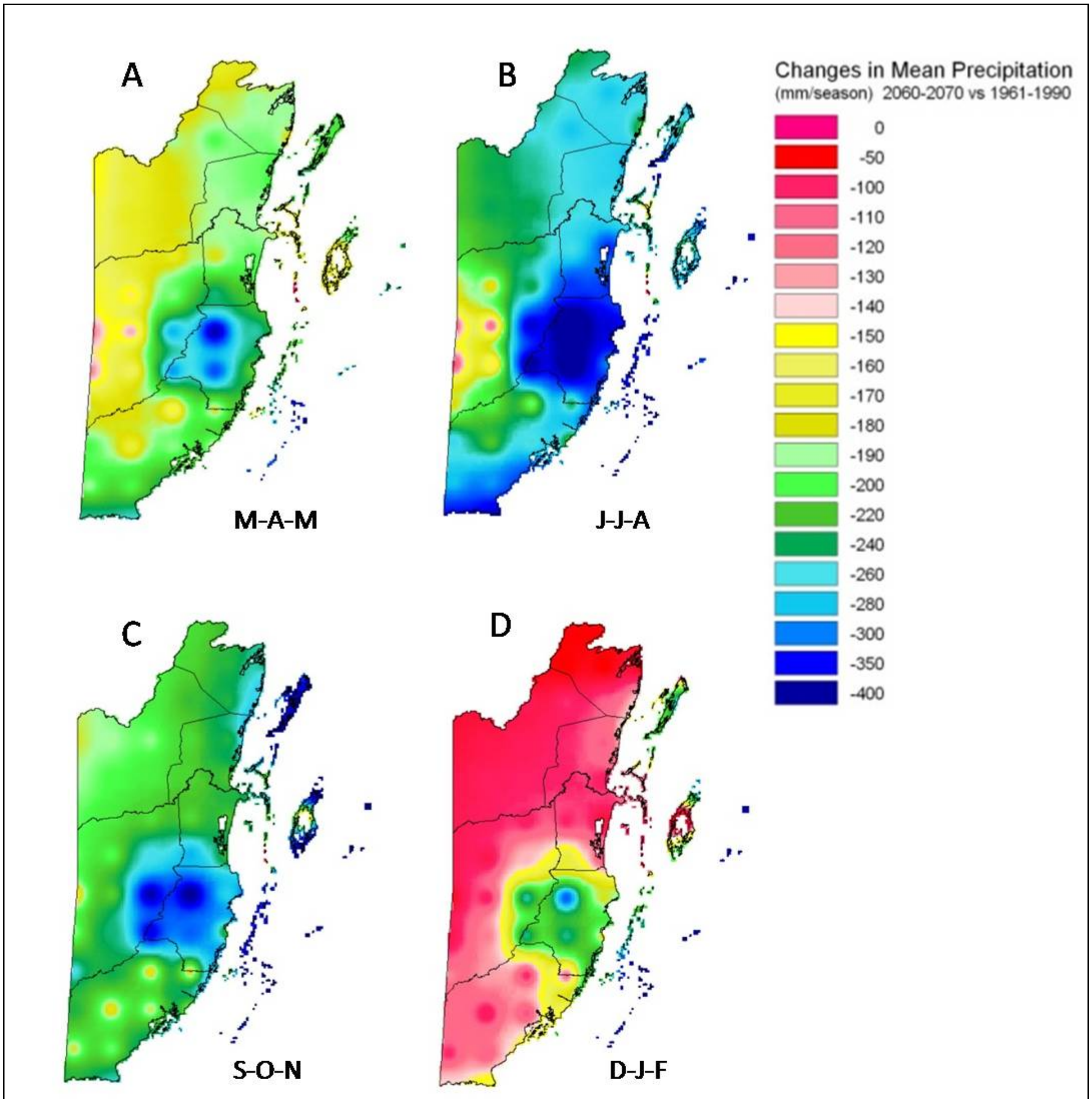

Figure 28 - Changes in mean seasonal rainfall (mm/season) (2060-2070 vs 1961-1990) for the March-April-May (A), June-July-August (B), September-October-November (C), and December-January-February (D) season according to the HadCM3Q11 climate model

Source: Singh et al., 2014

3.1.9 Output Summary

It would appear that according to the UNDP Country Profiles studies that an increase in air temperature ranging from 2°C to 4°C and a general decrease in annual rainfall of about 10% is projected for Belize by 2100.

As for the Climate Change scenarios, both the ECHAM5 and HadCM3Q11 climate models consistently project an increase in temperature (°C) for all Districts of Belize and for all seasons in the future (2060-2069) when compared to the present (1961-1990). Though the HadCM3Q11 projections are slightly higher, both models project increases in seasonal temperature (°C) that ranges from 2°C to 4°C which displays a fair level of spatial variation.

However, in the case of rainfall, both the ECHAM5 and HadCM3Q11 climate models generally project an overall decrease in seasonal rainfall in all seasons in the future (2060-2069) when compared to the present (1961-1990), especially in the June-July-August rainy season. Furthermore, wide temporal and spatial variations in seasonal rainfall (mm/season) are projected for Belize. But in a zone centred over Stann Creek District and covering parts of Cayo, Toledo and Belize Districts including the offshore Cayes and atolls, the decreases in seasonal rainfall are most significant.

Furthermore, Climate Change will provoke a rise in mean sea level in excess of 0.5 m by the end of the century. Storm surges are also expected to increase in intensity as a result of increases in the intensity of tropical storms and hurricanes.

These changes in temperature and rainfall and sea levels will have significant impacts on Belize, especially the coastal zone and the major socio-economic sectors of Belize, namely water resources, agriculture, tourism, fisheries and human health. These impacts and adaptation options will be elaborated upon in the sections to follow.

3.2 Coastal Zone

The coast comprises the interface between land and sea. The coast therefore represents a highly dynamic nexus between land and sea, which is adjusting over time to a range of drivers, including Climate Change, sea level rise and storm surges.

Climate Change and climate-driven sea level rise impose additional threats to coastal systems already under pressure from population concentration and increasing population growth in the future. Human presence, including infrastructure facilities, is becoming a significant direct and indirect impact on coastal ecosystems functions and coastal processes.

Increased coastal erosion and more extensive inundation are expected from rising sea levels; storm surges may flood greater areas than now, thereby impacting primary production, and may cause saline intrusion up estuaries and into groundwater aquifers. These biophysical impacts may cause loss of coastal habitats, property damage, flooding and loss of life, as well as having economic consequences for rural production and urban lifestyles. In many cases the effect of a change in climate and sea level are going to exacerbate problems that already exist.

Furthermore, the adaptive capacities of local communities to cope with the effects of severe climate impacts decline if there is a lack of physical, economic and institutional resources employed to combat the effects of the climate hazard, and to reduce the vulnerability of high-risk communities and groups exposed to them.

3.2.1 Methodology

For the coastal zone, we first examined the vulnerabilities to existing weather and climate variability, including sea level rise and storm surge scenarios (IPCC, 2007). These included low-lying coastal areas currently (2003-2012) affected by inundation, erosion and saline intrusions.

The coastal zone chosen covers an area of 3,481 km^2 stretching from the northern coastline of Belize and it extends southward to over 386 km of coastline. More specifically, the Area of Interest (AOI) is represented by a band of 10 km within the mainland and the islands of Turneffe, Chapel Caye and Caye Caulker.

As for the vulnerabilities of the coastal zone to projected future (2060-2069) Climate Change and sea level rise, this was assessed using data on sea level rise and storm surges gleaned from climate models (A-OGCM) (IPCC, 2013) and the Caribbean disaster mitigation project.

In order to correct the Digital Simulated Model (DSM) to derive a Digital Terrain Model (DTM), especially where tall vegetation occurs, data from the Belize Ecosystem Shape file was used.

Data representing the projected sea level changes for the 2060s decade is derived from the latest IPCC (2013) Summary Report. However, sea level rise values of the IPCC (2013) are rather conservative when compared to other recent studies that integrate the land ice contribution to sea level rise (Rahmstorf, 2007, 2010; Horton et al., 2008; Vermeer and Rahmstorf, 2009; Grinsted et al., 2009). In view of this conservativeness, the extreme values of the IPCC (2013): 0.38 m was used for the 2046-2065 period and 0.82 for the 2081-2100 period.

As for the effects of storm surges, the storm surge and hurricane categories data from the Caribbean Disaster Mitigation Project (2005) were used including storm surge projections for a category 2 and a category 5 hurricane. Furthermore, the final values of the storm surges were derived by incorporating the sea level rise and the highest tide level for the 2046-2065 and 2081-2100 future periods (table 16).

In the final analysis, the sea level rise and the storm surge categories were superimposed on the Digital Elevation Map (DEM) of Belize together with the major land use categories for the 2046-2065 and the 2081-2100 periods. These analyses allowed for the identification of ecosystems (mangroves, sea grass, coral reefs) and communities (fishing villages) that are likely to be at high risk to Climate Change and variability.

Table 16 - Final values of future sea level and storm surge scenarios: Belize

Sea Level Rise (RCP 8.5) (m)		Contribution of MHHW (Mean Higher High Water) (m)	Final Values of Future Sea Levels (m)	*Storm Surge Scenarios Category 2 Hurricane Mid Value (m)	Final Storm Surge Scenarios Category 2 Hurricane: Mid Value plus Sea Level Rise (m)	*Storm Surge Scenarios (m) Category 5 Hurricane Minimum Value (m)	Final Storm Surge Scenarios Category 5 Hurricane: Minimum Value plus Sea Level Rise (m)
2040-2065	0.38	0.9	0.47	2.00	2.47	5.4	5.87
2081-2100	0.82	0.9	0.91	2.00	2.91	5.4	6.31

*By adding the sea levels to the mid-value storm surges

Source: Singh et al., 2014

3.2.2 Coastal Zone Inundation: Land Use Classes

Figure 29-A and Table 17 shows the Coastal Zone and Land Use categories inundated by a 0.47 m rise in sea level (Level 0.47 m) for Belize for the 2040-2065 periods. It is evident in the Figure that all of the coastal zone and a large portion of the Cayes, a total area of ~ 210 km^2 will be affected by inundation from a 0.47 rise in sea level by 2040-2065. The land use classes that would be most affected is Sea grass (~ 88 km^2/42 %), wetland (~ 67 km^2/32 %) and mangrove and littoral forest (~ 48 km^2/23 %).

On the other hand, the Coastal Zone and Land Use categories inundated by a 0.91 m rise in sea level for Belize during the 2081-2100 period, shows (Figure 29-B and Table 17) that all of the coastal zone and a large portion of the Cayes, a total area of ~ 291 km^2 will be affected by inundation. Also, the land use classes that would be most affected are Sea grass (~ 110 km^2/38 %), Wetland (~ 93 km^2/32 %) and Mangrove and littoral forest (~ 77 km^2/27 %).

When a storm surge for a category 2 hurricane is considered, the Coastal Zone and Land Use categories inundated by a 2.47 m rise in sea level combined with the category 2 hurricane storm surge (Level 2.47 m) along with the highest tidal level for Belize (2040-2065 period), it is evident in (Figure 29-C and Table 17) that all of the coastal zone and a large portion of the Cayes, a total area of ~ 827 km^2 will be affected. Also, the land use classes that would be most affected are, in order of magnitude, Wetland (~ 323 km^2/39 %), Mangrove and Littoral Forest (~ 284 km^2/34 %) and Sea grass (~ 153 km^2/19%).

However, when a storm surge for a category 2 hurricane is considered, the Coastal Zone and Land Use categories inundated by a 2.91 m rise in sea level combined with the category 2 hurricane storm surge (Level 2.91 m) along with the highest tidal level for Belize (2081-2100 period), it is evident in (Figure 29-D and Table 17) that all of the coastal zone and a large portion of the Cayes, a total area of ~ 941 km^2 will be affected by inundation from a rise in sea level coupled with a storm surge. The land use classes that would be most affected are, in order of magnitude, Wetland (~ 356 km^2/38%), Mangrove and Littoral Forest (~ 335 km^2/36 %), Sea grass (~ 160 km^2/17 %) and Lowland Savannah (~ 12 km^2/4 %).

But, when a storm surge for a category 5 hurricane is considered, the Coastal Zone and Land Use categories inundated by a 5.87 m rise in sea level combined with the category 5 hurricane storm surge (Level 5.87 m) along with the highest tidal level for Belize (2040-2065 period), it is evident in (Figure 29-E and table 17) that all of the coastal zone and a large portion of the Cayes, a total area of ~ 1,651 km^2 will be affected by inundation. Also, the land use classes that would be most affected are, in order of magnitude, Mangrove and Littoral Forest (~ 606 km^2/37 %), Wetland (~ 486 km^2/29 %), Sea grass (~ 183 km^2/11 %) Lowland Savannah (~ 162 km^2/10 %), Urban (~ 52 km^2/3 %), Lowland Broad-leaved Moist Forest (~ 51 km^2/8 %) and Agricultural Land (~ 44 km^2/3 %) .

Finally, when a storm surge for a category 5 hurricane is considered, the Coastal Zone and Land Use categories inundated by a 6.31 m rise in sea level combined with the category 5 hurricane storm surge (Level 6.31 m) along with the highest tidal level for Belize (2081-2100 period), again, it is evident in (Figure 29-F and Table 17) that all of the coastal zone and a large portion of the Cayes, a total area of ~ 1,754 km^2 will be affected by inundation. Furthermore, the land use classes that would be most affected are, in order of magnitude, Mangrove and Littoral Forest (~ 631 km^2/36 %), Wetland (~ 502 km^2/29 %), Sea grass (~ 185 km^2/11 %), Lowland Savannah (~ 184 km^2/10 %), Lowland Broad-leaved Moist Forest (~ 63 km^2/4 %), Urban (~ 57 km^2/3 %), and Agricultural Land (~ 54 km^2/3 %).

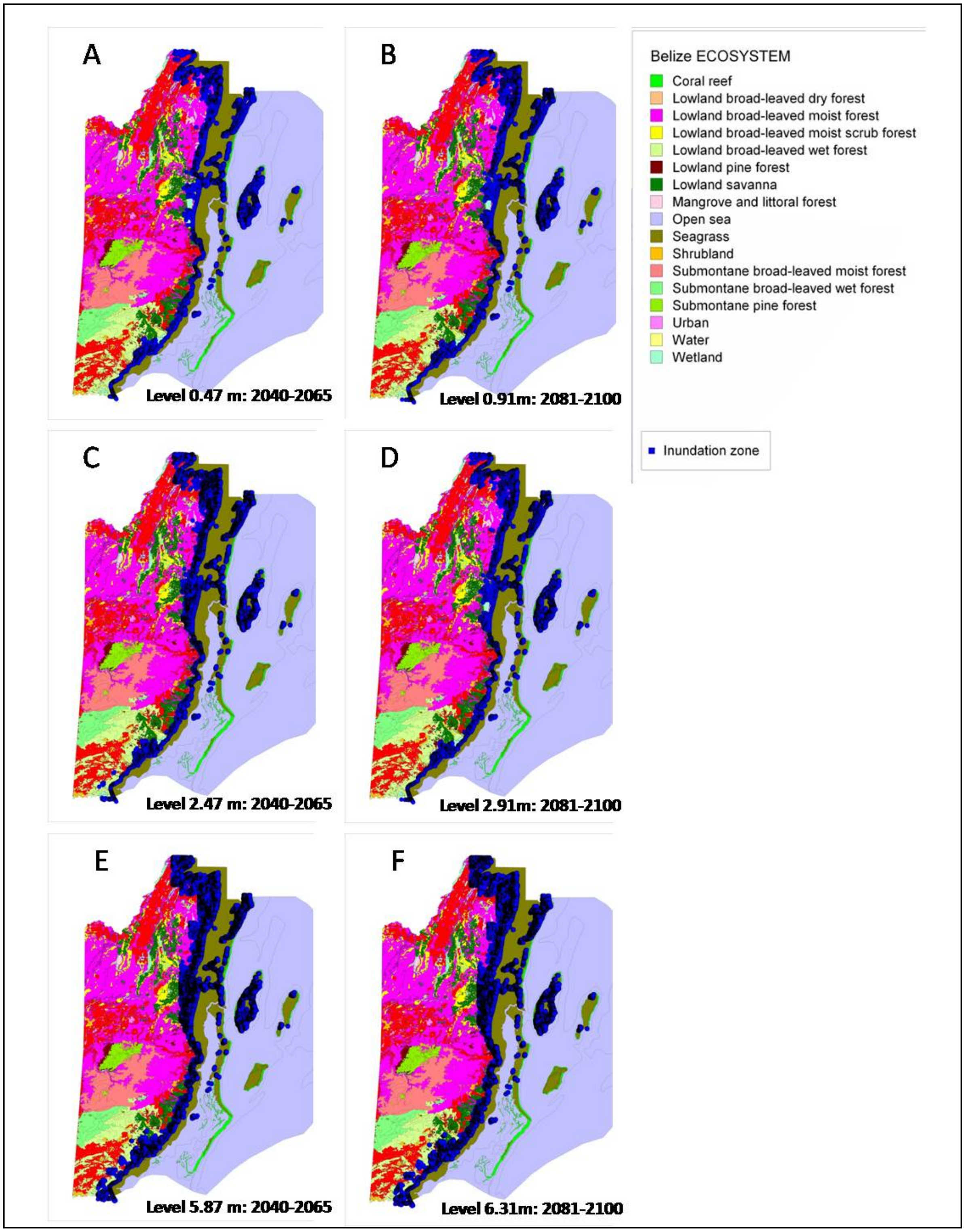

Figure 29- Coastal Zone and Land Use categories inundated by a combination of sea level rise (Level 0.47: 2040-2065 and Level 0.91: 2081-2100) (A and B, respectively) and storm surges for category 2 (Level 2.47: 2040-2065 and Level 2.91: 2081-2100) (C and D, respectively) and category 5 (Level 5.47: 2040-2065 and Level 6.31: 2081-2100) (E and F, respectively) hurricanes and during highest tide level

Source: Singh et al., 2014

Table 17 - Summary of Land Use categories inundated (km^2) by a combination of sea level rise (Level 0.47: 2040-2065 and Level 0.91: 2081-2100) and storm surges for category 2 (Level 2.47: 2040-2065 and Level 2.91: 2081-2100) and category 5 (Level 5.47: 2040-2065 and Level 6.31: 2081-2100) hurricane and during highest tide level

	Level 0.47	Level 0.91	Level 2.47	Level 2.91	Level 5.87	Level 6.31
Agricultural uses	0.3096	0.7551	6.0021	8.0262	44.2755	54.3051
Coral reef	1.1007	1.3779	1.8468	1.8927	2.0439	2.052
Lowland broad-leaved dry forest	1.4391	2.0529	6.3027	7.65	24.0327	27.4806
Lowland broad-leaved moist forest	0.2907	0.5922	5.5341	8.2827	51.8913	63.5526
Lowland broad-leaved moist scrub forest	0.1035	0.2088	2.4615	3.6297	25.5159	30.825
Lowland broad-leaved wet forest	0.0018	0.0036	0.0531	0.099	1.4445	2.0538
Lowland pine forest	0	0	0	0.0009	0.1854	0.2925
Lowland savannah	0.5697	1.6956	26.4762	38.5191	162.2934	184.7709
Mangrove and littoral forest	48.3156	77.5287	284.229	335.6352	606.8493	631.737
Sea grass	88.9164	110.3589	153.9297	160.0731	183.8619	185.9877
Shrub land	0	0	0.0045	0.0108	0.6318	1.161
Urban	1.0404	2.2023	11.5146	15.0966	52.2549	57.5775
Water	0.8964	1.5453	5.6475	6.1425	9.8586	10.5867
Wetland	67.3506	93.5775	323.1765	356.3793	486.2574	502.0533
Total Area	210.335	291.899	827.178	941.438	1651.397	1754.436

Source: Singh et al., 2014

3.2.3 Belize City

This section examines how Belize City in particular, where a large percentage (~ 22 %) of the population reside, will be affected by future scenarios of sea level rise and storm surges.

In order to protect the low-lying coastal area that is near sea level in the vicinity of Belize City, hard structures in the form of sea walls are being built around the city. However, the height and engineering quality of these structures vary according to location and for the most part are not high enough to protect the coastal zone of the city from future sea level rise and storm surges.

Although a variety of sea walls have been constructed in certain areas, they are at highest ~ 1m and may protect against these future scenarios of sea level rise. But since, the length of these walls is not continuous even at these levels, rising seawater would be able to penetrate from the unprotected sides and cause flooding even in the protected areas.

Focusing on the vulnerability of Belize City to future sea level rise and storm surges a graphic display of the low-lying coastal zones that would be at risk to sea level rise under futures sea level rise scenarios, namely 0.47 m in 2040-2065 and 0.91 m in 2081-2100 can be seen in Figure 30-A and 30-B. But when one considers the higher water level caused by a category 2 hurricanes, the flooding of Belize City increases substantially. For a category 2 storm, (2.47 m: 2040-2065) and (2.91 m: 2081-2100), the flooding increases at the low-lying boundary with the sea and the interior of the city via drainage channels as shown in Figure 30-C and 30-D. Furthermore, when one considers the higher water level caused by a category 5 hurricanes, the flooding of Belize City increases even more substantially, to the extent that almost the entire city is flooded for a category 5 storm (5.87 m: 2040-2065) and (6.31 m: 2081-2100) as seen in Figure 30-E and 30-F.

3.2.4 Climate Change and Sea Level Rise Socio-economic Impacts in the Coastal Zone

The impacts of Climate Change and climate-driven sea level rise and storm surges will certainly have an impact on coastal ecosystems and economic activities in the coastal zone of Belize. More information on these impacts can be found in Singh et al., 2014. The area most susceptible to the effects of Climate Change is the coastal ecosystem. Anticipated increases in sea surface temperatures, salinity, pH, sea level, and intensity of tropical cyclone events have direct implications on the future state of the coastal zone and the ability of Belizean people to utilize the resources it provides. Belize's coastal ecosystems and rich biodiversity will also be affected by global climate change. Delicate marine ecosystems such as sea grass beds, mangroves and coral reefs are directly dependent on climatic conditions for distribution, function and growth. Changes in climatic conditions can lead to degradation of these already threatened ecosystems (Clarke et al., 2013).

Agriculture in the coastal zone will also be vulnerable to the changing climate, sea level rise and storm surges. Generally, higher temperature and lower precipitation is expected to be amongst the major changes associated with Climate Change projections for Belize. Therefore, crops that favour warmer temperatures such as rice will thrive under Climate Change conditions. However, for more economically important crops such as sugar cane and citrus, decrease in precipitation will decrease yields leading to a decrease in export income.

Other sectors that will be vulnerable to future Climate Change, sea level rise and storm surges, via direct and indirect impacts are fisheries, tourism and agriculture (Singh et al., 2014). For instance, according to literature such as CARIBSAVE (2012) several coastal areas of Belize, such as Monkey River in Toledo District, Caye Caulker, Rocky Point and San Pedro (Ambergris Caye) are experiencing severe problems of coastal erosion and loss of beaches that is critical for the tourism sector. Furthermore, coastal communities that depend on fishing and agriculture would also be at risk to Climate Change, sea level rise and storm surges.

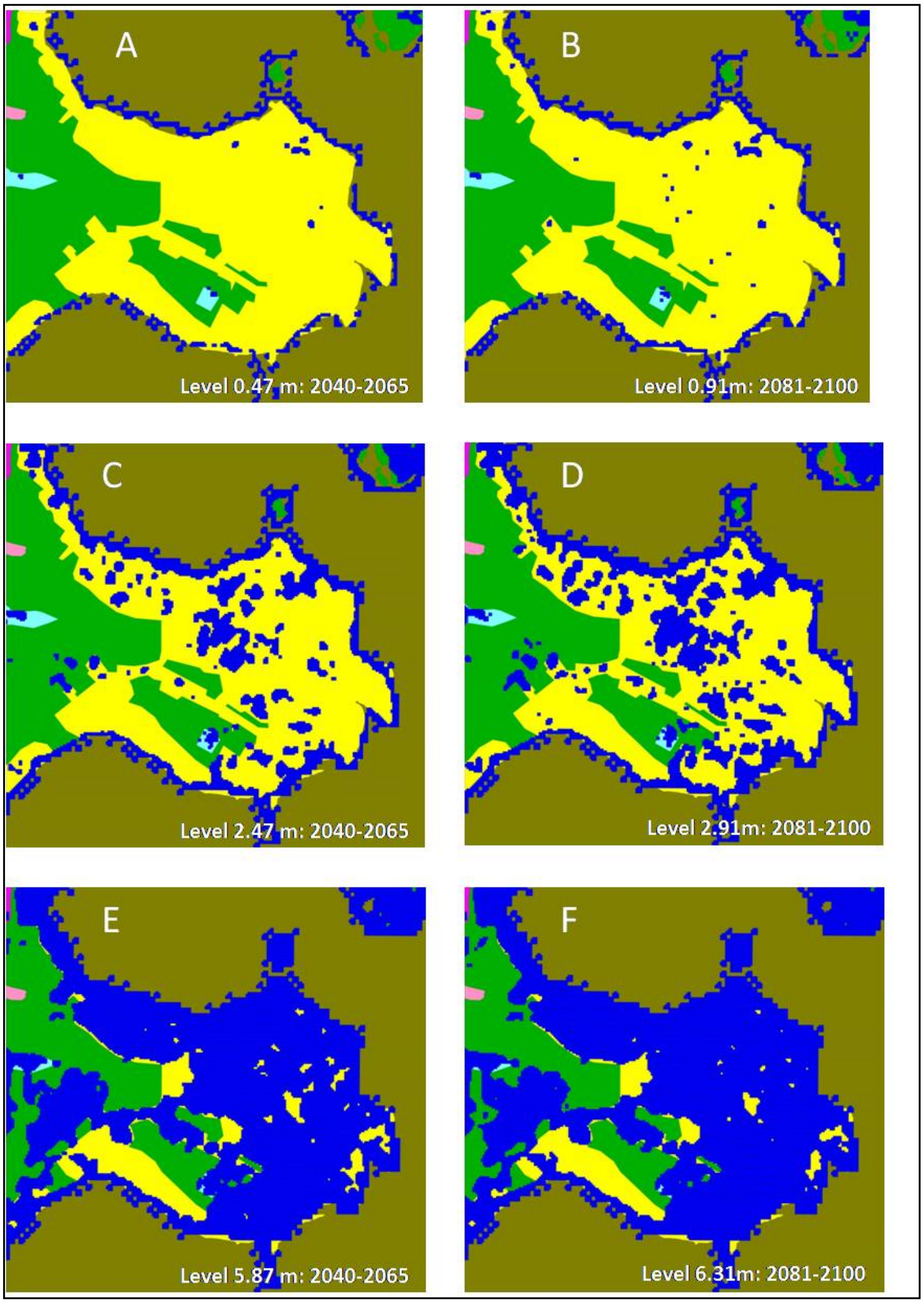

Figure 30- Flooding zones for Belize City following a rise in sea level and during highest tide (Level 0.47: 2040-2065 and Level 0.91: 2081-2100) (A and B, respectively) and combined with storm surges for category 2 (Level 2.47: 2040-2065 and Level 2.91: 2081-2100) (C and D, respectively) and category 5 (Level 5.47: 2040-2065 and Level 6.31: 2081-2100) (E and F, respectively) hurricanes and during highest tide level

Source: Singh et al., 2014

3.2.5 Coastal Zone Adaptation

From the foregoing sections, it is very evident that climate-driven sea level rise is expected to have far-reaching consequences on the coastal zone of Belize. When extreme events such as storm surges are also considered the impacts on the coastal zone of the mainland and the Cayes could be disastrous. This is due to the diverse coastal assets found in this region. These include the major settlements, such as Belize City, San Pedro, Dangriga, Placencia and Punta Gorda that represents close to one half of the population. Furthermore, these flooding events would certainly cause damage to human settlements, infrastructure (including roads), mangroves ecosystems (that stabilizes the coast while also purifying runoff water and serving as an invaluable habitat for various flora and fauna), and agricultural land and crops. These resources and activities are extremely sensitive to Climate Change because, in the event of sea level rises and storm surges, inundation and flooding, erosion, saline intrusion into surface and ground water sources would very likely occur.

Adaptation options, guided by policy changes and legislation, that may warrant immediate short-term consideration would include (Leary et al, 2008a; 2008b):

1. The formulation and implementation of land-use planning policies to address people and settlements and agricultural lands at risk to inundation deriving from sea level rise and storm surges;
2. Fortification of sea and river defences in accordance with sea level rise and storm surges in vulnerable areas;
3. Further implementation of early warning systems in the event of storm surges (NEMO);
4. The building of more shelters on higher ground either near the coast or inland to house people in the event of inundation due to storm surges;

Longer-term policy changes and adaptation measures to address sea level rise and storm surges would include:

1. Adopt more proactive mitigation measures such as the use of building set-backs legislation to limit buildings and other major developmental work on the coast and encourage gradual retreat to higher grounds by making land available in the interior, in an effort to decentralize economic activities and settlement on the coast;
2. Undertake detailed surveys to identify most vulnerable areas along the coast, such as Belize City, San Pedro, Dangriga, Placencia and Punta Gorda, and determine appropriate adaptation strategies;
3. Also undertake evaluation of agricultural lands, coastal aquifers and drainage and irrigation systems.

However, these adaptation response strategies should also be integrated with economic development policies, disaster mitigation and management plans and Integrated Coastal Zone Management (ICZM) plans.

The costs of coastal protection works are enormous, ranging from 0.1 % to 10 % of GDP, depending on the sensitivity of the coastal zone and the extent of sea level rise and storm surges (IPCC, 2007). These huge costs, which are very likely to be applicable to Belize, could be prohibitive, unless funding can be leveraged through sources such as the Adaptation Fund.

When beaches are destroyed by storm surges, the cost of beach nourishment could also be very expensive. For example, in Caye Caulker (Playa Asuncion), a beach of 1, 000 feet long and 30 feet wide underwent beach nourishment following Hurricane Keith (2000); this activity totalled to a sum of $170,000.00 BZ. Since then, half of the nourished beach has already been lost (Interview: Mr. Alberto Villanueva, formerly with the Caye Caulker Council).

3.2.6 Conclusion

The results of the preceding section highlighted the vulnerability of the coastal zone of Belize to climate-driven sea level rise and the potential impacts of extreme events such as storm surges. But, all things being equal, these results provide credible scenarios of the vulnerability of the coastal zone of Belize to future sea level rise and storm surges. Not only would settlements, infrastructure and people be at risk of coastal inundation, but also valuable tourism facilities and agricultural lands and crops that form part of the most significant economic sectors of Belize. Given these potential losses, investing in the most beneficial adaptation measures would significantly increase estimated national income in Belize, and would likely be essential to attracting investors.

Based on these analyses, adaptations options and barriers to adaptation to Climate Change (economic resources, technical knowledge, adaptive capacity, land availability for displaced peoples, etc.) were identified for the coastal zone sector. This component also addressed possible opportunities and priorities (coastal infrastructure and development, coastal zoning changes, setback limits...) for enabling effective and proactive adaptation to Climate Change and sea level rise in the coastal zone of Belize (Singh et al., 2014).

3.3 Water Sector

Water supply in Belize comes mainly from, surface water (rivers, lakes and lagoons) and desalinisation of seawater (Ambergris Caye and Caye Caulker). The underground water resources are considered extensive, especially in the Savannah and Campur provinces. In the Ministry of Agriculture, the Irrigation Unit promotes and encourages irrigation systems using underground water. However, no assessment of the underground water resources is done prior to the installation of the irrigation systems, so the knowledge of groundwater resources and quality is limited (BEST, 2008; 2009).

Climate Change is very likely to have a significant impact on the water sector of Belize. Rainfall is projected to decrease slightly and become more variable leading to intense rains and flooding while also worsening drought conditions (McSweeney et al., 2009; IPCC, 2007 and 2013).

Rainfall amounts and variability are critical to the economy of Belize. Not only would there be risks of flooding from excessive rainfall in the low-lying coastlands, but also agricultural production, a key contributor to GDP, would be subject to the alternating conditions of excessive rainfall and flooding on the one hand and drought on the other.

Sea level rise and storm surges, will also affect the water sector through saline intrusions into coastal aquifers and soils, including the flooding of coastal lowlands and towns, where the bulk of the population of Belize is located (Singh and El Fouladi, 2007).

Other related sectors, especially human health also risk to be directly affected, through loss of life due to flooding or indirectly though the impacts on food supply and the proliferation of disease-spreading vectors.

3.3.1 Methodology: Climate Change Impacts on Regional Water Excess/Deficits

For the water resources sector, we focused on the increase (excess water and flooding) or decrease (more extreme droughts) in rainfall based on the relationship between Precipitation (P) and Evaporation (E), namely (P-E) for the future climate (2060-2069) compared to the current climate (1961-1990). The latter extended to the stations with good quality data within the major hydrological regions of Belize, namely Tower Hill in Hydrological Region 7 representing the northern districts (Orange Walk and Corozal); Central Farm in Hydrological Region 9 representing central (Cayo and part of Belize);Melinda in Hydrological Region 11 representing the central and southern mountainous districts (Stann Creek and Toledo) and Punta Gorda, close to Hydrological Region 13, representing the extreme southern district (Toledo).

Table 18, below, shows the stations that had reliable observed data needed for calibration purposes and these locations were used as demonstrations to evaluate the influence of Climate Change on water excess or deficits for Belize.

Table 18 - Stations and locations for data analysis

Station	District	Hydrological Region	Latitude-deg. N	Longitude deg. W
Tower Hill	Orange Walk	Region 7	18^0 34'	88^0 34'
Melinda Forest	Stann Creek	Region 11	16^0 59'	88^0 19'
Maya King	Stann Creek	Region 11	16^0 43'	88^0 25'
Punta Gorda	Toledo	Region 11 (13)	16^0 8'	88^0 51'

Source: Singh et al., 2014

3.3.2 Socio-economic Impacts of Water Deficits or Excesses

Belize is a country rich in surface water sources including streams and rivers as well as many groundwater aquifers found in calcareous rock. The main source of freshwater in rural areas is predominantly groundwater, where approximately 95% of freshwater is extracted from groundwater supplies. There are also two desalinisation plants operating in the country one on Ambergris Caye and the other on Caye Caulker. Freshwater supplies are sufficient for the current population, there is, however, an increased stress on these supplies due to population growth increases in economic and agricultural activities, as well as an increase in droughts (BEST, 2009;

CARIBSAVE, 2012).

The Belize Water Services (BWS) is the agency responsible for water distribution in the country. Rates for water use have increased many folds for tariffs and connection rates (CARIBSAVE, 2012). Recently, there was an increase of 6.9% as approved by the PUC.

Despite its water abundance, recent issues with water scarcity in some areas and water quality have become more predominant as various stresses on the country's water resources increase. Key issues with water vulnerability in Belize are the uneven distribution of water resources. The southern region (Toledo) has the lowest population, with the highest amount of freshwater availability, whereas the central and northern regions (Orange Walk and Corozal) both have much larger populations and much less water resources (CARIBSAVE, 2012).

Several Cayes have become popular tourist destinations, but have low availabilities of freshwater. In particular, Caye Caulker is vulnerable to contamination of its underground water through poor sewer construction and intrusion of salt water into aquifers. It has also been noted that there has been changes in precipitation which has led to severe droughts that have affected many parts of the country (CARIBSAVE, 2012).

In Belize, the distribution of all wells that have been drilled or dug out by hand is unknown. There is a lack of coordination between the BWS and the local village water boards; there are approximately ninety (90). Under the village water boards, the households are usually charged a flat rate per month as these are not often metered. Where there is no access to piped water service, or no local provider, then the water is accessed using hand pumps (CARIBSAVE, 2012). There is no fully operational central administration for water resources management and because of this main issue, financial resources for water management have been minimal and have been focused on the delivery end primarily for residential/domestic use (CARIBSAVE, 2012).

The development of a mechanism to facilitate Integrated Water Resources Management (IWRM) in the form of a water management authority was formed in the Ministry of Natural Resources and Agriculture in 2008. They are responsible for the implementation of the integrated water management policy. This will allow for the equitable management of water resources, which will be particularly important with declining water resources under Climate Change (CARIBSAVE, 2012).

Belize consumed around 579 million m^3 (15.3 billion gallons) of water in 2007 (BEST, 2009). The demand for fresh water resources in Belize emanates from three (3) broad economic sub-sectors: agricultural, industrial and domestic/residential. In 2007 agriculture, industrial and domestic /residential users required 43.7%, 36.5% and 19.7%, respectively, of the total demand (BEST, 2009) (Figure 31). With a growing population and economy, this will lead to a greater competition amongst key sectors, namely agriculture, industry and domestic/residential (including tourism) for increasingly lesser and lesser water supplies.

The economic effects of climate variability and extremes on agriculture are already noticeable as seen in recent incidents of flooding and drought (BEST, 2008; 2009). Decreasing rainfall amounts and increased variability of rainfall will make it more difficult to plan for agricultural production.

Belize has three hydropower sites: Mollejon (dam), Chalillo and Hydro Maya (run of the river) which supply the nation with 25 MW, 7 MW and 0.50 MW of hydroelectricity, respectively. There is also a small-scale power plant at Blue Creek on the Rio Hondo which provides 15KW of power to the Mennonite community. Belize Electricity Limited sources the remainder of electricity for the country from producer's diesel-burning thermal plants (BEST, 2008; 2009). Hydropower generation utilizes high volumes of water. Therefore, any significant change in the hydrological cycle will affect hydropower facilities and will threaten the reliability and security of Belize's electricity supply. Falling river levels will affect water intake and availability of water in the reservoirs. River flow would be further reduced if agriculture and potable water demands were given higher priority. Consequently, water replenishment rates may not keep up with rates of desired usage. This will cause hydroelectric dams to be less efficient leading to higher costs of electricity as the country becomes increasingly reliant on fossil fuels (BEST, 2008; 2009).

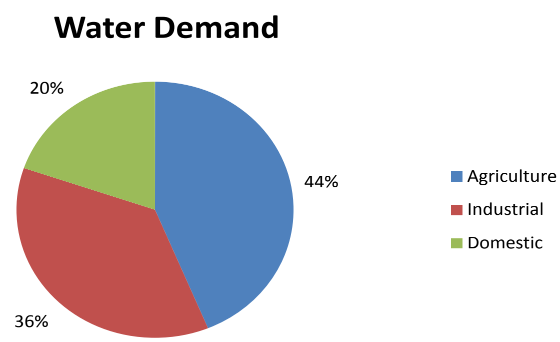

Figure 31: Water demand by economic sectors (2007)

Source: BEST, 2009

3.3.3 Adaptation Strategy and Action Plan

The impacts of Climate Change on the water resources of the Belize are outlined in the National Adaptation Strategy and Action Plan (BEST, 2008; 2009) so as to ensure that Belize has the capacity to conserve and efficiently use this most critical resource. The Strategy and Action Plan are guided by the principles inherent in IWRM. Belize has a particular water security concern because the potable water supply for more than fifty percent of the population originates in neighbouring countries (BEST, 2008; 2009).

Water can become scarce especially in localized areas. Scarcity of this resource will lead to conflict. The nature of conflict will have to be understood and appropriate conflict resolution mechanisms put into place. Communication with stakeholders is required from the outset for those sub-sectors of the economy that are directly affected such as: food producers and processors, manufacturers, the Belizean people and their visitors.

Although there are various water management institutions in existence, the country lacks the complete range and integrated responses required for adaptation to Climate Change. However, recommendations can be made in regards to adapting to Climate Change (BEST, 2008; 2009).

3.3.3.1 Water Conservancy Management Systems and Protection of Watersheds

Water Conservancy Management Systems and Protection of Watersheds should take into consideration:

- The enhancement of mechanisms for the protection and restoration of ecosystems;
- Adoption of forest management plans to prevent and control soil erosion;
- Encouraging water harvesting;
- Protecting the water environment, preventing and controlling water pollution;
- Raising awareness to promote the effective and efficient use of water.

3.3.3.2 Efficient Use of Water in Agriculture

The Banana Industry relies heavily on surface water for the irrigation of its plantation and processing. Likewise, the aquaculture industry uses surface water for their ponds and processing.

To minimize costs and to conserve water, farmers should (BEST, 2008; 2009):

- Develop drip and sprinkle irrigation practices to increase water efficiency;
- Improve management practices;
- Select and cultivate stress-resistant varieties.

Furthermore, in order reduce excess soil water under increased precipitation; the following options can be implemented:

- Improve drainage infrastructure as well as improved harvesting practices to maintain quality of crop;
- New cultivars with higher resistance to soil anaerobiosis would be suitable;
- Enhance national capacity to test new cultivars and to conduct genetic improvement;
- Change management practices such as planting dates to compensate for crop cycle modifications;
- Use of technology to enhance management practices to improve crop yield;
- Research pest/disease resistant crop varieties.

3.3.3.3 Hydroelectricity

As for hydroelectricity, the following adaptation measures are proposed:

- Improve hydrology and meteorology observation network and data collection;
- Improve flood and drought forecasting;
- Promote energy efficiency;
- Promote alternative sources of energy.

3.3.4 Conclusion

Belize may face challenges in responding to Climate Change. Climate Change is already upon us and Belize must be prepared to adapt to this challenge. A priority would then be the further development of the Water Sector Adaptation Strategy to Climate Change in the Water Sector of Belize (BEST, 2008; 2009).

The Strategy and Action Plan (SAP) points to critical areas which require further development and strengthening. These areas have to be pursued if the country is to sustain its abundant supply and preserve a sufficiently high quality of water for all users (BEST, 2008; 2009). The implementation of the SAP will require a concerted effort by all the stakeholders from both the private and public sectors. It will also require effective trans-boundary cooperation between Belize and Guatemala to the west and Mexico to the north. Similarly, the financing of the SAP will require the mobilization of national, bilateral and international resources (BEST, 2008; 2009).

3.4 Agriculture Sector

Agriculture is very important for the economy of Belize. In earlier years, agriculture was the primary sector which contributed substantially to the growth of the country's GDP. For instance, in 2007, Agriculture and Forestry contributed 9.1 % to the GDP of Belize (GEO Belize, 2010). In recent years, this has changed, but the sector is still important because of its export earnings and the employment it creates for a large percentage of the population in rural areas of Belize (Environmental Statistics for Belize, 2012).

Economic performance in the agriculture sector is primarily dependent on traditional export crops such as sugar, citrus and banana which currently account for about 60% of the earnings with citrus exports being the principal source of income followed by sugar and banana. Rice, corn and beans are the main domestic food crops.

It is expected that Climate Change would have severe impacts on the agriculture sector of Belize. Currently, changes in Belize's climate are already affecting the agriculture sector: variability of yields/harvests for rain fed agriculture is already suffering from changes in the timing and amounts of rainfall and there is widespread perturbation of the agricultural calendar. Intense rainfalls are causing problems of soil drainage and erosion while warmer temperatures are leading to the increased incidence of yield-reducing weeds, pests and diseases.

Future, changes in the climate would very likely exacerbate these conditions. Climate Change is expected to be accompanied by increasing water deficits and moisture stress, increased practice of irrigation and increased use of chemicals and fertilizers, changes in the choice and mix of crops/cultivars, all of which would definitely increase the costs of agricultural production and threaten the overall food security in Belize (IPCC, 2007).

Previous studies have shown that Climate Change may lead to yield reductions of sugarcane, citrus, beans, rice and maize (MNREI, 2011).

But apart from climate, non- climatic factors also need to be considered. For instance, the sugar sector in Belize suffers from a lack of investment and the need for modernization at the farm, processing and transport levels. Also, the costs of producing sugar cane are steadily increasing because of poor or non-existent farm drainage systems, lack of modern plant types, lack of harvesting machinery, and badly maintained roads that at times due to heavy rains and floods prevent collection trucks from reaching farms. After harvest, sugar cane is transported to the Belize Sugar Industry (BSI) mill by trucks owned or hired by the farmers. A lack of coordination results in large numbers of trucks converging at the mill creating lengthy queues which have a detrimental effect on the quality of the cane thereby affects the ability of the mill to produce high quality sugar.

3.4.1 Methodology

For the agriculture sector, the vulnerabilities of the sector to current climate conditions were first examined through a review of existing documents including the IPCC (2007), GEO Belize (2010), Environmental Statistics for Belize (2012) and Belize Second National Communication to the Conference of the Parties of the United Nations Framework Convention on Climate Change (2011) along with focus group meetings with technical experts in the Ministry of Agriculture and Famers Associations. Attempts to correlate and examine changing yields of the major crops, namely, sugarcane, rice and beans using the Decision Support System for Agrotechnology Transfer (DSSAT) crop model, the possible impacts of water shortages on citrus and bananas using the CROPWAT[1] model and trends from the literature on climate and non-climate factors (Hoogenboom et al., 2010; Jones et al., 2010).

Based on discussions with the relevant stakeholders (Ministry of Natural Resources and Agriculture: September - October, 2013), it was agreed that the crop simulations will be for the following locations/ stations and the crops: Sugarcane (Richmond Hill or Tower Hill in Orange Walk District); Rice (Blue Creek or Richmond Hill in Orange Walk District); Citrus (Melinda Forest Station in Stann Creek District); Banana (Maya King in Stann Creek District); RK Beans (Central Farm in Cayo District).

In order to evaluate crop yield changes caused by Climate Change, a comparison in crop yield simulations for a current (2003-2012) decadal period to crop yield simulations for a future (2060-2069) decadal period was made.

3.4.2 Simulation of Sugarcane Yield Changes

In the DSSAT simulations of annual sugarcane yields, the following planting-harvest cycle was used. For the first year of crop production, the sugarcane stalks were planted in October-November and harvested 15 to 16 months later, namely in January-March of the following year. For the second and following 10 to 12 years, the ratoon system, where the plant is considered as perennial, is used and the sugarcane is harvested 12 months later, namely in January-March. The

[1] CROPWAT is a computer program for the calculation of crop water requirements and irrigation requirements based on soil, climate and crop data. In addition, the program allows the development of irrigation schedules for different management conditions and the calculation of scheme water supply for varying crop patterns. CROPWAT can also be used to evaluate farmers' irrigation practices and to estimate crop performance under both rain fed and irrigated conditions.

sub-model used is CANEGRO[2] within DSSAT. The sugarcane crop is treated as rain fed; namely no irrigation. The row spacing used is 5 feet. The CO_2 fertilisation effect is held constant at 380 parts per million (ppm). The addition of nutrients and the effects of pests and diseases are not included in the crop simulations. The choice of cultivar is selected from within the DSSAT library and corresponds to the one closest to the varieties used under the new planting-harvest cycle (BBZ80240 and CD7121312) (Personal Communication: Mr. Saul Osorio - Field Supervisor: Sugar Industry Research and Development Institute (SIRDI), Orange Walk Town).

3.4.2.1 DSSAT-CANEGROW Simulations vs. Observed Data

At first, simulated data using ECHAM5 and HadCM3Q11 climate model data coupled with the DSSAT-CANEGRO crop model is compared with observed sugarcane production data, both as aerial biomass sucrose mass, for the Orange Walk District in the vicinity of the Tower Hill station for the current period, namely 2000-2009.

Table 19 shows that both yearly (1-10: 2000-2010) and mean values of simulated (ECHAM5 and HadCM3Q11) values of aerial dry biomass of sugarcane harvested (t/ha) matches very closely with aerial dry biomass of sugarcane harvested calculated in DSSAT with observed data for Tower Hill station (t/ha). In fact, mean and standard deviation (σ) statistics bear out these relationships. Mean observed (50 t/ha) aerial biomass harvested is very close to the DSSAT-CANEGRO/ECHAM5 (52.6 t/ha) and to the DSSAT-CANEGRO/HadCM3Q11 (49.0 t/ha) aerial dry biomass harvested.

Similarly, table 20 presents data on sucrose dry mass (sugar) production, also shows that both yearly (1-10: 2000-2010) and mean values of simulated (ECHAM5 and HadCM3Q11) values of sucrose dry mass of sugarcane harvested (t/ha) matches very closely with sucrose dry mass of sugarcane harvested calculated in DSSAT with observed data for Tower Hill station (t/ha).

Moreover, mean and standard deviation (σ) statistics again bear out these relationships. Mean observed (11.8 t/ha) sucrose dry mass harvested is very close to the DSSAT-CANEGRO/ECHAM5 (12.8 t/ha) and to the DSSAT-CANEGRO/HadCM3Q11 (11.9 t/ha) sucrose dry mass harvested.

3.4.3 Simulation of Rice Yield Changes

This section examines the changes in upland and irrigated rice yields between the current decadal period (2000-2009) and the future (2060-2069). The current decadal period was selected based on data availability. The site selected for the case study is the Blue Creek valley in Orange Walk District, the main rice-producing region in Belize. The station data used for the current observed climate was Tower Hill in Orange Walk District. Other rice farms can be found at Little Belize in Corozal District, Shipyard and Hillbank in Orange Walk District, Spanish Lookout in Cayo District, and at several locations in Toledo District.

Rice production in Blue Creek comes in two varieties: 1) upland farming (rain fed), where the regular fields are planted at the beginning of the rainy season around June-July and are harvested

[2] CANEGRO is a leading sugarcane crop simulation model and has been used extensively in agronomic research and management.

in September-October; and 2) irrigated rice farming, practiced mostly in lower-lying areas and are planted in December-January and harvested in April-May.

Table 19 - DSSAT-CANEGROW simulation of aerial dry biomass at harvest (t/ha) for sugarcane production in Orange Walk District with observed (Tower Hill Station) and modelled (ECHAM5 and HadCM3Q11) climatic data: 2000-2009.

Year	Observed	ECHAM5	HadCM3Q11
1	52.2	48.6	40.1
2	55.3	51.7	53.9
3	52.4	53.7	53.2
4	51.3	58.8	45.2
5	46.7	47.7	50.7
6	45.8	51.2	47.1
7	45.8	54.8	53.2
8	49.6	57.8	48.2
9	51.0	50.3	46.2
10	50.1	51.4	51.7
Mean	**50.0**	**52.6**	**49.0**
σ	**3.0**	**3.5**	**4.2**

Source: Singh et al., 2014

Table 20 - DSSAT-CANEGROW simulation of sucrose dry mass at harvest (t/ha) for sugarcane production in Orange Walk District with observed (Tower Hill Station) and modelled (ECHAM5 and HadCM3Q11) climatic data: 2000-2009.

Year	Observed	ECHAM5	HadCM3Q11
1	11.7	12.3	9.4
2	13.8	11.7	13.6
3	12.7	11.6	11.7
4	11.9	14.5	11.8
5	11.6	12.6	12.9
6	10.7	12.5	12.5
7	9.5	14.4	12.0
8	12.3	14.4	12.3
9	12.4	12.8	11.9
10	11.7	11.1	10.7
Mean	**11.8**	**12.8**	**11.9**
σ	**1.1**	**1.2**	**1.1**

Source: Singh et al., 2014

Circle R, a private company run by Mennonites and one of the largest rice farms in Blue Creek plants ~ 2,000 acres of irrigated rice, drawing water from the Rio Bravo River and ~ 1,500 acres of non-irrigated rice and supplies ~ 60 % of rice consumption for all of Belize. Yields of irrigated rice are normally 4,500 to 5,000 pounds per acre, whereas yields of rain fed rice are normally 3,000 to 3,500 pounds per acre (Jacob Neufeld of Circle R Mills: Personal Conversation).

Rice cultivation for both upland and irrigated rice is mechanical. Since the 1980s, about 25 farmers are involved in rice production in Blue Creek. Farmers in Blue Creek have historically planted the variety, Cypress, due to its superior grain characteristics. But in recent years, due to increasing disease pressure, they have imported the variety Cheniere from Louisiana which has better resistance to blast; therefore, requiring less fungicide to control the disease. Farmers in Blue Creek are growing more and more hybrids the past two years with Rice Tec products, XL753, XL723 and Clearfield XL745 making up the majority of the acres. The cultivar used was the IR43 variety in DSSAT CERES-RICE[3] which most closely matched the varieties used in Blue Creek (Robert Miller, Rice Tec, Texas, USA: Personal Communication).

In recent years, government policy aimed at controlling prices, namely crippling taxes on input for rice production, particularly fuel and electricity, have sent the average price of a pound of rice soaring from $0.85/lb. to $1.31 in 2012-2013. This conflict with the Government of Belize has caused one of the major rice growers in Blue River (Peter Dyck Rice Company) to temporarily shut down its operations (Amandala Newspaper, Sunday October 13, 2013).

3.4.3.1 DSSAT-CERES-RICE Simulations vs. Observed Data

At first, simulated data using ECHAM5 and HadCM3Q11 climate model data coupled with the DSSAT CERES-RICE model is compared with observed rice production data for upland rice for the Blue Creek valley in Orange Walk District in the vicinity of the Tower Hill station for the current period, namely 2000-2009.

Table 21 shows that both yearly (1-10: 2000-2010) and mean values of simulated (ECHAM and HadCM3Q11) values of upland rice harvested (t/ha) matches very closely with rice yields calculated in DSSAT with observed data for Tower Hill Station (t/ha).

A significantly low mean and standard deviation (σ) statistics bear out these relationships. Mean observed yields (11.8 t/ha) of rice harvested is very close to the DSSAT RICE-CERES/ECHAM5 (11.1 t/ha) and to the DSSAT CERES-RICE/HadCM3Q11 (11.3 t/ha) simulated rice yields.

Similarly, table 22 presents data on irrigated rice yields. The table show that both yearly (1-10: 2000-2010) and mean values of simulated (ECHAM5 and HadCM3Q11) rice yields (t/ha) matches very closely with observed (ECHAM5 and HadCM3Q11) values of rice yields (t/ha) (t/ha).

[3] DSSAT CERES-RICE model is normally used to simulate the seasonal yield with long term weather data and to establish relationships between weather variables and crop yield and forecast rice yield.

Moreover, very low mean and standard deviation (σ) statistics again bear out these relationships. Mean observed (13.7 t/ha) irrigated rice yields calculated in DSSAT with observed data for Tower Hill station are very close to the DSSAT CERES-RICE/ECHAM5 (12.8 t/ha) and to the DSSAT CERES-RICE/HadCM3Q11 (11.5 t/ha) simulated.

Table 21 - DSSAT- CERES-RICE simulation of upland rice yield (t/ha) for Blue Creek with observed (Tower Hill station) and modelled (ECHAM5 and HadCMQ11) climatic data: 2000-2009

Year	Observed	ECHAM5	HadCM3Q11
1	10.2	11.9	12.4
2	11.8	7.9	11.6
3	11.2	11.3	11.2
4	12.1	6.6	11.5
5	13.8	13.8	11.5
6	11.2	12.0	12.8
7	10.8	12.1	10.6
8	12.0	11.9	13.4
9	11.9	12.5	6.8
10	12.5	11.4	11.4
Mean	**11.8**	**11.1**	**11.3**
σ	**0.9**	**2.1**	**1.7**

Source: Singh et al., 2014

Table 22 - DSSAT- CERES-RICE simulation of irrigated rice yield (t/ha) for Blue Creek with observed (Tower Hill station) and modelled (ECHAM5 and HadCMQ11) climatic data: 2000-2009

Year	Observed	ECHAM	HadCM3Q11
1	13.9	13.0	11.2
2	14.3	12.4	11.3
3	14.7	12.0	12.5
4	13.5	13.6	10.8
5	13.2	12.1	11.2
6	13.2	12.5	12.2
7	13.9	12.7	12.0
8	12.8	14.1	11.8
9	13.2	13.0	11.1
10	13.8	12.2	10.9
Mean	**13.7**	**12.8**	**11.5**
σ	**0.6**	**0.6**	**0.6**

Source: Singh et al., 2014

3.4.4 Simulation of Citrus Yield Changes and Irrigation Requirements

This section examines the changes in citrus (oranges and grapefruit) yields between the current decadal period (2000-2009) and the future (2060-2069). The current decadal period was selected based on data availability. The site selected for the case study is the Melinda Forest station in Stann Creek District, one of the main citrus-producing regions in Belize.

The conditions for producing citrus in Belize are among the best in the Caribbean region. Citrus blooms in Belize are controlled by both rainfall and temperature. In Belize, oranges normally bloom twice each year. The first bloom usually occurs during December to January and the second during last week of May to June or after the start of the rainy season. Grapefruits usually bloom during February to March and then again during May to July. For oranges, the first bloom is triggered by temperature. Trees that are dormant in the cool December weather begin their bloom as the temperature rises. Citrus blooms occurring from April through July are induced by the rain since the trees undergo water stress due to the dryness of the March and April months.

In total, there are 43,000 to 45,000 acres of citrus in Belize, mainly in the Stann Creek, Toledo and Cayo Districts. Of this total area, ~ 38,000 acres are Valencia oranges (Rhode Red variety); and ~ 7,000 acres are Grapefruit (White Navel variety). There is a total of 591 citrus growers in all of Belize: 80 large growers account for 90 % of total citrus production and 511 small growers account for 10 % of total citrus production (Personal Communication: Mr. Luis Gabriel Tzul, Belize Citrus Growers Association, October 2013).

3.4.4.1 CROPWAT Simulations vs. Observed Data for Yield Reductions of Citrus

CROPWAT simulations of citrus yield changes (%) are limited to yield changes due to a lack of water at the rooting depth, whether from rainfall or irrigation.

At first, simulated data using ECHAM5 and HadCM3Q11 climate model data coupled with the CROPWAT crop model is compared with observed citrus yield reduction (%) data for the area in the vicinity of Melinda Forest station in Stann Creek District for the current period, namely 2000-2009. The current period (2000-2009), when using observed data, showed minimal yield reductions with a mean value of 1.1 %, due to lack of water.

3.4.5 Socio-economic Impacts

It is apparent from the foregoing that the agricultural sector of Belize would suffer mainly negative impacts from future (2060-2069) Climate Change. Yields of the major crops, namely sugarcane, rice, bananas, citrus and RK beans, are all expected to decrease. These decreases in crop yields would result from an increase in air temperature accompanied by higher evaporation rates, variable rainfall and increases or decreases in rainfall, depending upon the location in Belize.

3.4.6 Adaptation Options

It is expected that the agricultural sector of Belize will be seriously affected by future climate change. This creates the need to facilitate adaptation in the sector’s industry and markets, producer and rural development strategies, with the objective of reducing social and economic costs.

Adaptation to Climate Change needs to be seen as an iterative process, where the likely state of the climate will not be at a stable equilibrium, rather an ongoing transient process. Therefore, adaptation responses need to be viewed and shaped appropriately. At the centre of Climate Change, adaptation efforts are interventions aimed at enhancing adaptive capacity and stimulating adaptive actions.

Agricultural adaptation options are normally grouped according to four main categories that are not mutually exclusive: (1) technological developments, (2) government programs and insurance, (3) farm production practices, and (4) farm financial management.

Technological adaptations are developed through research programs undertaken by governments and research and development programs of private sector industries. The development of new crop varieties including types, cultivars and hybrids, has the potential to provide crop choices better suited to temperature, moisture and other conditions associated with Climate Change. This involves the development of plant varieties that are more tolerant to climatic conditions such as heat or drought through conventional breeding, cloning and genetic engineering. Technological adaptation options have been proposed in crop development, to increase their tolerance to Climate Change and variability; weather and climate information systems, to provide future seasonal weather forecasts; and resource management to deal with climate-related risks. Weather predictions over days or weeks have relevance to the timing of operations such as planting, spraying or harvesting. Farmers may use this information with respect to the timing of operations such as planting and harvesting, the choice of production activities such as crop varieties and the type of production, such as irrigation or dry-land agriculture (Bárcena et al., 2013; Ramirez et al., 2013).

Government programs involve financial management activities such as the use of crop insurance and agricultural subsidies. Crop insurance is very important when considering the effect of natural hazards on crop production and yields.

Farm production practices involve changes in farm operational practices, which may be stimulated or informed by government programs or industry initiatives. Farm production adaptations include farm-level decisions with respect to farm production, land use, land topography, irrigation, and the timing of operations. Changing farm production activities have the potential to reduce exposure to climate-related risks and increase the flexibility of farm production to changing climatic conditions. Production adaptations could include the diversification of crop varieties, including the substitution of plant types, cultivars and hybrids, designed for higher drought or heat tolerance and that have the potential to increase farm efficiency in light of changing temperature and moisture stresses. Altering the intensity of chemical fertilizers and pesticides, capital and labour inputs has the potential to reduce the risks in farm production to climate change, but may increase the cost of production (Bárcena et al., 2013; Ramirez et al., 2013).

Farm financial adaptation options are farm-level responses using farm income strategies, both government and private supported, to reduce the risk of climate-related income loss. Government agricultural support and incentive programs greatly influence farm financial management decisions. Farm financial adaptations involve decisions with respect to crop insurance and income stabilization programs (Bárcena et al., 2013; Ramirez et al., 2013).

However, these adaptation options may face a variety of challenges and barriers in Belize. These barriers to adaptation to Climate Change will include: economic resources, technical knowledge, and adaptive capacity in the agriculture sector. Climate Change may, therefore, present possible opportunities and priorities for the modernization of agriculture in Belize by enabling effective and proactive adaptation to Climate Change.

3.5 Fisheries Sector

The fishing industry of Belize has contributed significantly to the development of the country by providing direct employment to fisher folks and processing plant personnel. In addition, it has added to foreign exchange earnings strengthening the country's economy. The fishing industry is divided into two main sectors, namely, the wild capture fisheries and the aquaculture sectors. The wild capture fisheries sector is predominantly a small-scale fishery, which is carried out mainly within the shallow protected waters of the main Barrier Reef (reef flat and reef slope) including the three atolls (Turneffe, Glovers Reef and Lighthouse Reef atolls). The aquaculture sector contributes significantly to the employment and income of rural communities besides the generation of foreign exchange earnings. Additional benefits of shrimp farming and aquaculture development in Belize includes: business opportunities for ancillary services such as freight haulage, customs brokerage, and development of rural area. Currently, the aquaculture sector is divided into two areas: inland aquaculture and mariculture. Due to changes in policy, the Fisheries Department is responsible for mariculture whereas the Agriculture Department is responsible for inland aquaculture (for example shrimp farms, tilapia farms, etc.).

3.5.1 Fishermen Communities/Socioeconomic Importance

The fishing industry of Belize provides direct employment for 2,459 licensed fishermen. More than 50% of these fishermen are between the ages of 15 and 35 years and most originate from impoverished rural and coastal communities. Also, the fishermen cooperatives employ 102 fulltime employees and the aquaculture farms employs 562 employees who are responsible for processing, packaging and administrating the daily activities (Wade, 2010).

In most coastal and rural communities, young Belizeans have encountered reduced opportunities in recent times to pursue further education. Most of the fishers and plant workers are only equipped with a primary school education. In some instances, youngsters are removed from school to fish commercially with their fathers and brothers to supplement the family's income (Wade, 2010).

3.5.1.1 Total Number of Fishermen and Boats

Presently there are over 2,459 registered part-time and full-time fishermen and 560 registered fishing vessels that are involved in the fishing industry (table 23). The decrease in fishers since 2009 is a result of new regulations allowing persons to obtain sport fishing license from the Coastal Zone Management Authority.

Table 23: Belize licenses issued to fishers and boats (2003-2014)

TABLE OF ISSUED LICENSES												
Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Fishers	2009	1731	2026	2131	2110	2267	2759	2472	2582	2759	2496	2459
Boat	689	621	652	653	593	643	628	703	752	717	543	560

Source: Belize Fisheries Department, 2014

3.5.2 Climate Change Impacts on Fisheries

The effect of Climate Change and sea level rise on the fisheries sector of Belize will be mostly indirect. Fisheries require healthy fish habitats to survive and reproduce. Essential fisheries habitats in Belize include all types of aquatic habitats (Figure 32), namely mangroves, coral reefs and sea grasses where fish spawn, breed, feed, or grow to maturity. Rising sea levels could lead to partial or complete disappearance of these habitats through inundation. On the other hand, rising near-surface water temperature and increasing acidification may cause massive bleaching and dieback of coral reefs.

In view of the projected changes in sea level, ocean acidity and especially in air temperature, one can expect mostly negative impacts on the fisheries sector of Belize. On a global scale, the ocean warming is highest near the surface, and the upper 75 m warmed by 0.11 °C per decade over the period 1971–2010. Furthermore, ocean acidification as expressed by the pH of ocean surface water has decreased by 0.1 since the beginning of the industrial era, corresponding to a 26% increase in hydrogen ion concentration (IPCC, 2013).

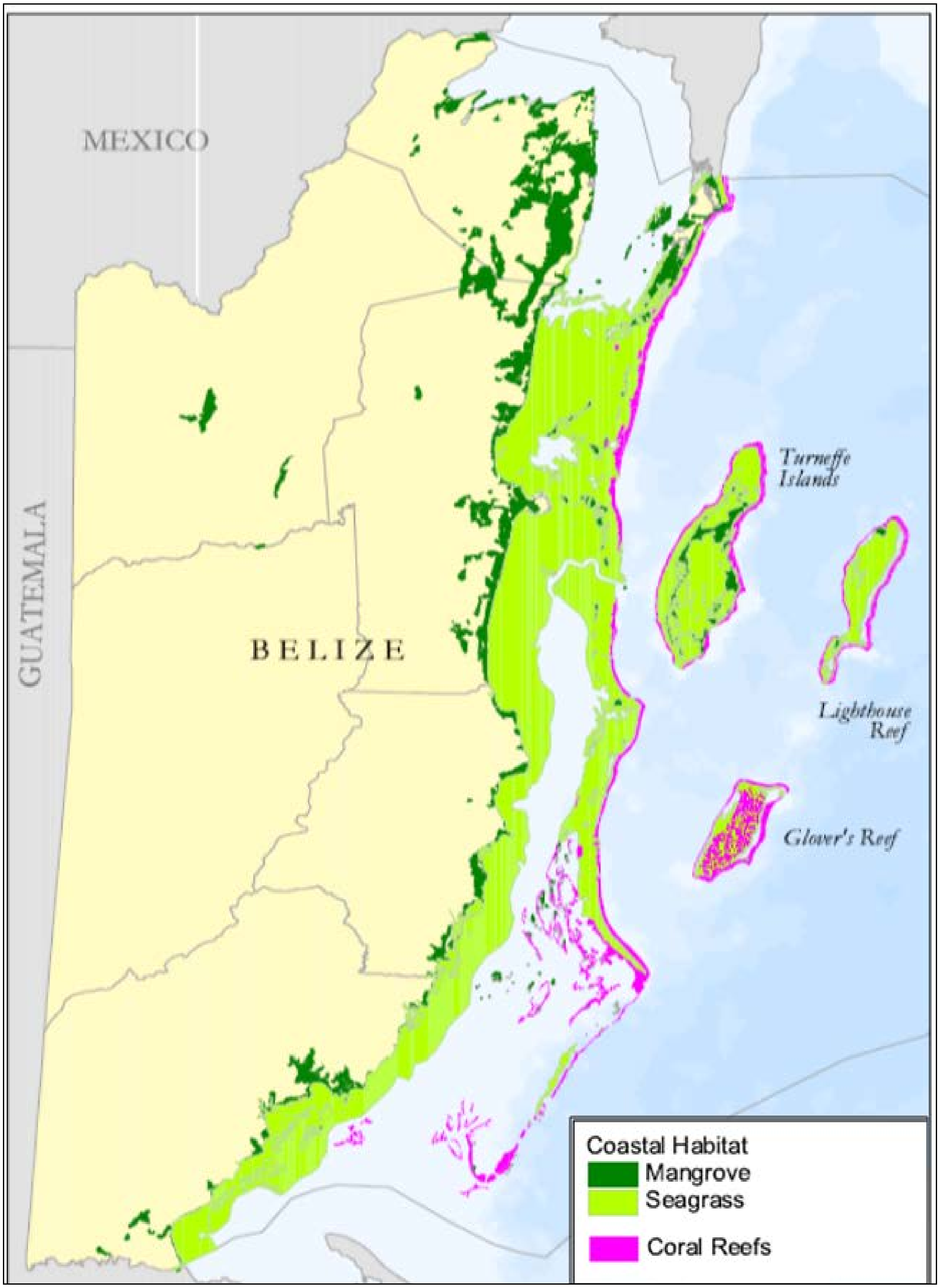

Figure 32: Belize's costal habitats

Source: LIC, 2006

3.5.2.1 The impacts of temperate rainfall on fishing zones

In this section, a comparison of current (2003-2012) and future (2060-2069) decadal temperature and rainfall for three locations were made in the major fishing zones of Belize, namely Ambergris Caye representing Zone 1, Belize City representing Zones 2 and 3 and Placencia representing Zones 3 and 6.

At first, examining the Ambergris Caye station the closest weather station to Zone 1, mean monthly near-surface air temperatures are expected to increase by > 1°C in all months of the year in the future (2060-2069). This would very likely also lead to warmer near surface ocean temperatures which can influence fish populations, fish varieties and zooplankton that provide food for fish. Mean monthly rainfall, that has less of an impact on fisheries are also expected to increase in general, especially in the high tourist months (November to May) and this may impact negatively on tourism fishing (Figure 33).

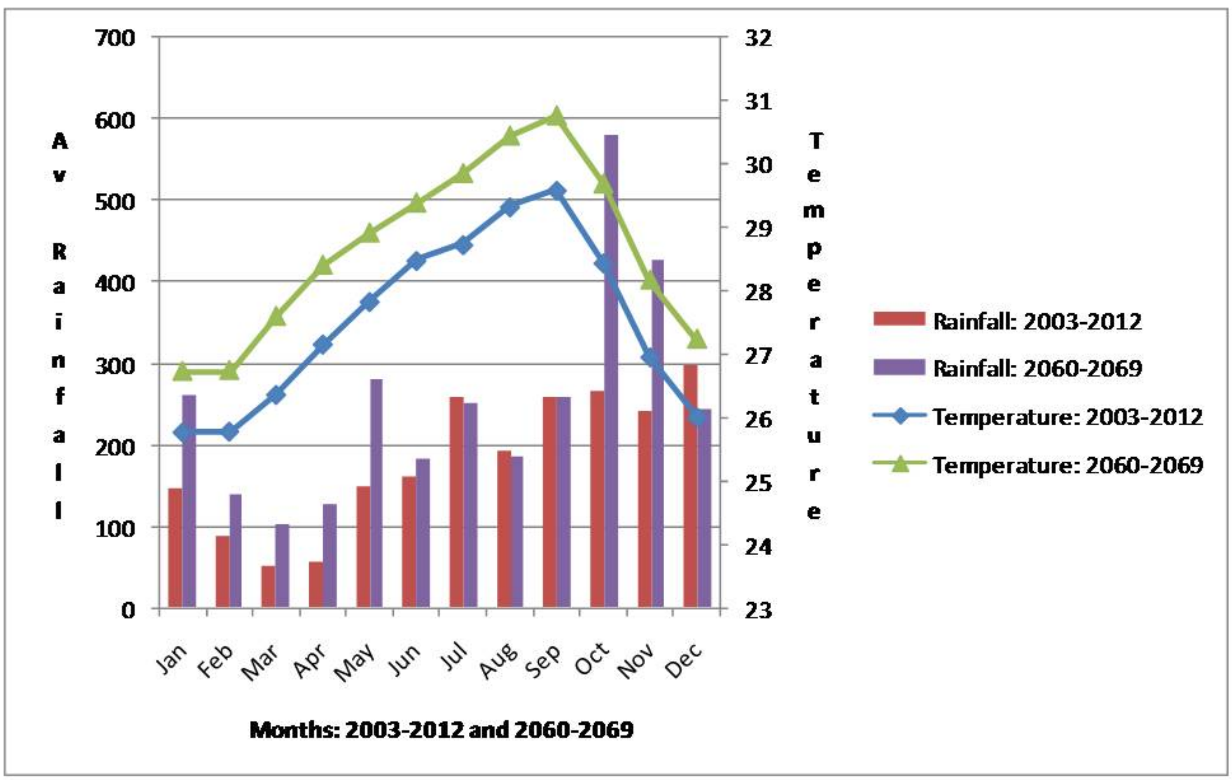

Figure 33 - Current (2003-2012) Mean Monthly Temperature (°C) and Average Monthly Rainfall (mm/month) for the Ambergris Caye area according to the ECHAM5 model data

Source: Singh et al., 2014

Next, examining the Belize City location (Zones 2 and 3), mean monthly near-surface air temperatures is expected to increase by ~1°C in all months of the year in the future (2060-2069). Mean monthly rainfall, that has less of an impact on fisheries are, however, expected to decrease in general and this may create increasingly favourable conditions for tourism fishing (Figure 34).

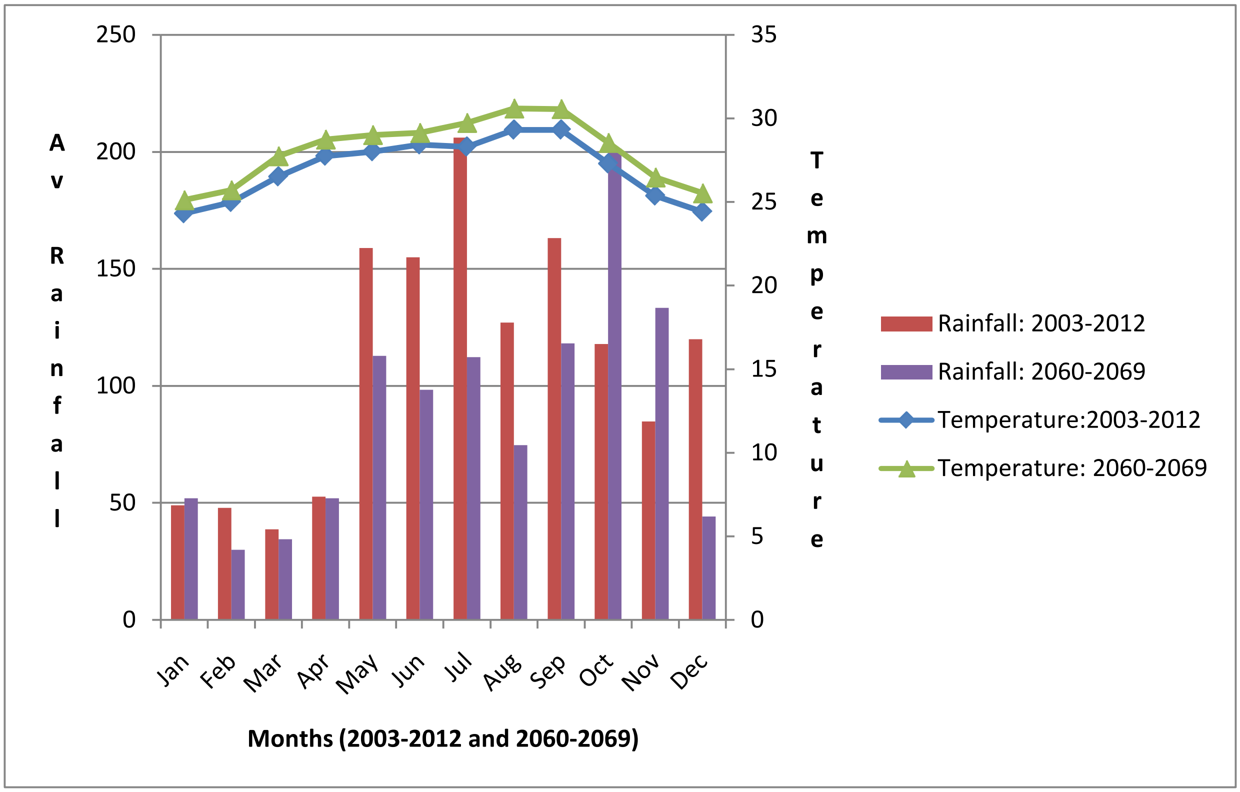

Figure 34 - Current (2003-2012) Mean Monthly Temperature (°C) and Average Monthly Rainfall (mm/month) for the Belize City area according to the ECHAM5 model data

Source: Singh et al., 2014

Finally, examining the Placencia location (Zones 3 and 6), mean monthly near-surface air temperatures is again expected to increase by > 1 ºC in all months of the year in the future (2060-2069). Mean monthly rainfall that has less of an impact on fisheries, however, does not change much except for the month of October, which is outside the main tourist season and would therefore have little or no negative impact on tourism fishing (Figure 35).

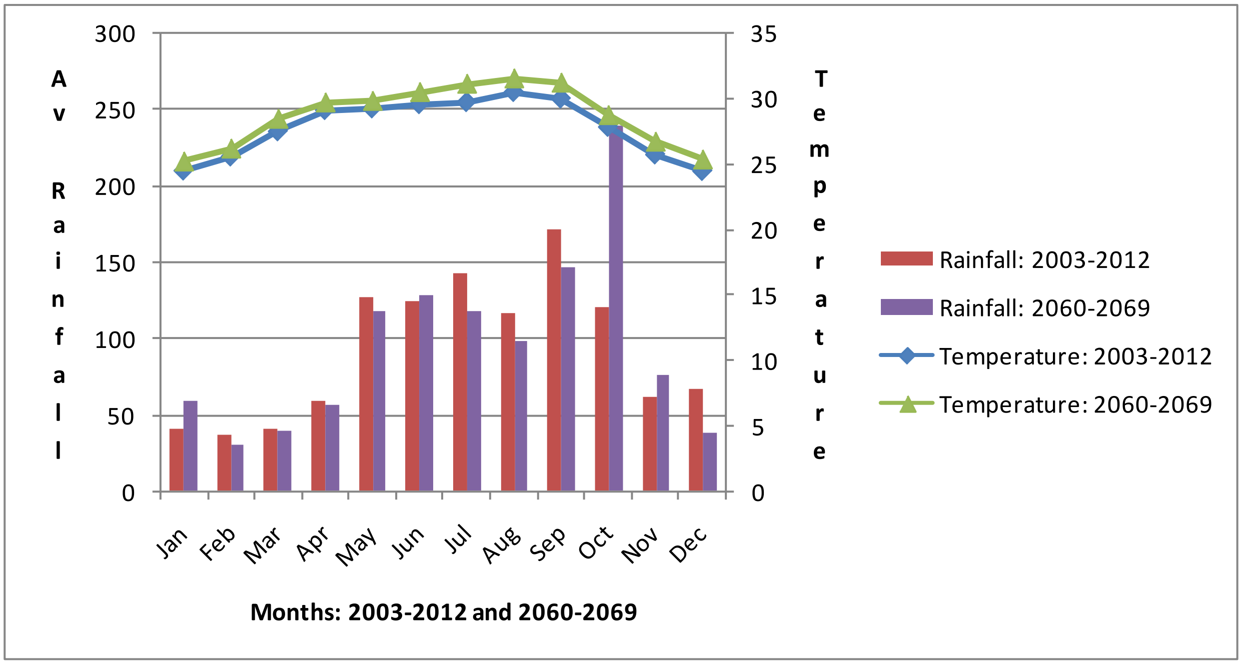

Figure 35: Current (2003-2012) Mean Monthly Temperature (°C) and Average Monthly Rainfall (mm/month) for the Placencia area according to the ECHAM5 model data

Source: Singh et al., 2014

3.5.3 Non-climate Factors

Fisheries stocks in Belize not only supply locals with an important food source but also generate income and livelihoods for fishermen. In addition, commercial fisheries have traditionally been important foreign exchange earners for many nations, particularly, coastal ones such as Belize. However, fish stocks in the Belize are overexploited. The largest pressure on Belize's fisheries' stocks is from overfishing, including illegal fishing. The fisheries production and exports data from recent years shows that there have been large-scale declines (GEO Belize, 2010).

Furthermore, the growing resident and tourist population will continue to place increased pressure on Belize's fisheries and that more opportunities for direct sales will be available making the enforcement of size regulations more difficult. In addition to the decline of large species like groupers, recent reports indicate that there is a great scarcity of apex predators such as sharks and rays (GEO Belize, 2010).

Employment, income and foreign exchange generation through capture fisheries will continue to decline if an adequate fisheries management regime is not implemented. It is likely that the role of aquaculture will continue to increase, perhaps eventually replacing capture fisheries. This, however, can add pressure to coastal ecosystems through land-use changes. Additionally, as long as there are still viable fisheries stocks, people will continue to fish legally or illegally. Therefore, apart from the economic losses, the health of the coastal and reef ecosystems may be lost as fisheries stocks decline beyond recovery (GEO Belize, 2010).

3.5.4 Recent Implemented Adaptation Measures

The Government of Belize has made various efforts to increase the resiliency of the Fisheries Sector. Some of the recent efforts taken are described below:

- The "National Replenishment Zone Expansion" initiative continues to be implemented by the Government of Belize in partnership with its NGOs, private sector stakeholders and partners. A draft map showing the proposed replenishment zones near shore and in deep sea areas has been developed and is awaiting endorsement for wider consultation with stakeholders. The project will seek to address economic alternatives for fisher folks through fisheries diversification, revision of strategies to address Climate Change. The project also facilitates the development of a marketing and communication strategy to socialize fishers about the initiative and to raise funds to implement the expansion of replenishment zones upon its endorsement.

- Through the Africa Caribbean Pacific (ACP) Fish II Program, the Fisheries Department drafted a new updated Bill and Subsidiary Regulations. The Government of Belize through the Solicitor's General Office of the Attorney General's Ministry is still reviewing the Fisheries Resources Bill and Regulations before its resubmission to Cabinet for approval.

- The Fisheries Department continues its partnership with the Environmental Defence Fund, Rare Conservation, Wildlife Conservation Society and Oak Foundation in the implementation of managed access and catch shares in Belize. Founded on the rights based approach to fisheries management, the pilot project within two of the marine reserves has been successful. It is envisioned that by the end of 2015 the roll out of manage access would be implemented nationally.

- Efforts to control the population of the Lionfish (*Pterois spp*.) in Belizean waters are still ongoing by the Fisheries Department in collaboration with the tour guide companies, fisher folks and other communities/groups. Eradication of lionfish is done regularly through hunts within marine reserves, dive tours and lionfish tournaments. The National Lionfish Management Plan, which was developed in previous years to aid in the control and eradication of the lionfish population was updated and adopted by the Fisheries Department in 2014.

- An initiative called the Marine Conservation and Climate Adaptation Project is a five-year project designed to implement priority ecosystem-based marine conservation and climate adaptation measures to strengthen the climate resilience of the Belize Barrier Reef System. The project will support improvement of the coral reef protection regime including an expansion and enforcement of Marine Protected Areas (MPAs) and replenishment (no take) zones in strategic locations to build climate resilience. The project will also build local capacity and raise awareness regarding the importance of the overall health of the reef ecosystem to its climate resilience and, consequently to community welfare as well as the growth prospect of the country's economy. Lastly, the project will provide additional support to the already established and ongoing coral restoration efforts in Southern Belize.

- The Belize Green, Clean, Resilient and Strong (2014-2024) National Environmental Policy and Strategy were developed through a consultative process with Public and Private Sector, Academia, Civil Society and Non-Governmental Organizations. The Strategy puts national focus on three areas: (i) Green Belize which proposes the transitioning of Belize to a Greener Economy; (ii) a Resilient Belize focuses on implementing disaster risk reduction and Climate Change adaptation; and (iii) a Strong Belize that focuses on strengthening environmental governance, transparency and institutions.

- The Forest Department is in the process of finalizing the National Forest Policy for Belize. Natural forest ecosystems including wetland and mangrove ecosystems are featured as areas of special interest. The Forest Policy focuses on integrated management of the forest ecosystems to ensure sustained provision of its goods and services. This requires integrating planning instruments such as, *inter alia*, the National Land-Use Policy and Implementation Framework, the Integrated Coastal Zone Management Plan and the Sustainable Tourism Master Plan. Upon finalization, the Forest Policy will be presented to Cabinet for official endorsement.

3.5.5 Recommended Adaptation Measures

Implement an appropriate Fisheries Management Policy as a measure to promote reef ecosystem resilience and fisheries sustainability in Belize. The resources for capture fisheries are already largely fully or overexploited in Belize. Measures need to adequately address overfishing and other human activities including rapid coastal zone development, land-based pollution amongst others that are negatively impacting the status and production of fisheries in Belize.

Climate Change adds another compounding influence on the fisheries sector of Belize. The vulnerability of fisheries and fishing communities to Climate Change in Belize will depend on their exposure to its physical and ecological impacts, the communities' dependence on the fishery and its sensitivity to physical effects, and the adaptive capacity of both the fishery and the community. Adaptive responses to Climate Change in fisheries could include (Grafton, 2010):

- management approaches and policies that further strengthen the livelihood asset base;
- improved understanding of the existing response mechanisms to climate variability to assist in planning adaptation;
- recognizing and responding to new opportunities brought about by Climate Change;
- monitoring biophysical, social and economic indicators linked to management and policy responses; and
- adoption of multi-sector adaptive strategies to minimize negative impacts such as instituting Government regulations on fishing seasons.

In contrast to capture fisheries, aquaculture is estimated to be the fastest-growing animal-food-producing sector in Belize. Adaptive responses in aquaculture include:

- the use of improved feeds, selective breeding for higher temperature tolerance strains to cope with increasing temperatures;
- shifting to more tolerant strains to cope with increased acidification ;
- better planning and improved site selection to take into account expected changes in water availability and quality including improved efficiency of water use in aquaculture operations; and
- integrated water use planning that recognizes and takes into account the water requirements and social and economic importance of fisheries and aquaculture in addition to other sectors;

It is important to note that in some near-shore locations like Placencia, there may be a need to shift property lines as the mean high water mark is displaced landwards by rising sea level (FAO Paper, 2009; Bell et al., 2011).

There are no simple, generic recipes for adaptation. But separate inter-related actions that could be taken to adapt fisheries and aquaculture in Belize to Climate Change could include (Bell et al., 2011):

- promoting economic development and transparent spending government revenue;
- maintaining the contribution of fish to food security; and
- maximizing sustainable livelihoods.

The use of Managed Access has been recently introduced and may help in promoting alternative livelihoods. Under this program, fishermen are expected to personally benefit from an increased in their individual production. This should provide the incentive for their commitment to comply and conform to the fisheries management measures being instituted in line with sustainable livelihoods and supporting bio-ecological stocks and ecosystems. It is expected that these initiatives will provide the necessary incentives to instil a greater sense of ownership of the fishery resource by the fishermen which bodes well for their commitment and support in restoring and maintaining the health and abundance of the stocks (Belize Fisheries Department, 2014; McConney et al., 2013).

Furthermore, actions and policies for adaptation in fisheries and aquaculture should also complement those for other sectors.

3.6 Tourism Sector

The tourism industry in Belize is developing at a fast rate, engaging a wide range of tourism operators and employing a significant number of Belize’s population in various activities and attraction (Figure 36).

Moreover, the tourism sector in Belize is one of the most important for the country’s economy. Belize’s tourism industry is the largest contributor to the GDP and the largest source of foreign exchange. Tourism was the largest income earner in 2005 and 2006, accounting for nearly BZ$350 and BZ$400 million in earnings, respectively. This equates to 16% and 17% of the GDP, respectively (BTB, 2012).

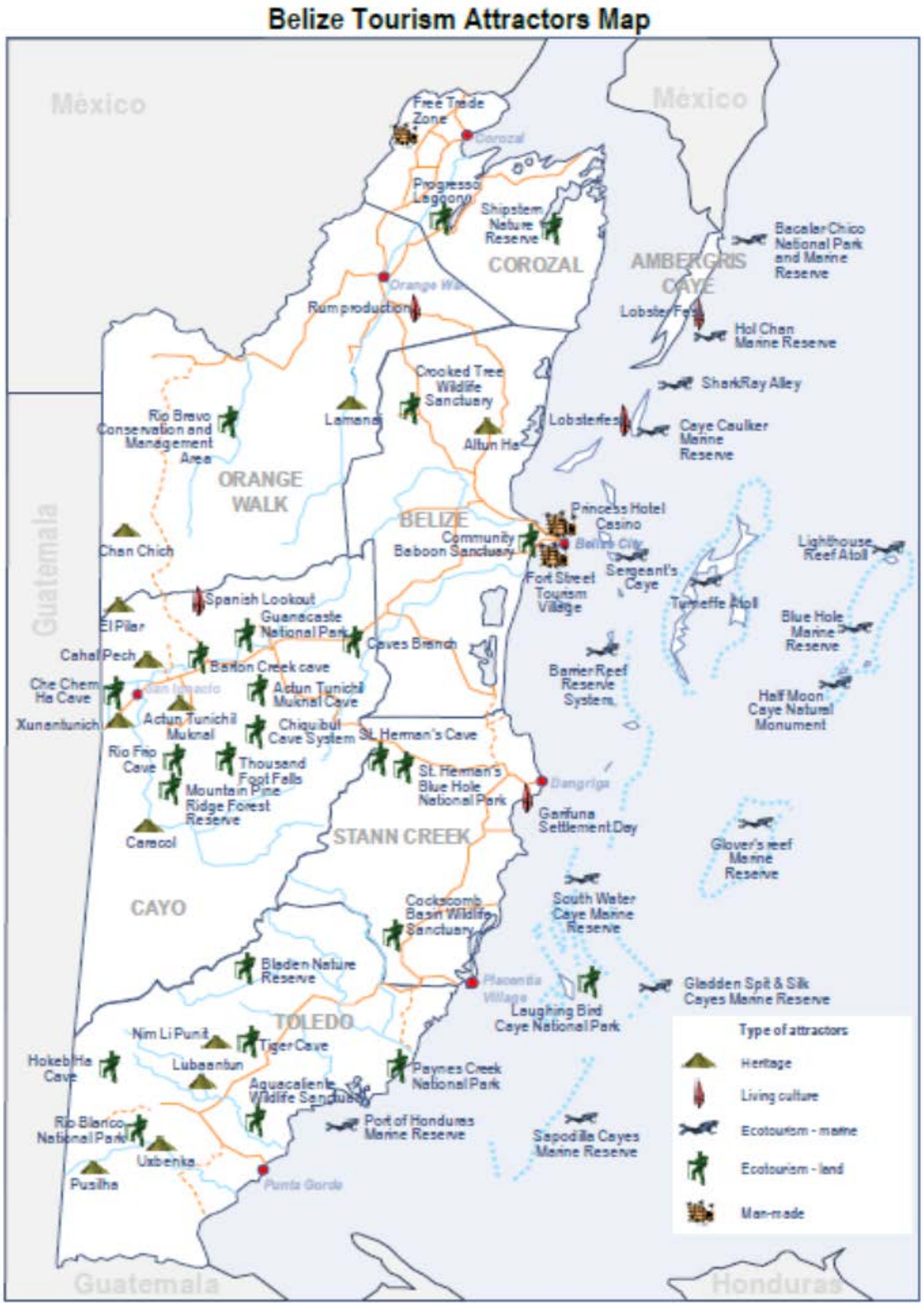

Figure 36 - Tourism Activities and Attractions in Belize

Source: Belize Tourism Board (BTB), 2012

A changing climate, along with sea level rise, would result in loss of beaches, properties and public infrastructure making Belize less attractive as a tourist destination.

Climate Change and climate-driven sea level rise will most likely have important and severe impacts on the tourism industry of Belize. Increases in air temperature of 2- 4°C towards the end of the century may make conditions unbearable, especially for the elder retired tourist population that makes up the majority of tourists visiting the country. Variability in precipitation that is also projected will very likely lead to extreme conditions such as increasing drought in the dry season, torrential rains and flooding in the rainy season and water and food shortages or higher prices if imported foods. Tropical storms and hurricanes compounded by sea level rise are also likely to increase in numbers and intensity. Apart from flooding and erosion of recreational beaches, they will also very likely cause flooding and damage to transport and other infrastructure.

These projected changes in climate will have indirect secondary and tertiary effects on supply-based and demand-based systems upon which the tourism industry of Belize is dependent. Supply-based systems include: loss of beaches, loss of coral reefs due to temperature-induced bleaching, loss of food supply chains and loss of coastal infrastructure. Demand-based systems on the other hand include change in weather conditions in countries of origin of tourists (mainly North America and Europe) and in host country, perception issues such as security from extreme weather events and pricing policies for transport, lodging and entertainment (Figure 37).

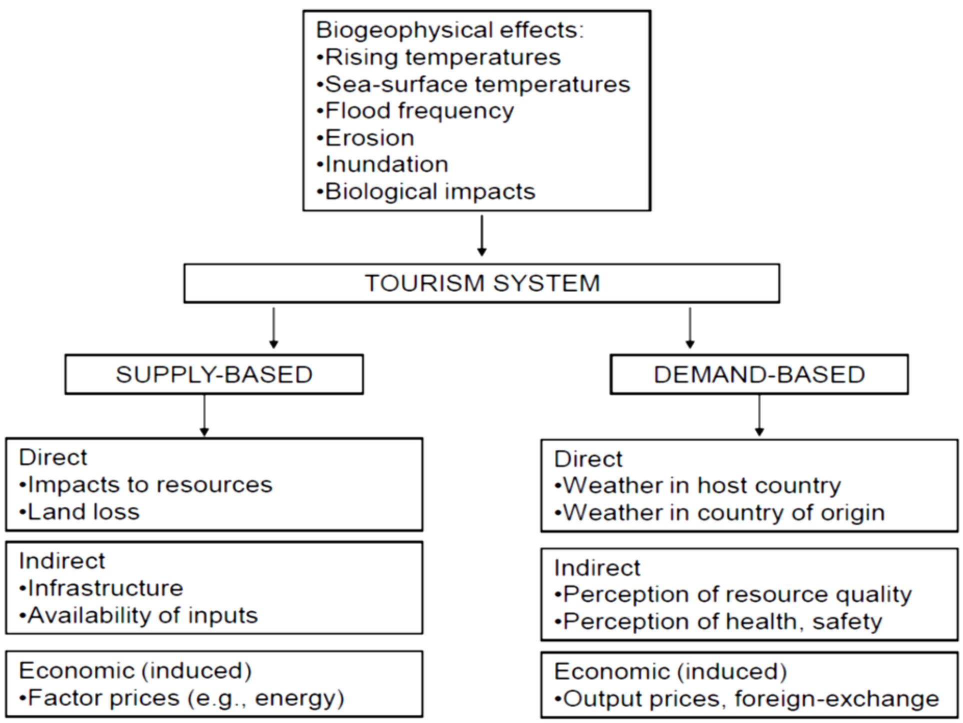

Figure 37: Tourism Sector Vulnerability Assessment

Source: Richardson, 2007

3.6.1 Belize City: Air Temperature and Rainfall

Air temperature in Belize City, as expected, does not seem to be a determining factor on the number of tourists visiting Belize under current climate conditions (2003-2012). Air temperature in Belize City fluctuates between ~ 25°C (December and January) and ~ 28°C (August and September). But the peak tourist season is from November to April, which is the dry hurricane-free season.

However, average monthly rainfall, as expected seem to be more influential as far as tourist arrivals at Belize City is concerned. Tourist arrivals at Belize City peak in the dry hurricane-free months of November to April. Of course, the other determining factor is that these months, namely November to April correspond to winter months in the countries of most tourists origins (the United States of America, Canada and Europe).

When looking at future (2060-2069) temperature (°C) conditions compared to current (2003-2012) conditions, using the ECHAM5/A1B projection, air temperature (°C) for the Belize City area is expected to increase by ~2°C. This may affect comfort levels of most tourists, especially the retired elderly population, who are most sensitive to excessive heat. Hotel operating costs and pricing for tourists may also increase because of a greater demand for energy to use for cooling.

This situation may have a negative impact on the tourism industry in Belize, in terms of the numbers of tourists wanting to visit Belize, particularly the interior regions such as Cayo District for tourist activities such as caving, hiking and visitations to the Mayan monuments. On the other hand, the Cayes and the coastal villages such as Placencia may not be impacted at the same magnitude.

However, when looking at future (2060-2069) rainfall (mm) conditions compared to current (2003-2012) conditions, according to the ECHAM5/A1B projection, monthly rainfall (mm) for the Belize City area is expected to change in both magnitude and phase. For the future period, mean monthly rainfall is expected to decrease by over 50 mm during the months of May to July. Nevertheless, the impact on tourism in Belize may be minimal since these months fall in the off-season. The negative impacts on tourism in Belize would be during the months of October and November, the beginning of the tourist season, when mean monthly rainfalls are expected to increase significantly (> 50 mm/month). These shifts in rainfall will, in all likelihood, be accompanied by a phase shift of the stormy season into November. This expected increase in rainfall and storms will delay the beginning of the tourism peak season, which would have major socio-economic consequences (Figure 38).

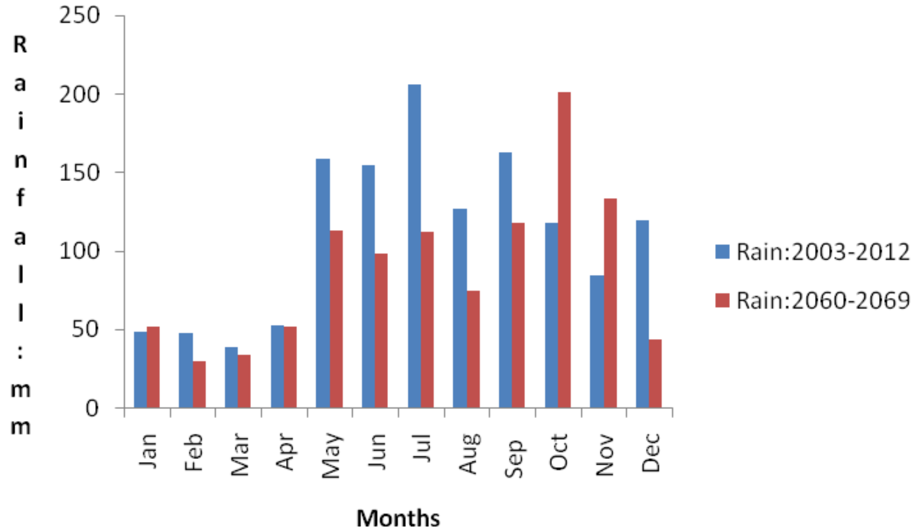

Figure 38 - Average monthly rainfall (mm) for the current (2003-2012) and future (2060-2069) periods according to ECHAM5/A1B for the Belize City area

Source: Singh et al., 2014

3.6.2 Ambergris Caye: Rainfall

Now, when looking at future (2060-2069) rainfall (mm) conditions compared to current (2003-2012) conditions, according to the ECHAM5/A1B projection, monthly rainfall (mm) for the Ambergris Caye area is also expected to change in both magnitude and phase. For the future period (2060-2069), compared to the current period (2003-2012), mean monthly rainfall is expected to increase in all months, except July, August, September and December, and even so the decreases are minimal. In October, future (2060-2069) mean monthly rainfall is expected to increase by over 300 mm/month, which is double the current (2003-2012) amount. Similarly, in November and January, mean monthly rainfall is expected to double their current (2003-2012) amounts of ~ 225 mm/month and ~ 150 mm/month, respectively (Figure 39).

These changes in both the timing and amounts of mean monthly rainfall and, in all likelihood, in the timing and intensity of stormy conditions, especially in October and November will delay and severely hamper the beginning of the tourism peak season. The latter will have major socio-economic consequences for the Ambergris Caye, one of the most popular tourist destinations in Belize.

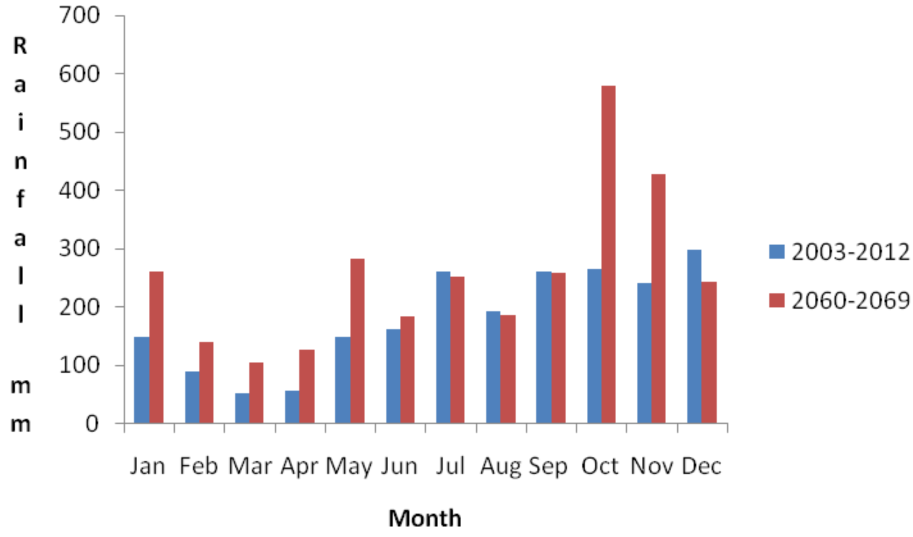

Figure 39 - Average monthly rainfall (mm) for the current (2003-2012) and future (2060-2069) periods according to ECHAM5/A1B for the Ambergris Caye area

Source: Singh et al., 2014

3.6.3 Placencia: Rainfall

For the Placencia area in the Stann Creek District, when looking at future (2060-2069) rainfall (mm) conditions compared to current (2003-2012) conditions, according to the ECHAM5/A1B projection, mean monthly rainfall (mm) is not expected to change. For the period 2060-2069 when compared to the current period 2003-2012, mean monthly rainfall is expected to increase significantly (by ~ 100 mm/month) only in the month of October, that is towards the end of the tourist off-season. But, in November and January, future (2060-2069) mean monthly rainfall is expected to increase slightly, compared to current (2003-2012) amounts of ~ 60 mm/month and ~ 40 mm/month, respectively (Figure 40).

These minimal changes in both the timing and amounts of mean monthly rainfall and intensities of stormy conditions should not hamper the peak tourism season, as was the case at Ambergris Caye and Belize City. This should have minimal socio-economic consequences for the Placencia area, one of the most popular tourist destinations in Belize. In fact, these conditions in the future may lead to a gravitation of tourist visits from the Ambergris Caye and Belize City areas to the Placencia area.

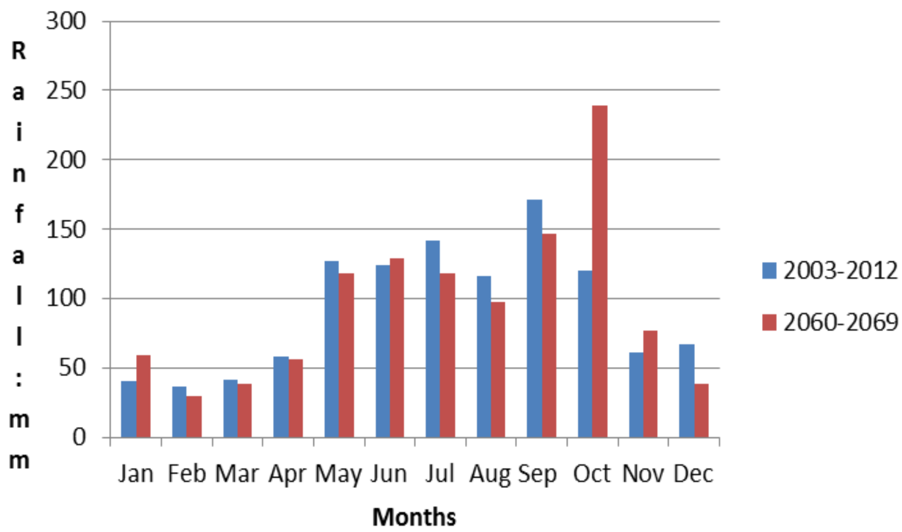

Figure 40 - Average monthly rainfall (mm) for the current (2003-2012) and future (2060-2069) periods according to ECHAM5/A1B for the Placencia area.1Sea Level Rise and Storm Surges

Source: Singh et al., 2014

As described above, sea level rise and storm surges, by-products of Climate Change would negatively impact Belize's tourism industry. Rising sea levels are expected to significantly affect coastal areas, especially the busiest tourist destinations such as Caye Caulker, Ambergris Caye and Placencia, which may experience a loss of land area through erosion, increased flooding, and increased threats to water supplies through salt-water intrusion.

3.6.4 Tourism Sector Adaptation to Climate Change

It is evident from the data and discussions above that the tourism industry of Belize, a major contributor to the economy, would face serious challenges and risks in the future on account of Climate Change, climate-driven sea level rise and storm surges. It is therefore incumbent on the managers of the tourism industry in Belize to begin to shape policies and integrate them into Government plans to adapt to the negative impacts of Climate Change. Furthermore, adaptation planning in this sector should also consider the expansion and diversification of tourism activities. These plans should be comprehensive including short-term, medium-term and long-term adaptation plans taking into account the vulnerabilities of the tourism industry to the adverse effects of Climate Change and sea level rise.

Within the tourism sector, plans to promote and expand the sector through promotional policies exist, but within these plans, there is little focus on building the sectors resiliency to Climate Change and its adverse effects. Nonetheless, knowingly or not, the country has engaged in some adaptation measures such as the construction of sea defences to protect against beach losses and coastal erosion. For example, sea walls are being erected haphazardly around Belize City, Caye Caulker and Ambergris Caye, but the design and integrity of these structures remain questionable as to its effectiveness since the structures are generally one meter high or less. Based on the results shown above, these structures would be easily overtopped by storm surges. It should also be taken into account that these hard structures can exacerbate the loss of beaches that is already occurring in Ambergris Caye, Caye Caulker and around Belize City. This is because these rigid structures lead to the transportation of beach sand resulting from wave action along the coast; this process is referred to as long shore drift. To counteract these hard structures, the installation of soft defences such as the planting of mangroves amongst others should be considered. One example of a soft defence that has proven it to be most effective nationally is the use of palmetto trunks that act as a barrier along beaches causing the dissipation of wave energy while at the same time retaining most of the sand during backwash; thereby, maintaining the integrity of the beach (Figure 41). This was done at both Placencia and Monkey River.

Figure 41 – Use of palmetto trunks to address beach erosion by dissipating wave action and promoting the accretion of beaches in Placencia and Monkey River

Source: Singh et al., 2014

3.7 Human Health Sector

Public health depends on sufficient food, safe drinking water, secure shelter, good social conditions and a suitable environment for controlling infectious diseases. The basic requirements for good health are clean air and water, sufficient food and adequate shelter; each of these conditions is very likely to be affected by future climatic changes (Heslop-Thomas et al., 2008; Leary et al., 2008a; Martens, 1996).

Climate Change will lead to higher levels of some air pollutants, an increasing number of extreme weather events, increasing outbreaks and transmission of diseases through unclean water and contaminated food, and will threaten agricultural production in some of the poorest countries such as Belize. Furthermore, Climate Change will also bring new challenges to the control of infectious diseases. Many of the major chronic diseases are highly sensitive to temperature and rainfall, including cholera and other diarrheal diseases, as well as vector borne diseases including malaria, dengue and schistosomiasis (WHO, 2012). Malaria and Dengue Fever (DF), two diseases linked to Climate Change, have become major public health problems in Belize in the recent past, although malaria seems to be under control.

3.7.1 Climate and Health

Reports of climate disasters are partly due to population growth in high-risk areas, such as the coastal zone including the Cayes, where the majority of the population inhabits. It is very likely that Climate Change is also a contributing factor and more people are placed in the path of weather-related disasters. At the same time, Climate Change has driven extreme high temperatures and has probably contributed to more frequent and extreme precipitation events and more intense tropical cyclone activity. Together, these trends will increase weather-related hazards to human health.

3.7.2 Health Impacts of Climate Change

In view of the fact that climate is already significantly correlated to human health and well-being, it is expected that Climate Change will further strengthen this relationship. Certain vector-borne diseases such as dengue and malaria, respiratory diseases such as asthma and water borne diseases such as cholera and dysentery may become more acute and prevalent in the future with Climate Change. Important determinants of vector-borne disease transmission include: vector survival and reproduction, the vector’s biting rate and the pathogen’s incubation rate within the vector organism. Vectors, pathogens and hosts each survive and reproduce within a range of optimal climatic conditions: temperature and precipitation are the most important, while sea level rise, wind, and daylight duration are also important (Lindsay and Birley, 1996; Martens, 1996).

However, this study focused on two of the most common vector-borne diseases, namely dengue and malaria. Based on available data (2004-2012) for all districts of Belize, it appears that in the case of malaria, recent years have shown a downward trend which indicates that the disease may be under control or eliminated in all districts. On the other hand, there has been an overall increase in the incidence of dengue (Figure 42).

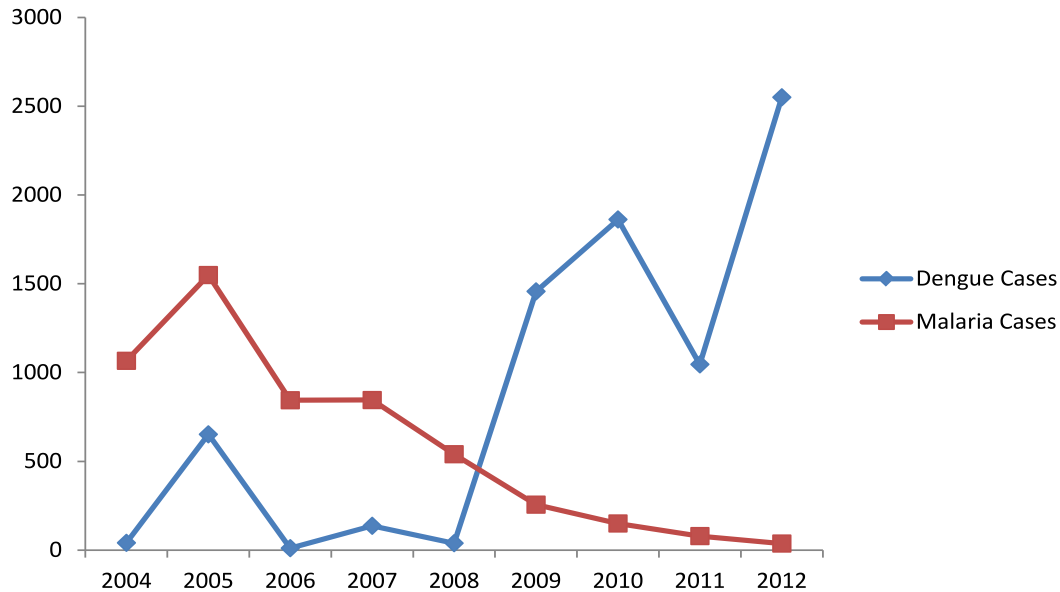

Figure 42 - Trends in the number of reported cases of Dengue Fever and Malaria by District, 2004 – 2012

Source: Belize Ministry of Health, 2013

3.7.3 Dengue Fever

In this section, the relationship between dengue fever and changing climate conditions is examined. There has been a recent increase in the incidence of DF in the Caribbean and the temperature increases expected from Climate Change may exacerbate this condition (Chadee et al., 2007; Taylor et al., 2008).

When focusing on the monthly incidence of dengue cases, over a three-year span (2010, 2011 and 2012) for which data is available, it is evident that the total number of dengue cases has been decreasing for the Districts of Belize: from a total of 483 cases (2010) to 182 cases (2011) to 139 cases (2012). The monthly incidences of dengue cases were also found highest in the Belize and Cayo Districts (Belize Ministry of Health, 2013; Singh et al., 2014) (Tables 24, 25 and 26).

Furthermore, it is evident, using the year 2011 as an example for Belize and Cayo Districts, that there is a close relationship between monthly rainfall and the monthly incidence of dengue – (Belize Ministry of Health, 2013) (Figure 43). Air temperature also plays a role since an increase in air temperature may lead to a shortening of the incubation period of the mosquito larvae and an earlier presence of mosquitoes in the environment.

This correlation between rainfall and the incidence of dengue diseases in Belize as seen in Figure s 65 and 66, show that the highest incidence of dengue cases are in the rainy season, namely July to November. However, there is normally a lag of about one month between peak rainfall (June to October) and peak incidence of dengue (July to November).

Table 24 – Relationship between monthly rainfall and incidence of dengue (rapid test-positive) for all districts of Belize, 2010

Month	District of Residence							
	Corozal	Orange Walk	Belize	Cayo	Stann Creek	Toledo	Unknown	Total
Jan	0	0	3	2	2	0	0	7
Feb	0	3	3	6	1	4	0	17
Mar	0	5	2	7	4	2	0	20
Apr	0	0	1	4	1	0	0	6
May	0	2	0	3	1	0	0	6
Jun	0	1	2	49	1	0	0	53
Jul	0	4	26	25	5	0	0	60
Aug	1	2	55	13	0	0	0	71
Sep	0	3	134	11	2	1	3	154
Oct	2	1	49	8	2	1	1	64
Nov	0	0	10	2	1	1	0	14
Dec	0	0	9	2	0	0	0	11
Total	3	21	294	132	20	9	4	483

Source: Belize Ministry of Health, 2013

Table 25 - Relationship between monthly rainfall and incidence of dengue (rapid test-positive) for all districts of Belize, 2011

Month	District of Residence							
	Corozal	Orange Walk	Belize	Cayo	Stann Creek	Toledo	Unknown	Total
Jan	0	0	2	0	0	0	0	2
Feb	0	0	0	4	1	0	0	5
Mar	1	0	0	1	0	0	0	2
Apr	0	0	0	0	0	0	0	0
May	0	0	3	0	0	3	0	6
Jun	0	0	1	3	0	1	0	5
Jul	0	0	6	5	0	1	0	12
Aug	0	0	8	12	1	2	0	23
Sep	0	0	5	6	1	5	0	17
Oct	0	2	14	18	1	4	1	40
Nov	1	2	21	10	0	5	0	39
Dec	1	0	21	8	0	1	0	31
Total	3	4	81	67	4	22	1	182

Source: Belize Ministry of Health, 2013

Table 26 - Relationship between monthly rainfall and incidence of dengue (rapid test-positive) for all districts of Belize, 2012

Month	District of Residence							
	Corozal	Orange Walk	Belize	Cayo	Stann Creek	Toledo	Unknown	Total
Jan	0	0	8	9	1	14	0	32
Feb	0	0	17	28	1	1	0	47
Mar	0	0	3	25	1	1	0	30
Apr	1	0	1	20	0	0	0	22
May	0	0	0	0	0	2	0	2
Jun	0	0	0	0	0	0	0	0
Jul	0	0	0	0	0	0	0	0
Aug	0	0	2	0	0	0	0	2
Sep	0	0	0	0	0	0	0	0
Oct	0	0	2	0	0	0	0	2
Nov	0	0	0	0	0	0	0	0
Dec	0	0	2	0	0	0	0	2
Total	1	0	35	82	3	18	0	139

Source: Belize Ministry of Health, 2013

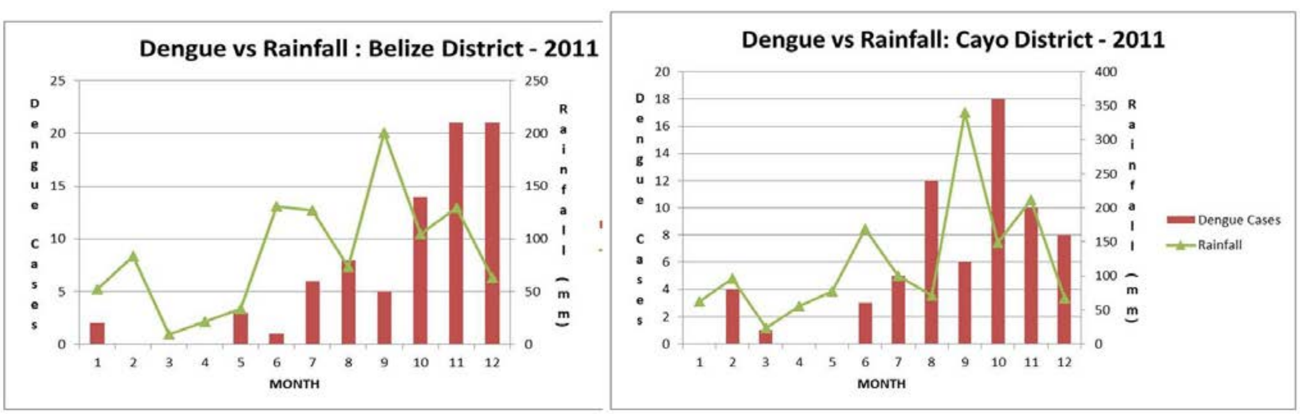

Figure 43 - Relationship between monthly rainfall and the monthly incidence of dengue (rapid test-positive) for the Belize and Cayo Districts, 2011

Source: **Belize Ministry of Health, 2013**

3.7.4 Climate Change and Incidence of Dengue

In view of the fact that the incidence of the dengue disease seems to be strongly correlated with lagged one month rainfall, based on available data, changes in climate, namely rainfall and how it would affect the incidence of dengue were examined. Available data on the annual incidence of dengue was compared with the total annual rainfall (mm) for a current decadal period (2003-2012) and the total annual rainfall for a future decadal period (2060-2069) from the ECHAM5 model for all Districts of Belize. The climate data point selected were close to the largest population centres in each District, namely, Belize City in Belize District, Orange Walk Town in Orange Walk District, Belmopan in Cayo District, Dangriga in Stann Creek District and Punta Gorda in Toledo District.

At first, when examining Belize District there is little or no relationship in the trends between current (2003-2012) total annual rainfall (mm) and number of dengue cases. However the number of dengue cases generally increases steadily from 2005-2010. Furthermore, total annual rainfall (2060-2069) is projected to decrease in all years. But the number of dengue cases increased significantly starting in 2009 (Figure 44). Based on the assumption that the incidence of dengue is related to rainfall amounts, then one would expect the number of cases of dengue to decrease in the future (2060-2069) in Belize District (Figure 44).

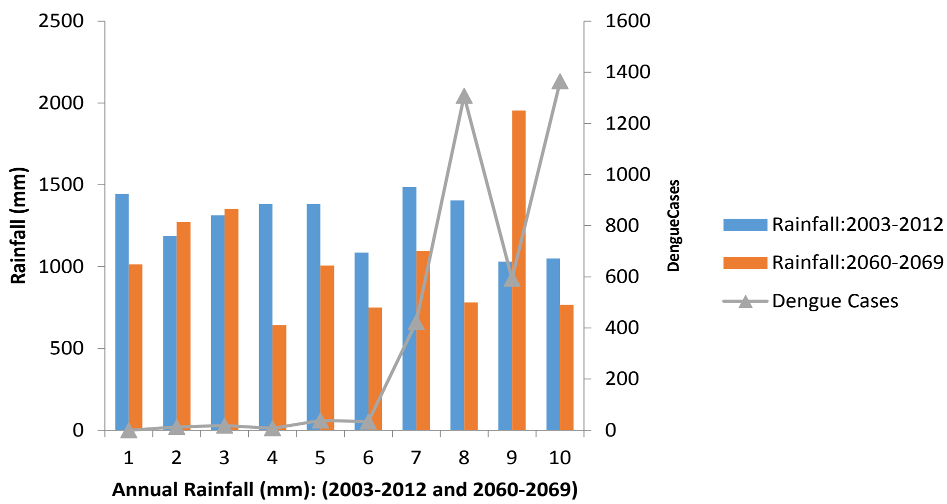

Figure 44 - Number of dengue cases and total annual rainfall (mm) for the current (2003-2012) and future (2060-2069) for Belize District

Source: Singh et al., 2014

Next, when examining Orange Walk District, there is also little to no relationship in the trends when comparing current (2003-2012) total annual rainfall (mm) and number of dengue cases. However, the number of dengue cases peaked in 2007 and again in 2010. Furthermore, total annual rainfall (2060-2069) is projected to increase in all years. Again, based on the assumption that the incidence of dengue is related to rainfall amounts, then one would expect the number of cases of dengue to increase in the future (2060-2069) for Orange Walk-Corozal Districts (Figure 45).

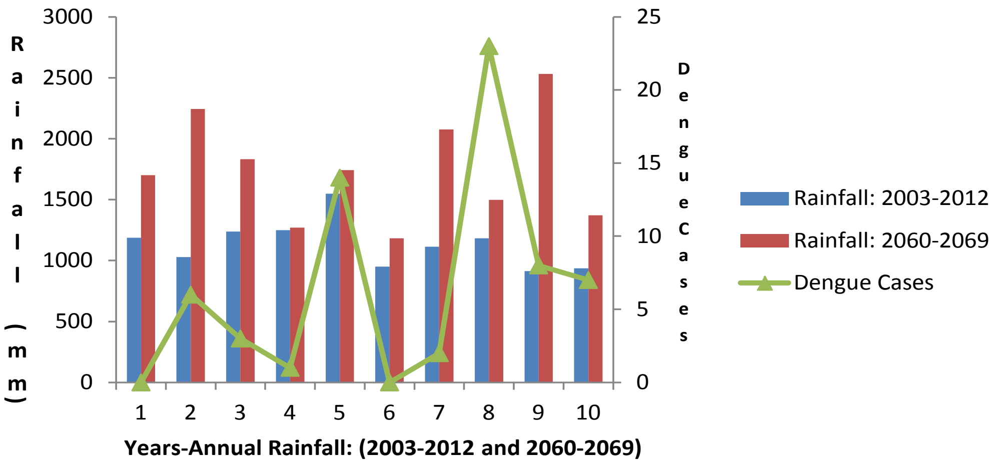

Figure 45 - Number of dengue Cases and total annual rainfall (mm) for the current (2003-2012) and future (2060-2069) for Orange Walk District

Source: Singh et al, 2014

When examining Cayo District, yet again there is little to no relationship between current (2003-2012) total annual rainfall (mm) and number of dengue cases. Also, the number of dengue cases is generally low but for some reason peaked at > 600 cases in 2005 and 2012 and even > 700 cases in 2009. Furthermore, total annual rainfall (2060-2069) is projected to decrease in all years. Assuming then that the incidence of dengue is related to rainfall amounts, then it can be expected that the number of cases of dengue will decrease in the future 2060-2069 period in the Cayo District (Figure 46).

Next, by examining Stann Creek District there is again little to no relationship between current (2003-2012) total annual rainfall (mm) and number of dengue cases. However, the number of dengue cases generally fluctuates from year to year but shows an upward and increasing trend from 2009-2012. Furthermore, total annual rainfall (2060-2069) is projected to increase in all years in the future, except 2063, 2065 and 2066. Based on the assumptions then that the incidence of dengue is related to rainfall amounts, then one would expect the number of cases of dengue to generally increase in the future 2060-2069 period in the Stann Creek District (Figure 47).

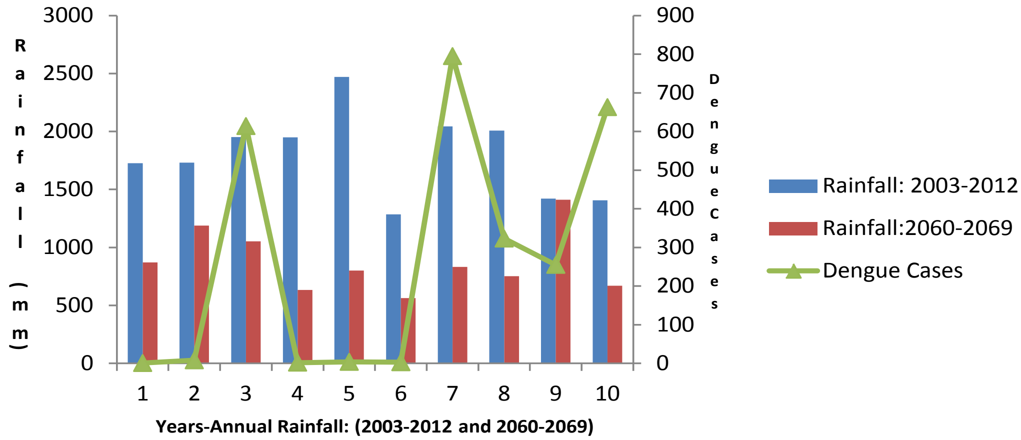

Figure 46 - Number of dengue cases and total annual rainfall (mm) for the current (2003-2012) and future (2060-2069) for Cayo District

Source: Singh et al., 2014

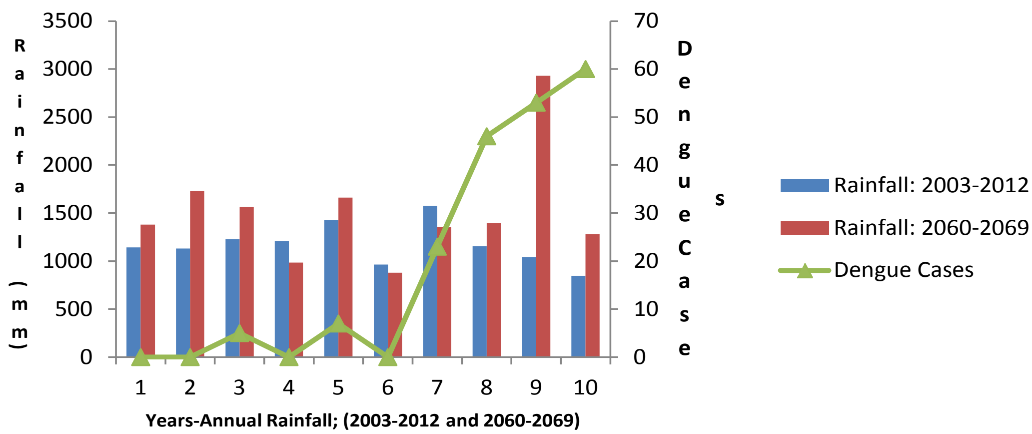

Figure 47 - Number of dengue cases and total annual rainfall (mm) for the current (2003-2012) and future (2060-2069) for Stann Creek District

Source: Singh et al., 2014

Finally, when examining Toledo District, it also shows little to no relationship between current (2003-2012) total annual rainfall (mm) and number of dengue cases. However in general, the number of dengue cases increases steadily from 2008-2010. Moreover, total annual rainfall (2060-2069) is projected to generally decrease in all years, except 2061 and 2064. Assuming that the incidence of dengue is related to rainfall amounts, then one would expect the number of dengue cases to generally decrease in the future 2060-2069 period in Toledo District (Figure 48).

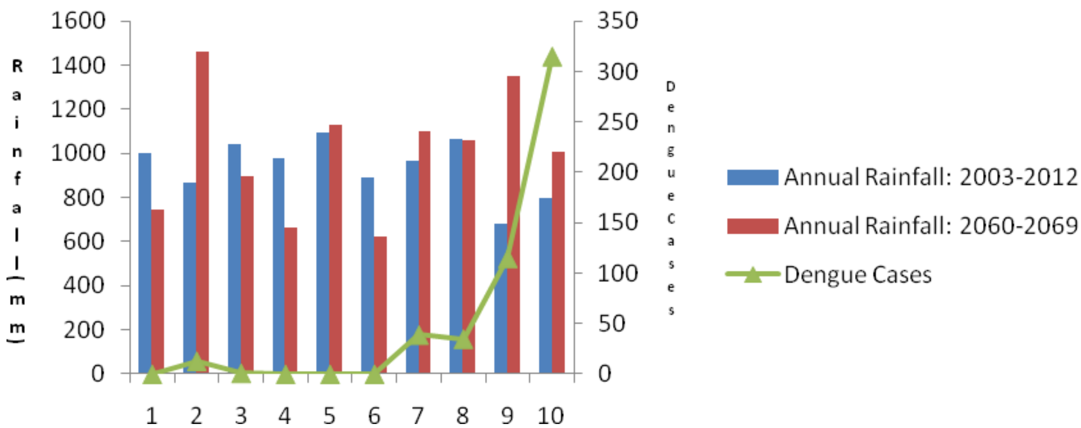

Figure 48 - Number of dengue cases and total annual rainfall (mm) for the current (2003-2012) and future (2060-2069) for Toledo District

Source: Singh et al., 2014

3.7.5 Climate Change Adaptation in the Health Sector

Adaptation options for the health sector in Belize include both climate and non-climatic factors. These adaptation measures are likely to include: a greater understanding of current and future incidence of diseases; control of vectors (mosquitoes) for diseases (malaria, dengue); stagnant water control measures and sanitation improvements in areas where houses are built in swampy locations; caring for the most vulnerable population at risk such as the elderly, infants and young children and the economically disadvantaged groups; lifestyle changes such as eating healthier foods to maintain good health, improved health care and access such as health alerts including more ambulances with more rapid response times, and more health care centres and hospitals with adequate professional staff.

The global public health community has a wealth of experience in protecting people from climate sensitive hazards. Many of the necessary preventive actions to deal with the additional risks of Climate Change are already clear (IPCC, 2007; Leary et al., 2008a; Martens, 1996; Lindsay and Birley, 1996). As a matter of fact, health impacts of Climate Change will be determined by both Climate Change and non-climatic factors such as, the quality of the environment, health care available and the health condition of the population. In fact, environmental risk factors play a role in more than 89 % of diseases reported (WHO, 2012).

It is evident then that adaptation has to follow a holistic path by integrating adaptation measures across sectors. There is a need for additional investment to strengthen key health functions and for forward planning to address the new challenges posed by Climate Change. This additional investment should include an increase in the capacity of the health system to extend services and continuity of care to both mobile and remote populations. Further, reinforcing health vulnerability and risk assessment, multi-sectoral disaster risk reduction, health emergency preparedness, early warning, and health action in emergencies can help to ensure that people are better protected from the increasing hazards of extreme weather and help communities recover faster following a disaster. This approach will need to strengthen the health coordination, health emergency management systems, early warning systems related to health incidences resulting from Climate Change, and interventions to control tropical diseases. The investment in hospitals, health facilities and other infrastructure should be protected from the long-term effects of Climate Change. Renewed emphasis should be placed on primary health care, and improving the environmental and social determinants of health, from provision of clean water and sanitation, to enhancing the welfare of women, especially in emergency situations (WHO, 2012).

Strengthened surveillance and control of infectious diseases can protect people's health well-being from local to global scale outbreaks. Effective disease surveillance and control become even more important under conditions of rapid environmental change and movement of people, disease vectors and infections. Rapid and accurate disease notification, in compliance with the International Health Regulations is essential for planning disease control. Approaches such as Integrated Vector Management, which make the best use of proven interventions, such as bed nets, insecticide spraying and environmental management, to control malaria, dengue and other vector-borne tropical diseases, are required to protect against the effects of Climate Change (WHO, 2012).

There is great potential for using meteorological information to enhance early warning and effective response over a range of time scales, from hours or days (for example for flood warnings), to weeks (for seasonal epidemics of vector-borne disease), to months (seasonal forecasts of precipitation anomalies allowing planning for flooding or drought) or to years (for drought and associated food insecurity). Also, there is a need for improved institutional arrangements to ensure that the roles of meteorological, humanitarian, health and other agencies are well-defined, that climate information products are demand driven, user friendly and relevant for operational decision making in health and other sectors, and that there is sufficient capacity for operational response.

Local public health interventions to build community resilience are also crucial. Action on environmental and social determinants of health is critical to protecting populations from Climate Change in both emergency and non-emergency situations. For example, scaling up water and sanitation services and disinfection at the household level would immediately reduce diarrhoea and, at the same time, lessen the health impacts of decreasing and more variable water supplies before and during emergencies.

Implementing community-based participatory approaches to empower local communities to manage disease vectors in an integrated manner; thus, increasing their capacity to protect their health will contribute to increased climate resilience. The use of Larvicide and ULV-Melathaion for controlling the Aedes mosquito that dengue and insecticides such as deltamethrin in repeated cycles for controlling the Anopheles mosquito which causes malaria is already producing very positive results in Belize, especially in the case of malaria, which is now almost completely eradicated (Belize Ministry of Health, 2013).

The benefits of such interventions are already several times greater than the costs, and the threat of Climate Change makes these preventive health measures an even more judicious investment. Improving social welfare in emergency situations, particularly educating and empowering women in developing countries such as Belize, is a fundamental requirement for improving health. It is also essential to strengthening community resilience to disasters and to Climate Change (WHO, 2012).

Furthermore, adaptation policies and forward planning, both short-term and long-term, including an enabling environment will be required to assess and cope with the threats posed by Climate Change and enhance capacity to deal with public health emergencies. This approach will need to strengthen the health coordination, health emergency management systems, early warning systems related to the health consequences of climate change, and interventions to control tropical diseases. The investment in hospitals, health facilities and other infrastructure should be protected from the long-term effects of Climate Change. Renewed emphasis should be placed on primary health care, and improving the environmental and social determinants of health, from provision of clean water and sanitation, to enhancing the welfare of women, especially in emergency situations (WHO, 2012).

All adaptation measures are designed to build the resilience of nations and communities to disasters and negative health impacts attributable to Climate Change through awareness raising, capacity building on interventions and relevant research (WHO, 2012).

However, these adaptation measures would need to be implemented by examining policies to facilitate the transformation process and need to be supported by policy, institutional and legal frameworks.

3.8 Cross-cutting Sector

The most recent IPCC V&A Assessment Reports on Climate Change indicated that countries that contain extensive low-lying coastal zones, as Belize where a significant percentage of the population is located, are likely to be among those most vulnerable to the adverse impacts of Climate Change (IPCC, 2007; 2013). In fact parts of the low-lying coastal zone of Belize, especially around Belize City, is already protected from sea inundation by a system of sea walls and other defences. The IPCC Assessment Reports (2007; 2013) and other similar reports point to a number of vulnerabilities that low-lying coastal zones in Small Island Developing States (SIDS) face in regards to Climate Change and variability, including vulnerability due to their size and limited resource base, vulnerability to existing weather events such as heavy rainfall, dry-season drought, tropical storms and storm surges, and restricted economic opportunities that are being exacerbated by globalization and trade barriers. Though there is more than ample space in the interior of Belize, economic resources and poor soils for agriculture make displacement to the interior difficult.

It is now widely recognized that Climate Change and global warming due to anthropogenic GHG emissions is one of the most pressing environmental concerns today. Low-lying coastlands, such as Belize, are highly vulnerable to Climate Change and sea level rise because of their low elevation and limited adaptive capacity.

The preceding sections on Climate Scenarios, the Coastal Zone, Water Resources, Agriculture, Fisheries, Tourism, and Human Health all focused on how future (2060-2069) Climate Change affect:

- vulnerabilities of these sectors and human livelihoods that are likely to be most critically impacted upon to current climate variability and future Climate Change;
- difficulties or barriers to adaptation in critical areas or sectors; and
- opportunities, positive and adverse impacts, and priorities for adaptation.

3.8.1 Methodology: Cross Linkages

Given the availability of data and resources, the methodologies used in the cross-cutting sector of the study used matrix tables, based on qualitative relationships criteria to indicate synergies between sectors study so as to assess cumulative or reduced impacts and vulnerabilities.

The essential components of this integrated approach incorporate:

- interactions and feedback between multiple drivers and impacts;
- policy options and some indication of costs, when available;
- cross-sectoral interactions; and
- integration of climate with other non-climatic drivers and stakeholder discussions.

3.8.2 Integration of Sectors/Cross-cutting Issues

For the coastal zone of Belize, for instance where representation of all sectors are found and are inter-linked, Climate Change impacts and vulnerabilities are not expected to occur in isolation. Non-climate factors such as population centres, linkages between sectors, for example, the link between sea level rise and excessive rainfall and flooding in the low-lying coastal zone and the subsequent impacts on agriculture, tourism and human health and settlements should also be taken into consideration.

It is evident from the separate sectors reports that Climate Change and sea level rise would affect all sectors considered, namely the coastal zone, water resources, agriculture, fisheries, tourism and human health (Table 27). The potential threats of Climate Change and sea level rise and storm surges along the coastal zone will be particularly acute due to the fact that a significant percentage of Belize's population resides within the coastal zone which is also the area where the most suitable soils for the cultivation of crops has been identified.

Table 27 - Cross-linkages between the targeted sectors

SECTORS	Climate Sea Level	Coastal Zone	Water	Agriculture	Fisheries	Tourism	Health
Climate - Sea		XX	XX	XX	XX		X
Coastal Zone	XX		XX	XX	XX		X
Water	XX	XX		XX	X		XX
Agriculture	XX	XX	XX		X		XX
Fisheries	XX	XX	X	X			XX
Tourism	XX	XX	XX	XX	XX		XX
Health	X	X	XX	XX	XX	X	

LEGEND - X: Significant Impact XX: Very Significant Impact

Source: Singh et al., 2014

3.8.3 Adaptation

It is clear that Climate Change and sea level rise will critically impact the coastal zone; the area where most of the population, infrastructures, fertile soils and agricultural lands are located. This zone also supports and contains the bulk of fisheries and tourist activities.

The Government of Belize should therefore urgently pursue finances from the UNFCCC Adaptation Fund to revitalize and upgrade its coastal protection infrastructures, including drainage and irrigation, since these measures will go a long way in promoting adaptation in other key sectors such as agriculture, water resources, tourism, and even humans- settlements and human health (well-being).

Another social component of adaptation to Climate Change and other stressors is the promotion of sustainable alternative livelihoods for vulnerable peoples such as fishermen. A good example of such an initiative is the Sustainable Natural Resources-based Livelihoods (SNRL) project in Belize funded by the Japan Social Development Fund (JSDF) and World Bank (WB). The project provides methodologies, instruments, procedures and responsibilities for environmental management to be applied by the Belize Enterprise for Sustainable Technology (BEST), the implementing agency, in order to ensure that potential environmental impacts are prevented or mitigated. It is developed in the context of the existing national legislative framework, WB safeguard policies and existing best practices for the sectors involved (BEST, 2013).

The Sustainable Natural Resources-based Livelihoods Project will address the issues of natural resource degradation that results from overexploitation and misuse. The objective of the project is to promote viable and sustainable natural resource-based livelihoods for poor communities in Belize, thereby reducing anthropogenic pressures, such as Climate Change, on the key natural resources through (1) support for social mobilization, facilitation, and community co-management, (2) development of community-based sustainable livelihoods of non-timber forest products in and around the selected protected areas, (3) support for innovative models of green livelihoods of fishing communities through mariculture development, and (4) community-led natural resources vigilance and knowledge dissemination (BEST, 2013).

3.9 Summary and Conclusions

From the previous sector reports, it is apparent that the country of Belize will be very susceptible to Climate Change, sea level rise and extreme storm surges.

Furthermore, the coastal zone of Belize, where a significant percentage of the population is located and where the most of agricultural production takes place, is for the most part below the high tide level. This places the coastal zone in a very precarious position with regards to climate-driven sea level rise, especially when augmented by storm surges. The cross-linkages between the coastal zone, agriculture, fisheries and by extension tourism and human health are thus very strong. Therefore, adaptation measures designed to protect the coast will also address these inter-linked sectors.

The agriculture sector report also recognized that agricultural production, especially of sugarcane, would also be negatively affected, primarily due to decreasing yields on account of more frequent and prolonged droughts. This emphasizes the cross-linkages between Climate Change, water resources and agriculture.

The water resources sector would also be affected by extreme and variable rainfalls leading to flooding and droughts, thereby affecting agriculture, limiting industrial activity, including tourism, and commercial and domestic activities. Adaptation measures then in the water sector will go a long way in addressing concerns in the agriculture, tourism and health sectors.

Finally, the health sector will also be at risk as the incidence of diseases (such as dengue fever and malaria) can be expected to increase on account of warmer temperatures, variable and excessive rainfalls causing flooding and promoting the proliferation of disease vectors such as mosquitoes. Inundation due to sea level rise and storm surges or excessive rainfall and flooding may also lead to injury and even loss of life. Food security and nutrition may be threatened due to risk posed to the agriculture sector.

The next steps should include, amongst others: cumulative impacts of Climate Change and sea level rise and how certain vulnerable groups may be affected in the short and medium term development and implementation of policy instruments such as National Adaptation Plans (NAPs) and the National Climate Change Policy, Strategy and Action Plan (NCCPSAP) to move this process forward.

3.10 References

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4 POLICIES AND MEASURES PROMOTING GREENHOUSE GAS EMISSIONS REDUCTION AND CLIMATE CHANGE ADAPTATION

Belize has made significant efforts to fulfil the objectives of the Convention, despite not being required to take on quantitative commitments for reducing GHG emissions as a Non- Annex I Party to the UNFCCC. These efforts have been seen in the form of appropriating and creating new policies, designing projects and programmes geared towards GHG emissions abatement and adapting to the negative impacts of Climate Change to bolster a low carbon development, climate resilient pathway.

In 2015, the Government of Belize adopted its first National Climate Change Policy, Strategy and Action Plan (NCCPSAP). Since the publication of its First National Communication (INC) to the UNFCCC, the Government of Belize (GOB) has sought, through several line ministries, to initiate policy-based activities, at the sector level, to address (adapt and mitigate) the impending impacts of Climate Change. Some of the key ministries identified are the Ministry of Forestry, Fisheries and Sustainable Development (MFFSD), the Ministry of Natural Resources and Agriculture (MNRA), the Ministry of Energy, Science and Technology and Public Utilities (MESTPU), and the Ministry of Finance and Economic Development (MFED).

4.1 Policy Measures supporting Adaptation and Mitigation

4.1.1 National Climate Change Policy, Strategy and Action Plan 2015-2020

National Climate Change Policy, Strategy and Action Plan (NCCPSAP) is to serve as a Road Map for all governmental entities in Belize to guide the development and implementation of adaptation and mitigation policies and programme in their respective portfolios. The various components of this document briefly detailed below.

4.1.1.1 National Climate Change Policy

The goal of the National Climate Change Policy is to guide the short, medium and long-term processes of adaptation and mitigation of Climate Change in accordance with national prospects for sustainable development in addition to regional and international commitments. This policy shall ensure an integrated and well-coordinated approach to Climate Change adaptation and mitigation by fostering the development of appropriate administrative and legislative mechanisms in alignment with national sectoral policies and adaptation plans. The policy will further provide guidance to mainstreaming along a low emission development, climate-resilient pathway by focusing on the reduction of anthropogenic emissions of GHGs as well as taking measures to adapt to Climate Change. The objectives of the National Climate Change Policy are to:

1. Integrate Climate Change adaptation and mitigation into key national developmental plans, strategies, laws, regulations and budgeting.
2. Build Climate Change resilience in order to prevent, reduce or adapt to the negative impacts of Climate Change on key sectors, economic activity, society and the environment through policies and strategic processes.
3. Promote capacity building and networking across all implementing/involved agencies in

addition to securing adequate financing over the short, medium and long term periods for effective and timely adaptation and mitigation responses.

4. Capitalize on opportunities currently available through the Climate Change negotiation processes that can also enhance the development prospects of the nation.
5. Ensure that all national sectors are adequately prepared to address the negative impacts of global Climate Change.
6. Encourage the private and public sectors to invest in Climate Change adaptation and mitigation initiatives by providing economic incentives.
7. Enhance diplomatic and negotiating capacities to better address Climate Change concerns and interests on the regional and international stage.
8. Promote the development of efficient and relevant institutional mechanisms that will enhance the planning and response capacity to Climate Change.

4.1.1.2 National Climate Change Strategy

Taking into consideration the guiding principles, vision, goals, and objectives which inform the National Climate Change Policy articulated in the NCCPSAP, the GOB will seek to have this Policy implemented through the adoption of a strategy which is consistent with the overall goal of the GSDS 2014-2017. In addition, the strategy should encourage the use of new economic and financial mechanisms including National Appropriate Mitigation Actions (NAMAs) and markets. It should also encourage the development of instruments to facilitate public-private sector partnership, research, innovation, development and adjustment to climate technologies and strengthening of capacities, as well as ensuring that policy makers, negotiators and civil society have access to relevant and best available scientific information for decision-making. In addition, it will also seek to encourage the development of the country's Intended Nationally Determined Contributions (INDCs) and communicate it to the UNFCCC.

The implementation of this policy and action plan shall be coordinated by the NCCO in the Ministry of Forestry, Fisheries and Sustainable Development (MFFSD) which is the National Focal Point for the UNFCCC and the Kyoto Protocol to which Belize is a signatory. Given the multitude of sectors likely to be impacted by Climate Change and the cross-cutting sectoral responses in adapting to and mitigating the impacts, several agents and agencies, in both the public and private sectors will be called upon to assume responsibility and assist in the implementation of the action plan by designing and adopting relevant sectoral policies, and strategic plans to ensure adequate adaptation and mitigation measures are executed to achieve the national goals of low carbon development resilient to Climate Change.

In coordinating the implementation of the NCCPSAP, the NCCO shall have regard to the need to:

a) provide adequate support on Climate Change adaptation and mitigation measures to stakeholders in the public and private sectors, and at the community level;
b) monitor the impact of the strategy against the goals and objectives that have been set; and,

c) adjust the policy and strategy in light of intended or unintended changes in the general environment.

An integrated and inclusive approach to Climate Change management is therefore needed to ensure the implementation of robust and comprehensive strategies and actions. Such an approach should be consistent with international and regional commitments stemming from obligations arising from various multilateral agreements (e.g. UNFCCC, Kyoto Protocol and Liliendaal Declaration) and membership in regional organisations (e.g., CARICOM and SICA). It must also be cross-sectoral and multidisciplinary in nature, addressing both adaptation and mitigation measures. This approach shall allow the country to transition strategically to low-carbon economic development while bolstering its resilience to the effects of Climate Change.

4.1.1.3 National Climate Change Action Plan

The Climate Change Action Plan is a five-year programme (2015-2020) to build the capacity and resilience of the country to meet the challenges of Climate Change. The Action Plan is divided into two thematic areas namely adaptation and mitigation. The choice of these two thematic areas is based on the fact that the country has, in its First and Second National Communications to the UNFCCC, identified a number of sectors, namely, coastal zone, human settlement, fisheries and aquaculture, agriculture, forestry, tourism, water, energy and health as national priorities for Climate Change mitigation and adaptation efforts.

The primary aim of mitigation initiatives is to reduce greenhouse gas sources and emissions and enhance greenhouse gas sinks. In Belize, like most SIDS, GHG emissions are relatively small, but commitments to international treaties as well as opportunities to benefit from associated mitigation initiatives (reduced deforestation and energy conservation) has prompted their inclusion in the development of the NCCPSAP. Agriculture, Land-use, Land use Change and Forestry sector, though usually considered prime areas for Climate Change adaptation are also known to be contributors to GHG emissions and will require the development of policy initiatives to reduce such threats. The energy and transportation sectors, because of the benefits to be derived through the pursuit of sustainable energy and low-carbon development initiatives, will also require policy initiatives which seek to limit emissions of GHGs. The sectors for which adaptation and mitigation strategy and action plans will be addressed are listed below:

- Agriculture
- Forestry
- Fisheries and Aquaculture
- Coastal and Marine Resources
- Water Resources
- Land use and Human Settlements
- Human Health
- Energy
- Tourism
- Transportation
- Solid Waste

4.1.1.4 Institutional Framework

The cross cutting nature of Climate Change means that several sectors not only are exposed to the impacts of climate variability and sea level rise, but also have a role to play in the management of policies being designed to address the problems identified. In recognition of this imperative, the GOB established, in 2009, the Belize National Climate Change Committee (BNCCC) and in 2012 a pro-tem National Climate Change Office (NCCO) in the Ministry of Forestry, Fisheries and Sustainable Development (MFFSD), with the assigned responsibility of coordinating the country's national, regional and international response to Climate Change and ensuring the development of a consistent framework across line ministries and agencies for mitigating the effects of Climate Change. The NCCO is also charged with the responsibility of coordinating Belize's external response to the various reporting and other requirements of UNFCCC and attracting or sourcing funds to support the national effort.

The BNCCC, which is Chaired by the Chief Executive Officer of the MFFSD, is comprised of three Sub-Committees: (i) Vulnerability and Adaptation, (ii) Mitigation, and (iii) Public Education and Outreach, with a total membership of twenty-three, primarily governmental institutions, though it does have representation from the private sector and civil society.

Even though the NCCO was established, it is recognized that there are several institutions whose functions and ministerial responsibilities are critical for the effective implementation of Climate Change abatement measures (Table 28).

The responsibilities assigned to the various Ministries/Agencies stems, in some cases are from their statutory mandate for example: Department of the Environment (DOE), Fisheries Department, Forestry Department, and the Land Utilization Authority. In other cases, it relates to their Ministerial responsibility such as energy, agriculture, roads and works, housing, tourism, etc. Some Government Departments and agencies (Tourism, Health, Municipal bodies, and Coastal Zone) having recognized the extent to which climate variability and Climate Change is impacting the respective resource sector. Recognizing this they have started to work with the NCCO to ensure that Climate Change adaptation and mitigation measures are incorporated into their revised policies and plans.

Table28: Ministries, Agencies and Climate Change Management Functions

Ministry	Key Agencies	Key Functions
Ministry of Fisheries, Forestry and Sustainable Development	• Department of the Environment • Forestry Department • Fisheries Department • National Climate Change Office • Sustainable Development Unit • Coastal Zone Management Authority • Protected Areas Conservation Trust	Preservation, protection and improvement of the environment and the control of pollution Climate Change management, UNFCCC Focal Point Fisheries, forestry, and coastal zone management Sustainable development Sustainable use of Belize's natural and cultural resources.
Ministry of Finance and Economic Development	• Economic Development	Economic Development
Ministry of Natural Resources and Agriculture	• Agriculture Department • Land and Survey • Physical Planning • National Integrated Water Resource Authority • Solid Waste Management • Pesticide Control Board	Agriculture, Agro-industry & Aquaculture Physical Planning, land use planning and management of national lands Water Industry (except water supply and services) Solid waste management Pesticide control
Ministry of Works and Transport	• Works • Road infrastructure	Public Works Road Construction and Maintenance Bridge Construction and Maintenance
Ministry of Health	• Ministry of Health	Public Health, sanitation and diseases prevention and control.
Ministry of Energy, Science & Technology and Public Utilities	• Geology and Petroleum Department • Public Utilities Commission • Energy Department	Energy etc./Climate Change mitigation Energy efficiency and conservation
Ministry of Labour, Local Government Rural Development and National Emergency Management	• Meteorological Office • National Emergency Management Organization (NEMO) • Department of Local Government and Rural Development	IPCC Focal Point National Meteorological Service. Municipalities, Village Councils National Emergency Management Organisation (NEMO), National Fire Service
Ministry of Tourism, Culture and Civil Aviation	• Belize Tourism Board	Tourism Development and Regulation Sustainable tourism Planning and Management Monitoring and Quality Management Marketing and Promotion of Tourism Assets
Ministry of Housing and Urban Development	• Housing and Planning Department • Central Building Authority	Housing and Planning Department, Central Building Authority Regulation of land use, housing and infrastructural development Approve building plans Issue building permits

Source: NCCPSAP, 2015

4.1.2 Low Carbon Development Roadmap

The development of the national roadmap for Belize to achieve a low carbon development strategy will create a platform for low carbon growth in new areas while still attaining the national development targets. The roadmap was developed by building on the results of the analysis based on the domestic context, on best available international practices and the results from consultations held with key stakeholders.

Phase I: (short-term, horizon 2015). This phase will focus on urgent needs at the technical, policy, and institutional levels, namely updating the GHG inventory and setting GHG emission reduction targets, finalizing the National Climate Change Policy, Strategy, and Action Plan, and reforming/building capacity for key institutions to reinforce Climate Change management.

Phase II: (medium-term, horizon 2020). This phase will focus on building technical capacity, strengthening institutions and policies, facilitating public-private partnerships and engaging stakeholders to adopt sustainable practices, designing technical tools such as Baseline Scenarios, and Mitigation Abatement Curves (MAC), along with developing and operating policy instruments tailor-made for the identified priority sectors, while implementing current sustainable plans.

4.1.3 Integrated Coastal Zone Management Plan (2013)

The Plan outlines a vision and implementation plan for the sustainable use of coastal resources, supporting an integrated approach to development planning and adapting to Climate Change. The plan contains critical measures for Climate Change adaptation relevant to this sector, which includes the identification of short, medium and long-term strategies to address the threats of Climate Change on coastal communities as well as coastal and marine resources. The management plan also takes into consideration the necessary adaptive measures to reduce projected Climate Change impacts and recommends that all developments within the coastal areas of Belize include an adaptation strategy to mitigate the effects of Climate Change. It also recommends the prioritization of ecosystem-based adaptation as it builds resilience and reduces the vulnerability of local communities to Climate Change.

4.1.4 Ministry of Energy, Science and Technology and Public Utilities (MESTPU) Strategic Plan 2012-2017

Belize's National Sustainable Energy Strategy was adopted in 2012 and includes a number of programmes and activities to support the development of the country's non-renewable and renewable energy resources. The strategy aims to improve energy efficiency, conservation, and the development of Belize's domestic energy resources to facilitate private sector participation and investment in the new low carbon energy sector. It also seeks to empower rural communities to participate in income-generating activities, particularly women and young people; and to encourage and advise the public and private sectors including the general public to become more aware of the critical energy issues in order to undertake appropriate actions and response measures. The strategy also commits to building MESTPU's institutional capacity in order to accomplish its mandate.

4.1.5 Sustainable Energy Action Plan for Belize

The Sustainable Energy Action Plan ('the Action Plan') is a tool to achieve Belize's renewable energy (RE) and energy efficiency (EE) potential while meeting Government's economic, social and environmental goals. This Action Plan provides the framework of actions and tasks to overcome the barriers to sustainable energy.

4.1.6 National Sustainable Tourism Master Plan of Belize (2010)

This master plan identifies and describes the four strategic goals for Belize's tourism sector as: leadership; optimization; sustainability and competitiveness. An economic overview of Belize's tourism sector and the identification of new strategic commercial segments are detailed. Further details are delineated with respect to building the competitiveness of the tourism sector in terms of product development, an integrated destination development, experiential quality enhancement, empowerment of stakeholders and a proactive solution to funding resources, governance and sustainability. Sustainability indirectly pertains to potential Climate Change issues insofar as it includes the identification, assessment and monitoring of specific natural and cultural safeguards needed to avoid degradation of tourism assets. Nonetheless, reference to Climate Change is virtually absent from this document.

4.1.7 Growth and Sustainable Development Strategy 2014 – 2017

The Growth and Sustainable Development Strategy (GSDS) is the guiding development plan for the period 2014 – 2017. It adopts an integrated, systemic approach and encompasses medium-term economic development, poverty reduction and longer-term sustainable development issues. The GSDS builds on previous documents including the Horizon 2030: National Development Framework for Belize 2010 – 2030. The GSDS is Belize's primary planning document, providing detailed guidance on priorities and on specific actions to be taken during the planning period.

4.1.8 National Agenda for Sustainable Development (2013)

The Strategy document acknowledges the various development strategies and policies being implemented in Belize, and advocates the mainstreaming of sustainable development principles and goals in national planning processes. This agenda is guided by Horizon 2030 as the latter identifies the core values and long-term vision for development of the Government of Belize. At the national level, the National Agenda for Sustainable Development will facilitate the mainstreaming of core values and principles of sustainable development into national visions and goals across sectoral strategies and activities. At the institutional level, this agenda will facilitate strategic planning, management and monitoring of Belize's initiatives to ensure their alignment with the sustainable development goals, values and principles.

4.1.9 The National Climate Resilience Investment Plan (2013)

This plan promotes a well-coordinated approach to national development by integrating planning processes across all sectors of the economy through participation among a broad spectrum of stakeholders. It provides the framework for an efficient, productive and strategic approach to building economic and social resilience and development. Special importance is given to building climate resilience and improving disaster risk management capacities across all sectors.

4.1.10 Enhancing Belize's Resilience to Adapt to the Effects of Climate Change- Vulnerability and Adaptation Assessment (2014)

This assessment provides an in-depth analysis of the impacts of Climate Change on the following key sectors in Belize: coastal zones, water resources, agriculture, fisheries, tourism and human health. It further delineates substantial recommendations for adaptation and mitigation measures for each sector in short, medium and long terms in order to build national climate resilience.

4.2 Programmes containing measures to abate greenhouse gas emissions

In accordance with the stipulations of the Convention, the Government of Belize recognizes programmes containing measures to mitigate Climate Change by addressing GHG emissions by sources and removals by sinks not only contribute to the global effort to address Climate Change but provide ancillary benefits that contribute to the national development objectives. This may not only involve the implementation of a range of policies and economy-wide packages of policy instruments, but also facilitating changes in lifestyle, behavioural patterns and management practices in order to mitigate Climate Change in relevant sectors.

4.2.1 Energy Sector Abatement/ Mitigation Programmes

Mitigation measures within the energy sector generally tend to reduce GHG emissions through application of technologies that decrease or remove the consumption of fossil fuels. Technologies which utilize renewable energy, such as water, biomass, and the solar are ideal for such objectives. Some measures, e.g. hydro, may generate different GHGs from those which being generated to produce the same amount of electrical power using fossil fuel. Others, like those consuming biomass, generate cleaner emissions; cleaner from the perspective of carbon dioxide emissions which can be taken up by plants, compared to the mix from diesel fuels which have more severe impacts because of its global warming potential.

In Belize, for the last decade the focus of the energy policy has been to increase supply without considering the source. Although this practice ensured a stable flow of energy, it increased dependency on imported fossil fuels and electricity. Fossil fuels will remain a significant source of energy in Belize for years to come, but it must be an imperative action in the country's energy policy to reduce Belize's dependency on imported fossil fuels and to decouple increased energy demand from increased fossil fuels imports. A move toward renewable energy solutions is sought as the most viable solution to improve energy security and reduce the volatility of energy costs.

4.2.2 University of Belize Solar Energy Project

Between August 2011 and August 2012, a BZ $20 million clean solar energy project was completed on the Belmopan Campus of the University of Belize. The ownership of the system was vested in the University of Belize, which means that the institution is now in a position to sell electrical power to the Belize Electricity Limited (BEL) grid (Figure 49). The project was facilitated under the umbrella of a Memorandum of Agreement between the university and the

Government of Belize (Ministry of Finance). Funding for the project was provided by the Japan International Cooperation Agency under its grant aid for environment and Climate Change programme.

Besides generating no GHG emissions, the University will benefit otherwise because of the opportunity to develop scientific research capability among people at the university in collaboration with other public agencies including the Ministry of Energy and Public Utilities, Belize Electricity Limited and international agencies such as the Caribbean Community Climate Change Centre.

The system generated 2000 kilowatt daily during the testing period. The engineers explained that the system provided alternating current energy at 400 volts that was transformed up to 11000 volts to feed into the BEL's grid. The systems electrical output is estimated at about 0.6 % of Belize's electrical energy needs, but the emissions avoided are the equivalent of combusting 8 gallons of diesel per hour to produce the same amount of energy.

Figure 49: Sections of the solar panel system on the UB campus, Belmopan.

Source: Third National Greenhouse Gas Inventory Report, 2015

4.2.3 Caye Caulker Renewable Energy Water Supply Project (2015).

Under the European Funded Global Climate Change Alliance Programme, a project is underway to supply and install a Photovoltaic (PV) system to provide renewable generated electrical power for the Belize Water Services (BWS) water supply system in Caye Caulker, Belize.

The system is expected to comprise a 70 kW three phase solar grid connected electricity system, hurricane resistant, reservoir and ground mounted on site at the BWS compound. Voltage and frequency will be compatible with the existing grid of Belize. This project is intended to shift the energy needs of that section of the utility service from that produced by the combustion of fossil fuel to a renewable energy source. This then contributes to a further reduction of the GHG emissions from Belize's energy sector.

4.2.4 BECOL Energy Generation (Avoided Emissions) (2007-2012)

Assessment of avoided emissions in the Energy sector due to the commissioning and operation of hydro-dams to generate electrical energy had previously been estimated for the Second National Communication. That exercise had evaluated the impact of the Mollejon and Chalillo plants as they were in operation at that time. Although the study period for the GHG study period was 1997 – 2000, this abatement assessment exercise covered the period up to 2007 for the Second National Communication. Another project had completed the installation of the Hydro Maya facility in the Toledo District, further avoiding GHG emissions from fossil fuels combustion. Combined, the hydro generation projects had resulted in the reducing of GHG emission that would have been emitted by diesel generating plants by 91%. By 2007, hydro power generation accounted for a 41% reduction of GHG emission, while the purchasing of power from Comisión Federal de Electricidad (CFE), Mexico accounted for an additional 50% reduction, in the energy producing industry.

The Vaca Hydro Plant began to supply a base load supply of power to BEL of 18 MW at the beginning of 2010, generating an additional 158 gigawatt-hours GWh of electrical energy, increasing BECOL's supply to 332.68 GWh. The additional benefit of these projections is that 75% of BEL power supply is no longer dependent on imported fossil fuel and subsequently variation in fuel prices.

With the remaining power demand contracted from CFE, BEL's contribution to GHGs becomes negligible. However, in February 2008 BEL signed an agreement with Belize Aquaculture Limited (BAL), located on the Placencia Road, to purchase up to 15 MW of firm capacity and energy of power. The BAL equipment is a heavy fuel generating plant which produces approximately 22 Gg of CO_2 emissions negating some of the gains through the utilization of hydropower.

Table 29 illustrates the amount of GHG emissions that have been avoided by the operation of the facility at Vaca Falls on the Macal River in the Cayo District. The avoided emissions are the amount of GHGs that were not produced since a renewable energy source was utilized. It is based on the projected energy production levels (output) of this plant if fossil fuel was being consumed to produce the same amount of electrical energy.

Table 29: Estimates of avoided emissions due to operation of VACA plant

Year	MWh	Possible emission from fossil fuel – BEL(Gg CO_2)	Reduced emission due to VACA (Gg CO_2)
2010	72,991.00	19.08	-19.08
2011	78,376.00	20.48	-20.48
2012	72,301.00	18.89	-18.89
2013	83,993.00	21.95	-21.95
2014	82,843.00	21.65	-21.65
Totals for the 5 years Vaca is on line	**390,504.00**	**102.05**	**(102.05)**

Source: Waight, 2015

4.2.5 Reducing Emissions From Deforestation And Land Degradation

It is anticipated that with the establishment of the National Climate Change Office, this office with representation at the highest levels of government, is best suited to take on the role of mainstreaming Climate Change into broader national strategies as well as overseeing the coordination of Climate Change mitigation activities through the Mitigation Sub-Committee. This also allows policies, legal and institutional arrangements supporting the REDD+ (reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries) strategy to be designed within the policy framework of relevant Ministries within the Government to ensure inter-ministerial participation. The office is placed within the Ministry of Forestry, Fisheries, and Sustainable Development, whose mandate would ensure that Climate Change and related matters will have very high levels of political attention. The Ministry of Economic Development being on board should also ensure that national development plans and strategies are mainstreamed and that Climate Change mitigation and adaptation measures including REDD+ will be considered at a national level. Aside from coordinating programs and projects focused on Climate Change, the MFFSD will lead the development and implementation of REDD+ including the operational aspects of REDD+ readiness activities through the Forest Department.

4.2.6 Planting Trees to Mitigate Climate Change

The Toledo Institute for Development and Environment (TIDE), a non-government organization operating in the Toledo District, hosted a two-day reforestation exchange for the leaders of communities in Toledo to learn how to positively manage the effects of Climate Change.

Participants were taught various innovative methods of reforesting riverbanks and deforested areas using successful local projects as examples (Figure 50). The training showed that by planting trees, communities could safeguard against the negative effects of Climate Change, but also positively manage their land; reforestation guarantees that ecosystems remain healthy; ensures riverbanks are stabilized in case of flooding; increases food security by planting fruit trees and vegetables in case of food shortages; removes carbon dioxide from the atmosphere and provides important habitats for animals. It is an important tool of ensuring a stable environmental future in Belize.

Figure 50: TIDE's reforestation of riverbanks in Toledo District

Source: Toledo Institute for Development and Environment

4.2.7 Establishment of Proper Solid Waste Management in Belize

In 2012, the GOB acquired a loan from the Inter-American Development Bank (IDB) and the OPEC Fund for International Development (OFID), for a Modern Solid Waste Management Project (Figure 51 and 52). The objective of the project is to improve waste management practices in the Western Corridor by moving away from harmful environmental practices such as the burning of household garbage, illegal dumping and unsanitary landfills, to a more sustainable and environmentally sound waste management system.

In 2013 the Belize City Transfer Station, San Ignacio/Santa Elena Transfer Station and Regional Sanitary Landfill was inaugurated. During 2012 and the first half of 2013, the Solid Waste Management Authority worked very closely with its partners to close and secure the old landfills located in Belize City, and at mile 73 on the Western Highway which previously served the San Ignacio/Santa Elena and Benque Viejo areas.

Figure 51: Sanitary Land Fill located at mile 23, Gorge Price Highway (Inaugurated 30th July 2013)
Source: Great Belize Productions Limited

Figure 52: Transfer Station located at mile 3, Gorge Price Highway (Inaugurated 6thAugust 2013)
Source: Great Belize Productions Limited

In 2014, the project was registered as a small-scale Clean Development Mechanism Project for the trading of Certifiable Emission Reduction. It is expected to reduce about 15,548 tons of carbon dioxide annually using technologies such as an active Land Fill Gas (LFG) collection/capture and flaring system to efficiently eliminate methane emissions and monitor the amounts of methane combusted.

4.2.8 Industrial Waste Water Treatment

The Bowen and Bowen wastewater treatment plant at the Ladyville factory utilizes a system known as "Anaerobic and Activated Sludge System with Methane Recovery". This process which treats all the wastewater produced at the soft drinks, water and beverage bottling factories is one that treats sewage and industrial wastewaters using air and a biological flock composed of bacteria and protozoa.

The goal is to reduce the amount of sludge that needs to be disposed. The most widely employed method for sludge treatment is anaerobic digestion. In this process, a large fraction of the organic matter (cells) is broken down into carbon dioxide (CO_2) and methane (CH_4), and this is accomplished in the absence of oxygen. About half is then converted into gases, while the remainder is dried and becomes residual soil-like material. This methane produced is used as fuel to meet some of the energy requirements of the factory.

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5 OTHER INFORMATION FOR ACHIEVING CONVENTION GOALS

This section includes other projects, programmes and initiatives that were implemented in an effort to achieve the objectives of the convention.

5.1 Climate Change Research and Systematic Observation

Meteorological observations in Belize date back to 1887. Observations at that time were recorded by a number of individuals and organizations such as the Agriculture, Forestry and later Civil Aviation Departments. With the establishment of the Belize Weather Bureau in the early 1970's, weather observations were officially assumed by the newly formed department. In 1978, under a cooperative agreement between the United States of America, the Belize and British governments, the Upper Air and Marine Forecasting Centre in Swan Island were transferred to the National Meteorological Service (NMS) of Belize. By 1981, the NMS was transformed from an outpost meteorological station in the 1960's to a real established entity.

5.1.1 Observation Network

This segment is structured to address issues of systematic observations as a priority since research is hinged upon having sufficient, adequate and accurate observation data. It considers only two of the three domains namely, Atmospheric, Oceanic and does not include the Terrestrial domain which falls under the jurisdiction of a different agency.

5.1.1.1 Present Status

Atmospheric Domain

- Surface Observations

The NMS maintains a network of sixteen (16) conventional or traditional type weather plots/stations. These are equipped with instruments that are manually read once per day at 1500 UTC (9:00 a.m. local time). The Essential Climate Variables (ECV) measured at these stations is air temperature, water vapour and precipitation. There are some measurements of solar radiation but none of these stations measure wind direction and speed. In addition, soil temperature and evaporation measurements are made at a few of these conventional stations.

The Department also operates nine (9) automated weather stations as part of its network. The network distribution of all stations around the country shows gaps in the northwest and west-central portions of the country. To complement its surface observation network, the NMS tries to maintain communication with private owners of automated weather stations to informally share data and to assist with technical advice on issues that might arise with the operation, maintenance and proper exposure of their instruments.

- Upper Air Observations

Since the inception of upper atmospheric observations locally, the Department has maintained one upper air observing station located at the main station at the Philip Goldson International Airport. Observations are done once per day at 1200 UTC (6:00 a.m. local time). In the tropical cyclone or hurricane season, observations are increased to twice per day with the second observation time at 0000 UTC (6:00 p.m. local time). The ECVs measured are temperature, wind speed and direction and water vapour. Cloud properties are inferred from the sounding profiles.

5.1.1.2 Future Plans (Five Year)

Surface Observations (Atmospheric Domain)

It is planned to eventually phase out the conventional stations and replace with automated stations. These have the distinct advantage of not only transmitting real time data but to maintain continuous time series essential for the identification of trends. It is also the intent to fit the network with a homogeneous set of instruments from one supplier. This homogeneity would largely facilitate for the efficient management of recorded data. It is proposed that an additional twenty (20) automated weather stations be constructed over the next two to three years.

- Upper Air

Since the upper air observation programme is a cooperative with the United States Weather Service of the National Oceanic and Atmospheric Administration (NOAA) any improvements in such observations will be largely driven by NOAA/NWS initiatives.

Oceanic Domain

It is proposed that two offshore automatic weather stations located in the extreme eastern and southern seas be fitted with sensors to measure sea surface temperature, sea level and sea state with the third coastal station refurbished within the fiscal year 2015/2016. A customized data base management system costing US$78,500 is nearing completion and is expected to be installed and fully functional by mid-2015 at the offices of the NMS.

5.1.2 Research

Very limited research is done under the direct auspices of the NMS due to the fact that the focus of the Department still largely remains at maintaining the operational forecasting and climate services. The suitably qualified staffs to undertake any research studies are used to fulfil the operational demands of the Department. To cause a significantly larger and more active participation in research, the NMS would require a greater cadre of qualified individuals. This increase would obviously translate to larger annual fiscal budget allocations.

5.1.3 Recommendation to Improve National Programmes in Research

Although the willingness exists for collaboration with other institutions involved in Climate Change research, the NMS cannot fully participate in such cooperative undertaking due to the professional staffing situation. The charge to increase research in the climate sciences should be led jointly by the NMS and the tertiary level educational institutions. Such research could be integrated into their Natural Resources Management curricula at those educational institutions.

5.1.4 Participating in Activities in Global Research and Observation Systems

The NMS is actively involved in Global Climate Observing System (GCOS) activities. The main station at the NMS compound is designated and maintained as part of the GCOS Upper Air

Network (GUAN). The Principal for the Group on Earth Observation (GEO) lies with the Chief Meteorologist at the NMS. In terms of contributing to Climate Change assessment reports, the country's Focal Point for the Intergovernmental Panel on Climate Change (IPCC) is also the Chief Meteorologist.

5.2 Education, Training and Public Awareness

In spite of immense efforts to mainstream Climate Change in recent years, there is still a great deficiency of information in regards to its causes, impacts and consequences, and furthermore, the effective diffusion of that information to all sectors across Belize. Therefore, it is imperative that effective tools that contribute to the communication and understanding of Climate Change is a primary objective of initiatives aimed at building resilience and increasing adaptive capacity to Climate Change.

The Government of Belize through various sources of funding and with various partners made great efforts towards educating, training and building overarching awareness on Climate Change. A part of some of these efforts led to the awarding of scholarships (12) to members of the public sector and civil society to pursue courses relevant to Climate Change and Sustainable Development. The Government of Belize through its National Climate Change Office underwent several awareness building campaigns including informative advertisements on Climate Change printed weekly in local newspapers, the airing of a short video on the results of the integrated V&A assessment utilising various media houses and the publication of sector dockets based on the findings of the V&A assessment and general Climate Change information. The Climate Change awareness campaign presented Climate Change information at various national events such as Agriculture Trade Show (held annually in May), Earth Day (held annually in April), World Water Day (held annually in March), Forest Fisheries and Finance Expo (held in May), Fisheries Fair for Reef Week (held annually in May), even Europe Day (held in April 2014).

Other Climate Change training, education and awareness building campaigns conducted includes but are not limited to the following listed below:

5.2.1 Climate Change Clubs

In May of 2014, the Caribbean Community Climate Change Centre devised a concept for the integration of Climate Change focused clubs in secondary schools across the Caribbean region. In April of 2015, the first pilot was rolled out in Belize with the collaboration of and funding provided through the National Climate Change Office. The creation of school based environmental clubs with a Climate Change focus would improve current efforts of incorporating Climate Change within secondary institutions. The outcomes included the increased sensitization and awareness of Climate Change impacts, increased capacity to conduct vulnerability assessments, identification of practical adaptation measures and the ability to link personal actions to broader Climate Change discussions. The latter will be achieved via the weekly meetings, experimental learning and interactive group exercises and discussions. It is the hope of the NCCO and the CCCCC that Climate Change can be embedded within the education sector of

Belize. The curriculum, developed by the CCCCC, encompasses four units: (i) Warming Climate, (ii) Sea Level Rise, (iii) Pine Forest and (iv) Social Impacts of Global Warming. Each unit would incorporate face-to-face interaction, field trips and a workbook to achieve a holistic learning interface for the students.

5.2.2 1.5 Stay Alive: an Educational Initiative Teacher's Continuous Professional Development Workshop

The 1.5 Stay Alive: an "Educational Initiative Teacher's Continuous Professional Development workshop" was held from August 4 to 15, 2014. The workshop provided teachers with student friendly resource materials which would aid in the effective dissemination of Climate Change information to students. The teaching and learning activities can be modified to suit local situations and student groups of all ages. The intent is to teach complex concepts with uncommon terminologies to young people. If they are to appreciate what is being taught, the terminologies must be clear to them. Under this initiative, the teachers learnt who will be vulnerable and in what ways. Armed with the necessary information, it is hoped that awareness will be developed to cause changes in habits, practices and values. The resources used comprised teaching and learning activities which includes a range of supporting materials such as worksheets, photographs, posters, suggestions for power point presentations, videos and field trips. Most importantly, there is much resource information for the teachers in the event they may need further clarification of concepts they are expected to teach. The cross-curricular approach used in most lesson plans is in accordance with accepted philosophies and principles of education.

5.2.3 Agro-forestry and Riparian Reforestation Exchange: Tools for Climate Change Adaptation and Mitigation

The Toledo Institute for Development and the Environment (TIDE) in conjunction with the National Climate Change Office held a two day interactive training program entitled, 'Agro-forestry and Riparian Reforestation Exchange: Tools for Climate Change Adaptation and Mitigation.' The training was geared at educating local communities on Climate Change, agro-forestry and riverine reforestation. It involved the participation of community leaders from the Toledo District. Detailed discussions and first-hand experiences of agro-forestry and riverine reforestation were used to equip participants with the necessary tools to incorporate these activities within their own communities. Agro-forestry and riverine reforestation were tools being employed at two villages in the Toledo district to mitigate the effects of Climatic Change. At the completion of the training, participants planted 20 riparian trees along the San Miguel River. In addition to this and as a follow-up of the project, TIDE has also purchased 300 riparian trees to be planted by communities.

5.2.4 Creating Awareness and Educating the Communities Adjacent to the Rio Bravo Conservation and Management Area on Climate Change Adaptation and Mitigation

Programme for Belize in conjunction with the National Climate Change Office conducted two complimentary workshops under the theme 'Creating Awareness and Educating the Communities Adjacent to the Rio Bravo Conservation and Management Area on Climate Change Adaptation and Mitigation.' The target group for these workshops included persons from communities neighbouring the Rio Bravo Conservation and Management Area (RBCMA) including Scotland Half Moon, Double Head Cabbage, Bermudian Landing, Willows Bank, Flowers Bank, Burrell Boom, Rancho Dolores, San Felipe, August Pine Ridge, Blue Creek, San Carlos, San Lazaro, Indian Church, Trinidad Government School, Lemonal and St. Paul's Bank. The first two day workshop 'Learning About Climate Change and Its Impacts, Sharing and Exploring Adaptation Measures', at La Milpa Ecolodge was comprised of introductory presentations on Climate Change, adaptation and mitigation, cultural aspects as well as impacts and current employed solutions for adaptation. In the subsequent visit to the La Milpa Archaeological Site, participants were educated on the methods used by the Mayans to adapt to the changing climate factors that affected their civilization. Discussions held by the participants entailed visible effects of Climatic Changes in local communities in addition to current and future adaptive measures to be taken. Corresponding topics such as agriculture, livelihood, housing, natural disaster, waste management and protected areas were also covered. In the workshop held at the Hill Bank Field Station, participants were exposed to the ongoing adaptation and mitigation measures by Programme for Belize, including the sustainable timber extraction programme in the RBCMA, Rio Bravo Carbon Sequestration Pilot Project, and the San Carlos Solar Panel and Agriculture project.

5.2.5 Fundamentals of Climate Change Adaptation

The National Climate Change Office via the World Wildlife Fund (WWF) held three workshops entitled the Fundamentals of Climate Change Adaptation which was designed to target three different audiences: (i) Middle managers of key stakeholders (public and private sectors), (ii) staff within the MFFSD (ministry responsible for Climate Change), and (iii) the members of the BNCCC (decision-makers on Climate Change). The workshops featured a multitude of modules each with its own deliverables. The workshops featured presentations on: the effects of Climate Change on conservation and development goals, challenges for communicating adaptation to audiences, vulnerability assessment in climate adaptation and importance of integrating people, species and ecosystems. Various climate related concepts were covered including climate variability, impacts and mainstreaming adaptation, to name a few.

5.2.6 Caribbean Climate Online Risk and Adaptation Tool (CCORAL)

The Caribbean Community Climate Change Centre (CCCCC) in conjunction with the National Climate Change Office hosted training on the Caribbean Climate Online Risk and Adaptation Tool also known as CCORAL. This online support system for climate resilient decision making is an invaluable tool that has been uniquely developed for the Caribbean Region. As such its application within Belize is imperative. CCCCC has further enabled the country to fulfil its obligations by providing the necessary training to pertinent organizations and sectors. The five-day training comprised of a multitude of elements. The objectives of which were to train participants in the use and application of CCORAL, identify and agree on case applications to be undertaken in Belize, organise and schedule in-country application, identify and train key individuals as national CCORAL trainers. The training also aimed to provide the ongoing technical assistance throughout the in-country process, which is a long-term objective not achieved during the five-day workshop. The above objectives were achieved via short presentations from members of the CCORAL team in addition to application of the program by participants.

5.2.7 Belize Climate Change Negotiator's Training Workshop

Participants from various governmental sectors were trained at the Belize Climate Change Negotiator's Training Workshop. The aim of the workshop was to equip those members of the government sector with valuable knowledge to engage in discussions and negotiations related to the Climate Change under the UNFCCC by enhancing the participant's knowledge of Climate Change as well as their understanding of the negotiation process. This would enable Belize to effectively and efficiently carry out its obligations under the UNFCCC and to implement actions at the national level.

5.2.8 Building Climate Resilient Municipalities

The Belize City Council in collaboration with the National Climate Change Office and a few other national partners held a Climate Change symposium in October, 2014 under the title 'Building Climate Resilient Municipalities.' The Symposium contained three sessions, each of which had a specific focus: Introduction to Climate Change, (ii) Building Climate Resilience through Practical Actions, and (iii) Towards Building a Climate Resilient Municipality. The first session being a basic introduction on Climate Change had established the foundation from which the other sessions would build on. The other two sessions looked at practical actions that are already being undertaken and how to start taking action. The sessions included actions taken such as the establishment of early warning systems, greening of landscapes, clean energy and the diversification of the tourism industry. Other sessions covered the identification of vulnerabilities, how to look at disaster risk reduction and Climate Change adaptation in an integrated manner, the need for and to support integrating adaptation into development strategies and investments and how to integrate Climate Change risks and opportunities into municipal planning.

5.2.9 World Food Day 2014 - Family Farming: feeding the world, caring for the earth, creating affordable, accessible, sustainable, healthy and nutritious food in Belize

The Department of Agriculture along with the support of the National Climate Change Office hosted World Food Day 2014 under the theme, "Family Farming: feeding the world, caring for the earth, creating affordable, accessible, sustainable, healthy and nutritious food in Belize." World Food Day 2014 was celebrated on 16 October 2014. This event was aimed at developing and implementing effective public education, information, and awareness activities on disaster risk reduction and Climate Change within the agricultural sector.

5.2.10 Integrating Climate Change Adaptation into Planning Process with Specific Focus on the Agriculture Sector in Belize

In March 2014, the National Climate Change Office in partnership with the Agricultural Department with the technical support of the Inter-American Institute for Corporation on Agriculture (IICA) conducted a workshop entitled, "Integrating Climate Change Adaptation into planning Process with Specific Focus on the Agriculture Sector in Belize." The workshop aimed to strengthen the technical capacities of a cadre of public technicians in integrating Climate Change adaptation into the planning process targeting the agriculture sector using the participatory oriented training based on an OECD policy guidance trainer's handbook developed by German Federal Enterprise for International Cooperation (GIZ).

5.2.11 Climate Change and You

In October 2014, the University of the West Indies Open Campus: Belize in collaboration with the National Climate Change Office and other national partners held a Climate Change conference entitled, "Climate Change and You." The conference was aimed at increasing awareness of Climate Change and its impacts on food, forests, water systems, our workplace (reduce, reuse, recycle), our human rights, our region and the world. This knowledge sharing platform was rich with stories, case studies, research, testimonials and thoughts, presented by the US Ambassador, the Mayor, scientists, economists, NGOs, farmers to everyday men and women whose lives are or will be impacted by Climate Change served to make all its participants recognize that Climate Change is real and is happening now. Participants were urged to take action now on this reality in order to become more resilient to the adverse effects of Climate Change.

5.2.12 Climate Services Workshop

In November, 2013, a Climate Services workshop was conducted by the National Meteorological Services with the support of the National Climate Change Office. This workshop brought together experts from the National Meteorological Service, government departments, universities and research institutions, key decision-makers, and practitioners from the initial four priority areas (agriculture, water, disaster risk reduction, and health) of the Global Framework for Climate Services to join forces to improve the quality and quantity of climate services in Belize.

5.3 Barriers to Climate Change Communication

It is imperative to identify the barriers and limits which may impede the process of effective Climate Change communication. As defined by IPCC (2007), limits are obstacles that tend to be absolute in a real sense. They constitute thresholds within which existing activities can be maintained. While barriers are defined as obstacles that can be overcome with concerted efforts, creative management, change of thinking, prioritisation and related shifts in resources. In light of the above, it is imperative that a proactive approach is taken to find innovative solutions to address the barriers and limits identified to attain communication objectives. Some barriers identified at the NCCO regarding communication of Climate Change include:

- accessibility of Climate Change information to the layperson;
- availability of information on lessons learnt and successes of climate related projects implemented in Belize shared with the public; and
- presentation of Climate Change as a problem of the future.

These considerations form the basis of NCCO's communication strategy. The communication strategy prioritises the role of research and expert oversight in Climate Change communication. It also highlights the channels of communication and messaging that are likely to be effective for primary target groups.

For example, linking the role of individuals' attitudes and lifestyle in causing the problem and enabling a positive paradigm shift is difficult. Table 30 present the attitudes that ought to be achieved in order to confront the challenge of engaging with people effectively (NCCO, 2015).

Table 30: Transformation for Climate Change outreach in Belize

Where We Are	Where We Want to Be
People aren't clear what causes Climate Change and don't understand what needs to be done to tackle it.	People understand Climate Change and what is causing it. (Micro and macro linkages)
People think that Climate Change won't affect them personally.	People see the impact it may have on their lives.
People don't include Climate Change as an important issue when making decisions.	People feel empowered and positive about tackling climate change.
Climate Change is a depressing and negative issue.	People include Climate Change when making their decisions and embrace the positive changes that result.

Source: National Climate Change Office, 2015

5.4 References

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6 GAPS, CONSTRAINTS AND RELATED FINANCIAL, TECHNICAL AND CAPACITY NEEDS FOR ACHIEVING THE CONVENTION IMPLEMENTATION

The Government of Belize has taken steps to integrate Climate Change into its national development processes and mechanisms. As such the National Climate Change Policy, Strategy and Action Plan (NCCPSAP) identifies activities to be undertaken to mitigate and address the adverse impacts of Climate Change. The NCCPSAP also provides policy guidance for the development of a suitable administrative and legislative framework, which is coherent with other sectoral policies, for the achievement of a low-carbon development path for Belize.

In light of the successes mentioned above, Belize identified gaps and constraints and the related financial, technical and capacity needs during the process of preparing its Third National Communication. These gaps and constraints were in the areas of GHG inventory, vulnerability and adaptation assessment, research and systematic observation, the country’s financial and capacity building needs.

6.1 Greenhouse Gas Inventory

In order to develop a more robust GHG inventory, the following gaps need to be addressed:

1. Quality and reliability of Data - Data collection was not done in a consistent format; there were no standardization of units and periodicity. The units in which the data were recorded had to be converted in order to be entered to the Excel workbooks. In some cases, data were not disaggregated, for example, imports and use of aviation fuel were not separated into different classes, or vehicle records were not detailed enough to enable estimation of emissions from personal vehicles and public sector vehicles according to fuel type.
2. Data Gaps - Although Belize has made moderate progress in addressing data needs for the GHG inventory process, gaps in data remain an issue for all sectors. With computerisation, reaching a high level across all sectors of government, data collection and storage is becoming easier. Technicians and mid-level managers are recognizing the value of data and are applying this ethos to their work.
3. Accessibility of Relevant Information - Some private sector entities such as those dealing with alcohol production were reluctant to disclose their data; therefore, values were obtained from statistical reports published by the Statistical Institute of Belize.

In this context, coordination among data providers needs to be strengthened to ensure that collection and reporting of data are done at a regular basis to support reporting responsibilities such as the National Communication process, Biennial Update Report and institutional needs. Additionally, opportunities should be identified to link data collection needs with other data collection programmes such as REDD+ initiatives, “waste to energy” which has the potential to create renewable energy from waste matter, including solid waste, industrial waste, agricultural waste, and waste by-products. Institutionalizing linkages between GHGI estimation with broader Climate Change search is very much needed.

Capacity building and training will be an on-going effort at the institutional and technical level. Institutions generating the activity data will need to be trained in GHG inventory and data formats.

6.2 Vulnerability and Adaptation Assessment

For the Third National Communication, the V&A assessment was carried out in the following six economic sectors: Coastal Zone, Fisheries, Water Resources, Agriculture, Human Health, Tourism, and Agriculture. The major gaps identified during this exercise included financial, technical and capacity needs to sustain infrastructure for implementation of climate actions. Other gaps pertained to inadequate capacity at district and community level on Climate Change impacts, insufficient use of economic instruments and lack of input data for some sectors and inadequate capacity for modelling. Therefore, the next steps for the Fourth National Communication should include, amongst others: cumulative impacts of Climate Change and sea level rise and its associated costs. Below is a list of gaps and constraints identified during the assessment process.

1. Financial resources to maintain and sustain the institutional structure required for the effective implementation of a Climate Change mitigation and adaptation programme;
2. Establish and sustain formal mechanisms to ensure that the roles of meteorological, humanitarian, health, agriculture and other sectors are well-defined, that climate information products are demand driven, user friendly and relevant for operational decision-making in health, agriculture and other sectors;
3. Enhance capacity at district and community level to cope with the adverse effects of Climate Change by increasing resources and awareness of the stakeholders on vulnerabilities to Climate Change impacts of various sectors;
4. Identify policy instruments for linking science and policy such as, economic instruments;
5. Identify opportunities and priorities for the modernization of agriculture in Belize by enabling effective and proactive adaptation to Climate Change;
6. Revitalize and upgrade coastal protection, including drainage and irrigation, to promote adaptation of other key sectors such as agriculture, water resources and tourism, and even people, settlements, human health and well-being.
7. Collect information regarding groundwater, especially in northern Belize, to improve management of future water resources considering the effects of Climate Change.

6.3 Research and Systematic Observation

The UNFCCC calls on Parties to promote and cooperate in systematic observation of the climate systems. In this regard, the NMS is part of a wider global network responsible for the collection of observations relating to the essential climate variables.

The understanding of the processes influencing climate variability and change requires the assessment of long-term series of observations. The following processes have already been initiated by the NMS in collaboration with other national and regional institutions in order to better advance the scientific understanding of the climate. However, as a priority, assistance is needed in (2), and (3) with item (7) being the overarching priority.

1. <u>Assembling the Data</u>: The NMS maintains a data archive of ECVs assembled as part

of larger data collection. Projects have commenced involving searching archives of data stored by other organizations and digitizing those historical paper records. The addition of these records will increase both the spatial and temporal coverage of data under the stewardship of the NMS.

2. Adjusting Data to Account for Inhomogeneities: Good quality control procedures can remove errors. However, there are some observations that suffer from artificial inhomogeneities that are brought about by changes in observer or observation practices. The NMS has not developed any means of operationally detecting or assessing inhomogeneity.
3. Real Time Updates: Frequent updates are required if the data set is to be used to monitor changes. In its present condition, the observation system is managed by the NMS although adequate it is still in need of upgrades to obtain larger volumes of real-time data. The network improvement plan is an integral part of the Department's strategic plan for 2015-2020 which is being structured around the five components of the Global Framework for Climate Services (GFCS). The slow and systematic phasing out of conventional observation plots would contribute to the improvement in this observation system.
4. Post Production Quality Assurance: This involves the scrutinizing of the data to assess certain representative characteristics of the records. This lies along the lines of verifying the observations with actual occurrences on the ground.
5. Monitoring and Routine Maintenance: Observation platforms need to be monitored frequently and maintained according to a set schedule. This activity includes checking instruments, replacing disposable items and general housekeeping activities of bushing and cleaning.
6. Advancement in Data Assimilation Technology: Data assimilation technologies along with mode and speed of transmission advance at a far too rapid rate than the NMS's internet service provider can accommodate. Therefore to a great extent, technology-wise, the NMS is limited by the vision, scope and capability of its internet service provider in this regard. As a result, acquired technologically advanced equipment are underutilised at the NMS while waiting for the internet supplier to catch up with the technology requirements.
7. Manpower/Human Resource: The basic need for the greater involvement by the NMS in Climate Change research is the availability of enough suitably qualified staff who can be devoted to that specific activity.
8. Procurement of Equipment: Much of the observation platforms such as automated weather stations are procured through grants or donations from regional and international agencies. The procurement process, restrictive in most instances by the dictates of the donor institution, prevents the recipient from obtaining the particular platform that satisfies the need. At times, the recipient simply has to settle for whatever package is donated.

6.4 Public Education and Awareness

Education, training and public awareness will facilitate capacity building to participate and implement effectively the commitments to the Convention. This activity is also seen as a vehicle that can be used to drive support for actions regarding Climate Change issues nationally and encourage support for government policies and measures as well as influence change in habits. Despite moderate progress in this area, there is a need to improve public education and awareness and prepare communication strategies so as to make climate science accessible to the populace to enable them to reduce their vulnerability to the adverse effects of Climate Change. Besides awareness building at community and local levels, it is also important to involve high-level policy makers to ensure integration of Climate Change considerations into national development policies.

6.5 Proposed Projects for funding

There are a number of projects being proposed in various sectors. Some of these projects are likely to be funded; however, in most cases the funding mechanism is still uncertain.

6.5.1 Agriculture Project

The project would seek to diversify livestock, increase access to drought resistant crops and livestock feeds; adopt better soil management practices; and provide early warning/meteorological forecasts and related information to be competitive in the region. The estimated cost for the following planned activities is approximately BZD $26,000,000:

1. Review national agricultural policies and regulations to ensure the incorporation of Climate Change adaptation and mitigation measures in all aspects of the planning, decision-making, operational processes and related programmes including water resource management, erosion and flood control, soil conservation, drought, agricultural research, livestock, seeds, crops, markets, food security, disaster risk management and technology transfer.
2. Implement soil fertility management mechanisms and soil- water management systems to address soil quality issues.
3. Promote and ensure the use of drought resistant crop development techniques or climate smart agriculture technology and associated water management techniques that will increase yield per unit area.
4. Develop and endorse the use of climate-resilient seeds and livestock breeds that are better adapted to the increased temperatures.
5. Initiate Integrated Pest Management (IPM) practices to keep pests below economic threshold levels in order to minimize risks to human health, organisms and the environment.
6. Promote the reduction of agricultural GHG emissions through: altering crop cultivation methods; implementing effective livestock management that involves changing the feeding practices of livestock; and improved manure management that controls the way in which the manure is decomposed.
7. Strengthen agricultural research and development and improve on the data collection capacity and analysis capabilities of the sector.
8. Facilitate greater public-private initiatives to implement cost-effective measures to address crop development, livestock production, and improving soil quality in the interest of building resilience to Climate Change.

9. Initiate and enhance community-based agricultural extension services to support Climate Change adaptation.
10. Initiate education awareness programmes to draw attention to the impacts of Climate Change on the sectors and measures to adapt and mitigate those anticipated impacts.
11. Incorporate Early Warning systems.
12. Provide support for institutional strengthening of the Ministry.
13. Facilitate market access for agricultural products and incentives to add value along the production line.
14. Undertake research on the usefulness and applicable models of crop insurance to facilitate and provide recovery from various disasters affecting the agricultural sector.

6.5.2 Forestry Project

The proposed interventions will total approximately BZD $10,316,000.00 and it includes the following:

1. Mainstreaming adaptation and mitigation to Climate Change will be achieved by providing guidance for actions to be taken with regards to the direct and indirect threats posed by global Climate Change on forests and forest dependent people in order to reduce their vulnerability, increase their resilience and adaptation to Climate Change;
2. Systematically assess the potential impacts of Climate Change on Belize's forests and the extent of the vulnerability of forests to these impacts and actions for adaptation;
3. Developing a comprehensive monitoring system to evaluate changes in the forest cover, carbon stocks and forest biodiversity and to use this information for further planning in light of Climate Change mitigation and adaptation; and
4. Maintaining and restoring healthy forest ecosystems by sustainable forest management, increasing afforestation and reforestation in order to increase the resilience of human communities.

6.5.3 Fisheries and Aquaculture

A project geared towards the sustainable management of the fisheries resources, conservation and preservation of fisheries resources and marine habitats in promoting reef ecosystem resilience. Estimated cost is approximately BZD$ 1,000,000 - $1,500,000. Planned activities related to this intervention will cover 1-3 years and are as follows:

1. Develop and Implement management approaches and polices that strengthen the livelihood asset bases, and improve understanding of existing response mechanism to climate variability to assist in planning adaption.
2. Adopt the new Fisheries Resources Bill and subsidiary regulations that incorporate international principles and approaches which are required for responsible and sustainable fisheries management.
3. Develop policy and plan to conserve and protect sensitive and healthy habitats (mangrove, sea grass, reefs) to improve resilience of main commercial species to Climate Change.

4. Support mangrove and fisheries conservation and management plans to protect wetlands and sea grass beds for fisheries to become resilient to Climate Change. Encourage diversification in fish species.
5. Enhance marine protected areas (MPAs) of natural significance into climate smart sanctuaries.
6. Develop marine spatial plans, area-based fisheries management approaches, regulated coastal development, and embark on ecosystem rehabilitation.
7. Explore the development of alternative livelihood plans for fishers who are affected by the establishment of restricted fishing measures.
8. Develop an information-clearing house to provide regular and accessible public information on Climate Change effects in the marine ecosystems and coastal zone to promote behaviour change designed to minimize climate risks in MPAs and replenishment zones.
9. Consolidate and strengthen the MPA system by establishing Fisheries Reserve or expand no-take zone in MPAs.
10. Monitor compliance with the Environmental Impact Assessment (EIA) regulations requirements for coastal mangroves alterations.
11. Conduct annual reef health and fisheries stock assessments.
12. Monitor biophysical, social, and economic indicators linked to management and policy responses and adopt multi-sector adaptive strategies, such as instituting species specific management plans on fishing seasons, to minimize negative impacts.
13. Conduct further research on the vulnerability and sustainability of marine resources to Climate Change.
14. Conduct specie-specific studies (e.g. determine impacts of sea surface temperature and ocean acidification on conch and lobster).

6.5.4 Mariculture /Aquaculture

The resources to be included along with the estimated cost for this project are yet to be determined. The planned activities include:

1. Improved feeds and selective breeding for higher temperature tolerance strains to cope with increasing temperatures and shifting to more tolerant strains of molluscs to cope with increased acidification.
2. Undertake integrated water use planning taking into account the water requirements (availability and quality) and social and economic importance of fisheries and aquaculture in addition to other sectors.
3. Improve the efficiency of water use in aquaculture operations and other adaptation options; and;
4. Strengthen and endorse outputs from the National Water Quality Working Group (develop baseline and monitoring program and identify trends with respect to marine and fresh water fishery).

6.5.5 Coastal and Marine Resources

Planned activities for such a project are highlighted below with activities totalling approximately BZD $1,000,000 (annually).

1. Increase and strengthen the capacity of the Coastal Zone Management Authority and Institute (CZMAI) to ensure developments within the coastal areas of Belize include an adaptation strategy to mitigate the effects of Climate Change.
2. Implement recommendations in respect of the development of a coastal management plan to ensure proper land use.
3. Develop a programme and acquire equipment to monitor and provide early warning in respect of storm surges.
4. Implement mangrove restoration or sea and river defence structures to prevent coastal erosion.
5. Implement monitoring techniques to assess beach erosion and water quality.
6. Manage further development of the coastline, especially in vulnerable areas such as the Belize and Corozal Districts.
7. Inclusion of adaptation strategies in management planning in all coastal and marine sectors.
8. Undertake restoration projects to increase the coastline resilience to sea level rise.
9. Review and amend the Building Code, especially as it relates to coastal constructions.
10. Revise and streamline the current legislation and policies that relate to the management of the coastal zone to eliminate overlaps and close existing gaps.

6.5.6 Water Resources

The resources to be included along with the estimated cost for this project are yet to be determined. The planned activities include:

1. Design and implement an IWRM programme in watersheds to reduce the impacts of Climate Change.
2. Enhance the protection of water catchment (including groundwater resources) areas and make improvements to the management and maintenance of existing water supply systems,
3. Strengthen the existing human resource capacities in the water sector for improved management practice including an improved hydrology and meteorology observation network and data collection
4. Develop Water Conservancy Management Systems including improvements to the management and maintenance of existing water supply systems taking into consideration the:
    a. Protection and restoration of ecosystems and water management infrastructure;
    b. Adoption of forest management plans to prevent and control soil erosion;
    c. Introduction of water harvesting;
    d. Prevention and control of water pollution and raising awareness to promote the effective and efficient use of water.

5. Conduct water resource assessment (especially ground water).
6. Undertake water policy reform including pricing and irrigation policies,
7. Develop flood controls and drought monitoring.
8. Improve trans-boundary cooperation regarding water resources
9. Strengthen the compliance monitoring capacity of staff in the MFFSD's Department of Environment (DOE) and other key agencies including provision of equipment and training in thematic areas such as compliance monitoring, use of new equipment, site inspection techniques, environmental audits, interpretation of lab analyses, and water quality monitoring to ensure the critical input to assess the health of the ecosystems therein and ensure long-term ecosystem services.

6.5.7 Land Use and Human Settlements

The resources to be included along with the estimated cost for this project are yet to be determined. The planned activities include:

1. Undertake a comprehensive assessment of human settlements and related infrastructure at risk from the effects of Climate Change, using inter alia, risk mapping and incorporate findings into the National Land Use Management Plan, and into the planning processes of NEMO.
2. Develop strategic land-use and settlements policy to adapt to potential rise in sea level, and integrate with land use, flooding and drainage plans.
3. Build the appropriate infrastructural defences to protect communities from damage caused by flooding and sea level rise.
4. Improve drainage and sanitation facilities in rural and urban areas.
5. Develop Climate Change infrastructure risk assessment guidelines and methodology.
6. Creation of marshlands/wetlands as buffer against sea level rise and flooding, thereby offering protection to existing natural barriers.
7. Evaluate the feasibility of relocating vulnerable communities
8. Review and modify housing designs and building codes to climate-proof existing and future housing and other infrastructure.
9. Enforce existing regulations and develop new regulations, which promote good building practices to meet the threat of sea level rise and dangerous storms and hurricanes.

6.5.8 Tourism

The resources to be included along with the estimated cost for this project are yet to be determined. The planned activities include:

1. Undertake a sea level rise vulnerability mapping exercise as part of a revision of the Tourism Master Plans and Land Use Plans. Of particular concern should be assessment of the impacts of Climate Change on specific areas designated for tourism development and sites of historic and cultural importance.
2. Coastal management policies should be reviewed and revised to account for sea level rise and storm surge—with specific attention on regulations related to setback requirements,

mangrove and coral reef conservation, beach nourishment, and property decommissioning.

3. Identify coastal tourism areas in Belize that are vulnerable to Climate Change, and which should be prioritized for adaptation actions.
4. Analyse the current policy environment to determine whether pertinent public policies support or undermine sustainable tourism development, ecosystem health/function, and climate adaptation.
5. Develop and implement management strategies for enhancing the resilience of coral to Climate Change for example, by reducing pollution and overfishing through the establishment and demarcation of fish sanctuaries.
6. Acquire and use high-resolution remote sensing data to monitor and evaluate engineering adaptations and support insurance risk assessments.
7. Implement maximum carrying capacity limits for areas that are impacted negatively from excessive human activity, such as mining, engineering and building or re-building operations.
8. Improve infrastructure to facilitate increased access to sites and resources. This includes the paving of roads, renovation of docking facilities for water taxis and installation of professional signage at critical junctions.
9. Engage communities for the development of responsible tourism practices.

6.5.9 Human Health

Resources included estimated cost for the following planned activities are to be determined. Undertake a Climate Change Vulnerability and Capacity Assessment for the health sector which includes:

1. Assessment of impacts of Climate Change on human health and well being
2. Establish baseline conditions by describing the human health risks of current climate variability and recent Climate Change, and the public health policies and programmes to address the risks
3. Describe current risks of climate-sensitive health outcomes, including the most vulnerable populations and regions
4. Identify vulnerable populations and regions
5. Describe risk distribution using spatial mapping
6. Analyse the relationships between current and past weather/climate conditions and health outcomes
7. Identify trends in Climate Change related exposures
8. Take account of interactions between environmental and socioeconomic determinants of health
9. Describe the current capacity of health and other sectors to manage the risks of climate-sensitive health outcomes
10. Improve the capture, management and monitoring of diseases and vectors affected by Climate Change and related forecasting and early-warning systems
11. Increase human resources capacity and improve efficiency
12. Develop education awareness programme to educate population on adaptation measures as it relates to family health and hygiene.

13. Enhance the epidemiology capacity of our health sector to address efficiently epidemics/ outbreaks.
14. Implement community-based participatory approaches to empower local communities to manage disease vectors in an integrated manner and thus increase their capacity to protect their health and climate resilience
15. Improve disease control and prevention;
16. Support capacity-building, including institutional capacity, for preventive measures, planning, preparedness and management of disasters relating to Climate Change, including contingency planning, especially for droughts and floods in areas prone to extreme weather events
17. Promote greater investment in health Infrastructure to ensure increased access of population to improved health care. These could include:
    a. Retrofitting health facilities and equipment (eg. Mobile Health Clinics, Amphibious Ambulance Services)
    b. New Building Codes for Health Facilities

6.5.10 Energy Sector

Resources included estimated cost for the following planned activities are to be determined. Undertake a Climate Change Vulnerability and Capacity Assessment for the health sector which includes:

1. Improve energy efficiency to dramatically lower energy intensities across key economic sectors Transport, Industry, Buildings (Commercial & Residential), Public lighting and Agriculture
    a. Improve energy efficiency in buildings and appliances.
    b. Promote transition to sustainable transportation.
    c. Develop appropriate financial and market-based mechanisms that support energy efficiency and renewable energy.
2. Develop renewable energy to shift the energy matrix away from fossil fuels (especially oil) to alternative renewable energy technologies.
    a. Develop Belize’s human, technological and institutional capacity to accelerate the uptake of appropriate clean energy and clean production technologies.
3. Promote and facilitate Clean Production systems in the processing of Agriculture and Forestry outputs to co-produce bio-fuels and/or electricity.

6.5.11 Transportation

Resources included estimated cost for the following planned activities are to be determined. Undertake a Climate Change Vulnerability and Capacity Assessment for the health sector which includes:

1. Comprehensive assessment of transportation/communications infrastructure and their vulnerability to storm surges, floods and other forms of natural disasters, especially the major productive (tourism, agriculture, etc) sectors.

2. Review and update standards for construction and maintenance of transportation infrastructure to include an additional protective margin for the expected risks associated with Climate Change.
3. Develop risk assessments and response plans, including mapping and identification of high-risk and critical infrastructure (related to the productive sectors), and implementing key infrastructure reinforcements and relocations.
4. Promote energy efficiency in the transport sector through appropriate policies and investments: These improvements should include:
    a. Undertaking a traffic management study aimed at reducing traffic congestion in urban areas and along the Philip Goldson Highway into Belize City
    b. Improving public transportation
    c. Upgrading maintenance of bus fleet
    d. Improving scheduling
    e. Upgrading the industrial fleet
    f. Promoting the use of bio-fuels

6.5.12 Solid Waste Management

Resources included estimated cost for the following planned activities are to be determined. Undertake a Climate Change Vulnerability and Capacity Assessment for the health sector which includes:

1. Develop and implement a National (country-wide) Integrated Solid Waste Management Programme for Belize. Such a programme will seek to address and enhance current initiatives including:
    a. Institutional Strengthening
    b. Waste segregation, storage, collection and transport
    c. Waste minimization, reuse and recovery
    d. Cost recovery
    e. Education awareness and stakeholder's communication
2. Develop a solid waste mitigation strategy, and a detailed NAMA plan, including measuring, reporting and verification (MRV) and financing options for CDM capping and closing open dumps, capturing and utilizing landfill gas, and ensuring proper waste handling and organics management.

6.6 Existing/Pilot Project

Some adaptation to current and future Climate Change is occurring, however, on a limited basis. Examples of adaptation projects being undertaken are as follows:

6.6.1 Enhancing Belize’s Resilience to Adapt to the Effects of Climate Change

Through the Global Climate Change Alliance (GCCA), the European Union in collaboration with the Government of Belize (GOB) and United Nations Development Programme (UNDP) financed a three-year project “Enhancing Belize’s Resilience to Adapt to The Effects of Climate

Change”. Total cost of project was Euro 2.9 million. The above initiative aimed to create an enabling environment for effective Climate Change governance as well as to increase Belize’s ability to respond to the threats of Climate Change as a means of ensuring its goal for sustainable economic and human development. The building of national capacities, both institutional and operational, will stimulate improved effectiveness of national actions and investments and ensure better organization and coordination of stakeholders addressing Climate Change adaptation in Belize. The initiative also supported capacity enhancement within the national government structure (both central and local governments) as well as capacities within for effective Climate Change governance. The project targeted public sector employees, decision makers and Climate Change technicians in its creation of the critical mass required to advance supporting non-state institutions. More specifically, the project targeted actors within the water sector as adaptation approaches and best practices were demonstrated through piloted initiatives linked to this sector.

6.6.1.1 Enhancing Belize’s Resilience to Adapt to the Effects of Climate Change MNRA-Food Security: Building Resilience among Cattle Producers of the Belize District

The project “MNRA-Climate Change: Food Security: Building Resilience among Cattle Producers of The Belize District” objective is to reduce economic losses arising from the effects of Climate Change. This was accomplished through financing small local works that would help alleviate the impacts of Climate Change and reduce the vulnerability of the livestock industry in the Belize District. The challenges farmers faced in the Belize district included: poor access to markets, unexpected long drought and floods, diseases and pests, large wild cats preying on their cattle, poor management practices and inappropriate use of technologies. Furthermore, these cattle producers had sufficient forage with high moisture content during the normal rainy season but during times of drought and floods there was scarcity and poor quality of forage.

6.6.1.2 Enhancing Belize’s Resilience to Adapt to the Effects of Climate Change Ministry of Local Government and Rural Development (MLLGRD)- Accelerating Potable Water Coverage: Piloting Innovative Solutions in Securing Local Water Supply Sources

The project supported the establishment of community boreholes/ tube wells in Toledo, Orange Walk, Corozal and Belize Districts. Of the fifteen communities identified and well drilled, twelve had successful bores. The twelve successful bores were found to have viable ground water reserves and will significantly impact approximately 3,576 households. This has greatly enhanced the efficiency and effectiveness of adaptation in the following communities: Libertad, August Pine Ridge, Armenia, Dolores, Bomba, Santa Teresa, Aguacate, Big Falls, Blue Creek, Jacinto Ville, Pueblo Viejo, San Jose/San Pablo, Blackman Eddy, San Pedro Columbia, and Ring Tail. Regarding the well rehabilitation programme, communities of San Vicente, Billy White and San Pablo received support through the project impacting approximately 236 households. In addition, through this project, sixty-four (64) households were identified and rain water harvesting treatment systems were installed in Gracie Rock and Freetown Sibun. Also Los Tambos received a 20,000 gallons ground, storage tank that will store water during the dry season.

6.6.2 Alternative Production of Grains and Home Garden Crops in the Belize River Valley

The Belize River Valley Grain Producers project provided irrigation capability for farming in both the dry and rainy seasons to reduce the risk of crop loss due to erratic rainfall patterns and flooding resulting from Climate Change. Estimated cost of project totalled US$ 181,000. The GEF Small Grant Programme, Australia Aid and UNDP were among the donors of this project. This project also allows the Belize River Valley Grain Producers to address issues of Climate Change faced by grain producers and consumers, focuses on the future of grain producers in vulnerable areas, while ensuring economic security of its members. Education, training and adaptation practices were also provided to the communities.

6.6.3 Increasing adaptation and resilience of natural resources users and community stakeholders of Corozal Bay Wildlife Sanctuary to predicted Climate Change impacts

The aim of this project is to reduce the vulnerability of Corozal Bay Wildlife Sanctuary and dependent natural resource users to Climate Change impacts, and provide a foundation from which Sarteneja, Chunox and Copper Bank can increase their resilience to Climate Change impacts.

This project was developed by the community-based Sarteneja Alliance for Conservation and Development (SACD) following a series of community consultations. It received funding through the SIDS-CBA and other sources totalling US$ 90,477.50. The project focuses on strengthening management interventions for Climate Change adaptation for Corozal Bay Wildlife Sanctuary and its primary stakeholder communities, building awareness in Sarteneja, Chunox and Copper Bank of the value of the Wildlife Sanctuary and its coastal mangroves in protecting and assisting the communities in adapting to Climate Change. It also focuses on the critical need to assist communities and those community sectors identified as most at risk to take their first steps towards adaptation, increasing community resilience and decreasing community vulnerability. This is to be achieved through 1) building Climate Change resilience in the highly vulnerable, local artisanal fishing industry; 2) increasing awareness of Climate Change, its predicted impacts and potential adaptation mechanisms in these communities, with the associated development of participatory community adaptation plans.

6.6.4 Promoting Climate Change Adaptation through Resilient and Sustainable Agricultural Practices in the Medina Bank Community

The objective of this project is to improve adaptive capacity, increase food security and promote sustainable development in the Medina Bank community to combat the challenges posed by Climate Change, addressing the thematic areas of "Food Security" and "Natural Resources/Ecosystem Resilience and Related Livelihoods" through nationally replicable activities. Community participants will also see their knowledge on Climate Change increased and will be more able to adapt to its adverse effects. Total project cost is US$ 91,781.57 with funding from Australian Aid, GEF, and the GEF Small Grants Programme.

6.6.5 Management and Protection of Key Biodiversity Areas

The Government of Belize received a US $6.0856 million grant from the Global Environmental Facility to strengthen natural resource management and biodiversity conservation in Key

Biodiversity Areas of Belize. This project will support inter alia, forest protection and sustainable forest management and practices in targeted protected areas, rehabilitation of critical areas of high conservation values by local communities, and community-based sustainable use of ecosystem goods and services, improve management and monitoring of protected areas.

6.6.6 Marine Conservation and Climate Change Project

The Government of Belize under the leadership of the Ministry of Forestry, Fisheries and Sustainable Development with fiduciary management assistance from the Protected Areas Conservation Trust (PACT) as the National Implementing Entity (NIE) and the World Bank as Multilateral Implementing Entity (MIE) is implementing the Marine Conservation and Climate Change Adaptation Project in the coastal areas of Belize. The project cost is for US$6 million and is funded by the Adaptation Fund (AF). The objective of MCCAP is to implement a priority ecosystem-based marine conservation and climate adaptation measures to strengthen the climate resilience of the Belize Barrier Reef System and its productive marine resources. Specifically, the project will support, (i) improvement of the reef's protection regime including an expansion and enforcement of the Marine Protected Areas (MPAs) and Replenishment (no-take) Zones in strategically selected locations to strengthen climate resilience, (ii) promotion of sustainable alternative livelihoods for affected users of the reef, and (iii) building local capacity and raising awareness regarding the overall health of the reef ecosystem and the climate resilience of coral reefs.

6.6.7 Energy Adaptation Project

The proposed project is expected to be funded primarily by a GEF grant of $8 million from the Special Climate Change Fund (SCCF), which is mandated with supporting climate adaptation. Since Climate Change impacts create vulnerabilities in the energy sector in Belize, enhancing resilience of the system will strengthen its ability to adapt. The planned development objective of Energy Resilience and Climate Adaptation Project will therefore be to enhance resilience of the energy system to adverse weather and Climate Change impacts.

6.7 References

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