BELIZE'S FOURTH NATIONAL COMMUNICATION

PREPARED FOR

the United Nations Framework Convention on Climate Change (UNFCCC)

By

Belize

2022

National Climate Change Office, Ministry of Sustainable Development, Climate Change and Disaster Risk Management

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

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

National Climate Change Office
Ministry of Sustainable Development, Climate Change and Disaster Risk Management
The Green Complex Building
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City of Belmopan, Belize

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We would like to acknowledge and thank the National Climate Change Office for the great efforts made in organizing and coordinating the development of the Fourth National Communication. We are thankful for the different ministries and non-government entities who provided data and information in preparation of the document. We also extend our appreciation to the Global Environment Facility (GEF) for the funding and support for this Fourth National Communication.

FOREWORD

Statement from the Hon. Orlando Habet, Minister of the Ministry of Sustainable Development, Climate Change and Disaster Risk Management

Belize, like other Small Island Developing States (SIDS), remains vulnerable to the impacts of climate change. Its geographical location, low level coastline and its reliance on natural resources makes the country especially susceptible to sea-level rise, flooding, ocean acidification, drought, and more. The Vulnerability and Adaptation Assessment conducted in 2019 shows that the coastal, fisheries, water and agriculture sector are all at risk to these impacts of climate change, which in turn will impact the country's economy as these sectors are great contributors to Belize's GDP.

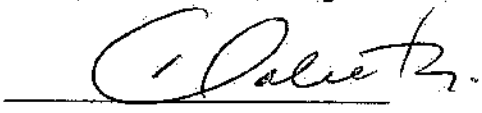
Efforts to facilitate adaptation and mitigation of climate change are important to protect the country and its resources, especially its people who are most at risk. Many coastal communities lack climate-resilient infrastructure and are threatened by tropical storms. Likewise, many rural communities suffer from the changing and now unpredictable weather patterns impacting their everyday lives as they depend on the natural resources for their livelihoods.

It is in this regard that Belize remains vigilant in building the country's resilience to climate change. Most recently Belize updated its Nationally Determined Contribution and worked diligently with national stakeholders in civil society, academia and more to develop a set of mitigation targets that are in line with the Paris Agreement, and a set of adaptation actions designed to develop resilience especially for the most critical sectors and populations in the country.

Our efforts to combat climate change are ongoing. Belize has been a Party to the United Nations Framework Convention on Climate Change (UNFCCC) for almost four decades since it ratified the Convention in 1994. Since then, Belize has submitted three National Communications, updated its Nationally Determined Contribution and, most recently, submitted its First Biennial Update Report (BUR). Belize has been continuous in demonstrating its commitment to the UNFCCC by ensuring that international obligations are met.

It is in this regard that Belize presents its Fourth National Communication which delineates the great strides made in adapting and mitigating climate change impacts. This Fourth National Communication presents the national circumstances, and the efforts and impacts made to address climate change, given our national circumstances. While the work is of great importance and many has been done, Belize recognizes its limitations and constraints, and acknowledges that support is needed.

Nevertheless, Belize aims to continue its efforts with the capacities that will allow us to do so while seeking and welcoming the support of partners across the world. Working together, nationally, regionally, and internationally, a difference will be made as we work toward the goal of the UNFCCC and as well as the Paris Agreement.



Honourable Orlando Habet
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List of abbreviations

AFOLU	Agriculture, Forestry and Other Land Use
APAMO	Association of Protected Areas Management Organizations
BAU	Business as Usual
BCCI	Belize Chamber of Commerce and Industry
BEL	Belize Electricity Limited
BELCOGEN	Belize Co-Generation Energy Limited
BEST	Belize Enterprise for Sustainable Technology
BLPA	Belize Livestock Producers Association
BNCCC	Belize National Climate Change Committee
BNE	Belize Natural Energy
BSWaMA	Belize Solid Waste Management Authority
BUR	Biennial Update Report
BWS	Belize Water Services
BZD	Belize Dollars
CAF	Development Bank of Latin America
CARDI	Caribbean Agricultural Research and Development Institute
CATHALAC	Centre for Humid Tropics of Latin America and the Caribbean
CCCCC	Caribbean Community Climate Change Centre
CCMRV	Climate Change Measuring, Reporting and Verification
CDMS	Climate Data Management System
CFE	Comisión Federal de Energía
CfRN	Coalition for Rainforest Nations
CGE	Consultative Group of Experts
CNTMP	Comprehensive National Transportation Master Plan
COP	Conference of the Parties
CRIP	Climate Resilient Infrastructure Project
CSA	Climate Smart Agriculture
CVRP	Climate Vulnerability Reduction Program
CZMAI	Coastal Zone Management Authority and Institute
DFC	Development Finance Corporation
DRM	Disaster Risk Management
DTM	Digital Terrain Model
EbA	Ecosystem-based approach
ECV	Essential Climate Variables
EIA	Environmental Impact Assessment
FNC	Fourth National Communication
FOLU	Forestry and Other Land Use
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GHG	Greenhouse Gas
IADB	Inter-American Development Bank
ICZMP	Integrated Coastal Zone Management Plan
IICA	Inter-American Institute for Cooperation on Agriculture
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
JCCCP	Japan Caribbean Climate Change Partnership

JICA	Japan International Cooperation Agency
LEDS	Low Emission Development Strategy
LPG	Liquid Petroleum Gas
MAFFESDI	Ministry of Agriculture, Fisheries, Forestry, Environment, Sustainable Development, and Immigration
MCCAP	Marine Conservation and Climate Adaptation Project
MNR	Ministry of Natural Resources
MOW	Ministry of Works
MSDCCDRM	Ministry of Sustainable Development, Climate Change and Disaster Risk Management
MSW	Municipal Solid Waste
MTCA	Ministry of Tourism and Civil Aviation
NAVCO	National Association of Village Councils
NC	National Communication
NCCO	National Climate Change Office
NCCPSAP	National Climate Chang Policy, Strategy and Action Plan
NDE	National Designated Entities
NEMO	National Emergency Management Organization
NIR	National Inventory Report
NMS	National Meteorological Services
OLADE	Latin American Energy Organization
PACT	Protected Areas Conservation Trust
PGIA	Phillip Goldson International Airport
PSIP	Public Sector Investment Programme
QA/QC	Quality Assurance / Quality Control
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SEA	Southern Environmental Association
SIB	Statistical Institute of Belize
SIDS	Small Island Developing State
SIF	Social Investment Fund
SIRDI	Sugar Industry Research and Development Institute
SLR	Sea-Level Rise
SSEL	Santander Sugars Energy Limited
SWMPSP	Solid Waste Management Policy, Strategy and Master Plan
TIDE	Toledo Institute for Development and Environment
TNC	Third National Communication
UB	University of Belize
UNDP	United Nations Development Programme
UNDRR	United Nations for Disaster Risk Reduction
UNEP	United National Environmental Programme
UNESCO	United National Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollars
VCA	Vulnerability and Capacity Assessment
V&A	Vulnerability and Adaptation
WRF	Weather Research Facility
WWF	World Wildlife Fund

Executive Summary

ES.1 National Circumstances

Belize, bordered on the east by the Caribbean Sea, on the north and north-west by Mexico, and on the west and south by Guatemala, is a part of both Central America and the Caribbean. Belize is highly forested, with more than 50% of the mainland covered with forests, and the remaining land consisting mainly of agriculture, arable land, and human settlements.

Belize's two main ecosystems are the marine and the terrestrial ecosystems. There are only two seasons which are wet (rainy) and dry. The wet season runs through June to November alongside the Atlantic hurricane season. There is a cool transition period where rainfall declines and about 12 cold fronts cross the country (National Meteorological Service, n.d.). This occurs from November to February and is known to introduce the true dry season which goes through to April.

According to the Statistical Institute of Belize (SIB), as of 2019 the estimated midyear population was 408,487 persons. Their estimates show majority residing in rural areas with the rural population being about 225,824 persons and the urban population being approximately 182,663 persons.

Also in 2019, Belize's GDP at market prices was 2,886.4 million Belize dollars (USD $1443.2 million) and its GDP per capita at market prices was 7,066.09 million Belize dollars (USD $3,533.05 million) (SIB, 2019). The GDP for 2019 increased by 4.72% when compared to that for 2017 which was 2,756.3 million Belize dollars. The agriculture and tourism sector are the two main sectors that contribute to the majority of Belize's GDP. In Belize, agriculture is driven by sugar, citrus and bananas contributing the most in that order. The tourism sector, on the other hand, is comprised of several subsectors that together is considered the tertiary industry which contributes greatly to Belize's GDP.

Belize's energy profile is categorized into two groups: (i) primary energy supply (indigenous non-renewable and renewable energy) and (ii) secondary energy supply (mostly imported petroleum products and imported electricity). The primary energy supply consists of biomass (57.4%), hydro (5.9%), crude oil (12.6%), petroleum gas (0.9%), wood (23.2%) and solar energy (0.1%) (2019 Annual Energy Report, Energy Unit). The secondary energy supply is contributed by diesel (26.5%), gasoline (26.1%), LPG (9.2%), CFE (9.6%), light fuel oil (0.9%), heavy fuel oil (5.3%), aviation gasoline (0.9%), jet fuel kerosene (15.2%) and kerosene (6.3%) (2019 Annual Energy Report, Energy Unit). Majority of this secondary energy is imported into the country including electricity from the interconnection with Mexico's Comisión Federal de Energía (CFE).

The transport system in Belize is made up of three modes which are road, sea, and air. The road system is made up of primary (highways) (601km), secondary (1,831 km) and lower-class roads (10,675 km) totalling to 13,000 km (CNTMP, 2018). It could be noteworthy to mention that most of the public transport buses in Belize are old school buses imported from the USA with an average age of 25 years and about 80% are diesel-fuelled. Belize's two main commercial seaports are called the Port of Belize and the Port of Big Creek. The port of Belize is the primary cargo entry port for containers and manufactured consumer products as well as fuel imports, while the Port of Big Creek is used to export agricultural products and crude oil. Belize has one international airport named the Phillip Goldson International Airport (PGIA), five aerodromes with 5 paved runways and 41 with unpaved runways.

Waste in Belize is categorized as non-hazardous waste (i.e., municipal solid waste (MSW)), hazardous waste, difficult waste, and inert waste. About 70% of non-hazardous or MSW is collected through an organized collection service by the different municipalities while hazardous waste follows stricter protocols as outlined in the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal to which Belize ratified in 1997 (SWMPSP, 2015). The Belize Solid Waste Management Authority (BSWaMA) is responsible for the safe and environmentally sound management of solid waste in Belize. This Authority oversees five transfer stations, and one sanitary landfill named the "Regional Sanitary Landfill".

The agriculture and food sector is one of the greatest contributors to the Belizean economy. Contributing approximately $590 million annually to economic output, agriculture represents 80% of domestic exports, and this sector directly employs 17.9% of the Belizean population (Ministry of Agriculture, 2018). Agriculture is distributed throughout the country with sugarcane being more concentrated in the north and citrus in the south. Agroforestry practices, relatively recent, also exist mostly in southern Belize for cacao-based and other rotational crop products. Belize has developed and finalized an Agroforestry Policy in 2020 to facilitate further agroforestry practices in the country.

Belize is home to various forest types including broadleaf forests, which is the most common, pine forests, mangroves, and mixed forests. Recent studies show Belize's total forest cover to be around 61.75% with a deforestation rate of 9712 ha per annum or 5.56% forest cover loss per year as of 2018 (Forest Department, 2019). According to the Forest Department Strategic Action Plan, 40% or 1.36 million acres of Belize's forested area is under protected area status with the remaining 60% consisting of either private or public lands which are not directly managed for forestry purposes.

The National Climate Change Policy, Strategy and Action Plan, developed and approved in 2015, is the guiding instrument in Belize that guides 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 Government of Belize remains committed to strategically combat climate change in an effort to protect its people, natural resources, and economy against the detrimental impacts that have and can result from climate change.

ES.2 National Greenhouse Gas Inventory

The National Greenhouse Gas Inventory Chapter, in accordance with article 4, paragraph 1(a), and article 12, paragraph 1(a) of the UNFCCC, communicates the country's anthropogenic emissions for the Energy, Industrial Processes and Product Use, Agriculture, Forestry and Other Land Uses, and the Waste sectors for reference years 2012, 2015, 2017, 2018 and 2019.

The energy sector presented that emissions have continuously increased from 2012 to 2019. The transport subsector contributes the highest number of emissions in the form of carbon dioxide. The electricity generation subsector experienced a slight increase in the use of petroleum fuels, and usage of renewable resources along with the importation of electricity from Mexico mitigated greater greenhouse gases emissions for this subsector.

The fuel usage for national aviation has now become significant compared to the last national report which categorized it as insignificant. There was a large increase in aviation fuel which was used by

international flights arriving in Belize. The greenhouse emissions for international aviation were reported under the caption of international bunkers and not accounted in national total.

Biomass usage for industrial and domestic energy production continued to increase as an alternative to petroleum products. Biomass is primarily used in the generation of energy by utilizing sugarcane bagasse from the sugar industry. The increase of biomass usage also increased the greenhouse gases emissions. However, the sugarcane plants that are used as biomass capture nearly the equivalent amount of CO_2 through photosynthesis which contributes to removal of CO_2 generated from the combustion of this biomass. For this reason, CO_2 emissions from biomass combustion are not included in the national total, however non-CO_2 emissions are.

For the Industrial Processes and Product Use (IPPU) sector, data revealed that emissions continue to be released from the same sources as those for the previous inventories. Indications are that industrial activities continue to increase slowly as Belize's economic development progresses. The results obtained for the study period indicated that overall emissions from the IPPU sector have shown slow increase between 2012 and 2015 and remained relatively consistent between 2015, 2017 and 2018, with a slight drop in 2019. The current inventory results show that only two areas are significant sources of GHGs in the IPPU sector in Belize. These are product uses as substitutes for ozone depleting substances, and mineral production.

As it relates to the Agriculture, Forestry and Other Land Use (AFLOU) sector, results suggest that the emissions from the agriculture sector vary depending on the annual crop and livestock production. Methane emissions from livestock demonstrated a trend of constant increase over the study period. On the other hand, emissions from rice production remained almost constant over the same period. Rice consumption has not increased rapidly and might even be affected by clandestine imports. Observations also suggest that the trends in local production also respond to the global markets for these commodities in any given year.

Enteric fermentation accounts for 46% of the emissions from agriculture on an annual average over the study period, 2012-2019. N_2O emissions from managed soils and manure management account for 20% each, followed by biomass burning and manure management at approximately 4% respectively. Rice cultivation and Urea Application both account for 3% of emissions in the sector.

Highly accurate activity data for Forestry and Other Land Use sector was derived from the Collect Earth image visualization tool to obtain spatially explicit annual data of land use and land use change for time series of 2000-2017. For this inventory, emissions and removals are shown for the reference years and the recalculated years (1994-2019).

The Forest and Other Land Use subsector shows a generalized increase in land-based emissions (subcategory 3B, Land) from 1994 to 1997. However, for the time 2000 onward the generalized trend is one of fluctuating decreases and increases which can be attributed to natural disturbances, and in some instances attributed to the change in land use.

Cropland (food crops) and Grassland (livestock pastures) were the major drivers of Forest conversion, with Grassland being the most significant contributor on average for the four reference years.

There was a major spike in emissions in 2011 when an estimated area of 16,386 ha of forest were converted to Grassland. This was due to Hurricane Richard in 2010. It is also noted that in the years 2001, 2002, and 2003, there were major conversions of Forest lands to Grasslands. This period of conversion was due to thousands of hectares of forested lands in the Mountain Pine Ridge and Coastal Plains area being affected by the southern pine bark beetle pest infestation that impacted the country between 1999 and 2001.

Examination of the data for forest conversions for the reference years of 2012, 2015, 2017 and 2019 revealed that both Cropland and Grassland were major drivers for forest conversions.

As for the disturbances occurring in national forests that were not converted to other land uses, it can be noted that hurricanes have impacted forests sink capabilities, and commonly lead to other disturbance types such as fire, logging activities, conversion to pasture, and cultivation. For the years 2001 and 2010, there were significant disturbances noted in areas that did not have a land conversion but still were affected by Hurricane Iris (2001) and Hurricane Richard (2010) showing once more the significance of the occurrence of hurricanes over the years.

The Waste sector presents an overall trend of increasing methane emissions from solid waste disposal that arose from increasing population. The improved treatment of waste has not totally cancelled the methane emissions as the population increases. However, there is a notable decrease in GHG emissions because of decreased open burning, particularly in municipalities that are serviced by transfer stations and sanitary landfills.

Emissions from wastewater discharge represent the majority emissions in the waste sector. For industrial liquid waste sub-sector, there is no formal registration or estimation of liquid waste generated within the industrial sector (including both large industries like banana, and smaller ones like shrimp). Some data is available from the citrus and sugar industries. This source of data is important because it is noted that the waste-water sector is increasingly becoming of greater significance in greenhouse gas emissions. Even with the limited data available about this source of greenhouse gas emissions, the total emissions from the waste sector increased significantly with the input of the wastewater sector data over the study period.

ES.3 Adaptation Information and Measures

This chapter discusses different aspects of adaptation, especially as it relates to the economically, environmentally, and socially vital sectors of Belize. The information for this chapter was provided by two methods of data collection via (1) a climate change survey and (2) a vulnerability and adaptation assessment.

The climate change survey allowed stakeholders to share information on their level of awareness on climate adaptation, document the current status of adaptation activities in their organizations and the obstacles they face, track changes in adaptation activities over time, and make recommendations based on the findings of the analysed adaptation actions.

The results of the survey have been grouped into three general categories in order to do an analysis: understanding climate change, adapting to climate change, and drivers & obstacles to climate change adaptation.

Many of Belize's organizations are informed about climate change to some level which is accurate as many of them have had a close working relationship with the National Climate Change Office as it relates to the coordination of climate change activities. The majority of them are also in agreement that climate change poses a serious problem for Belize and are aware of the impacts that comes with it, such as droughts, flooding, temperature increase, to name a few.

Many organizations or entities in Belize are at different stages of planning and execution as it relates to adaption actions. Most do not have a policy or plan to address climate change. While it may be integrated within goals, it is not specifically targeted. Most organizations within Belize are within the planning stages of adaptation, which involves developing a way forward, assessing options to prepare for and decrease vulnerabilities and risks to climate change, and increasing their organization's resilience. Fewer are within the implementation phase, meaning they have completed their planning and implemented the identified adaptation solutions and monitored their effects. Other organizations are still focusing on knowledge building, i.e., trying to gather information and knowledge to understand the potential impacts of climate change and vulnerabilities.

At a national level, the main drivers to adapt to the effects of climate change are related to increasing socio-economic resilience, mostly related to income generation and livelihoods; ensuring sustainable management of resources and productive sectors; and increasing knowledge and awareness. At an organizational level, the main obstacles faced as they become aware of or involved in adaptation planning include insufficient human and financial resources and insufficient technical expertise to analyse and utilize relevant information.

A Vulnerability and Adaptation Assessment was conducted in 2019 for the following sectors: coastal zone, water, agriculture, and fisheries, in Central Belize and South-Central Belize. Each of the nine types of hazards is assessed per sector and according to the corresponding sensitivity identified for four elements: Social, Infrastructure, Economic, and Natural Systems.

The Vulnerability and Adaptation Assessment focuses on two rectangular sites. It is estimated that 150,000 people live within the project's polygons in Central and South-Central Belize. The nine types of hazards considered in this study are: ocean acidification/warming, sea-level rise, storm frequency/intensity, coastal erosion, fluvial and pluvial flooding, water availability, temperature rise, and saltwater intrusion. Under each, the exposure and sensitivity analysis, social vulnerability economic vulnerability, and natural systems vulnerability was analysed under each of the four sectors that was assessed.

Based on the findings of the assessment, proposed recommended adaptation measures were proposed for each sector as well as proposed policy measures to support adaptation in each sector.

Tracking adaptation actions is one of the first steps to ensure that adaptation actions will lead to increased resilience. Through its Public Sector Investment Programme (PSIP) report, the Government of Belize tracks all projects. Those related to climate change adaptation have been reviewed and included in Belize's climate change adaptation action portfolio. Additional adaptation activities that are currently being carried out were also gathered from the Climate Adaptation Analysis

survey. Both sources help to provide a more comprehensive list of adaptation measures carried out from 2015 to 2019.

ES.4 Measures to Mitigate Climate Change

In 2019, Belize conducted a Mitigation Assessment that provided information for the preparation of this Fourth National Communication and its first Biennial Update Report. This assessment provided key information such as: the implemented mitigation actions for the country, how those actions affected the different sectors and the identification of other appropriate mitigation options (Biennial Update Report, 2020).

The Greenhouse Gas Emissions Profile is an assessment that provides specific data that shows GHG emission levels from the different sectors. Emission Profiles are utilized to make effective mitigation measures where the main structure of it is the GHG Inventory. From this assessment, the Forestry and Other Land Use (FOLU) Sector is shown to have the greatest impact in Belize's emissions. This sector, however, acts as a carbon sink and is responsible for Belize removing more GHGs than it is emitting for its historic period (which covers up to 2017). Even though Belize is a net remover, there are still GHG emissions occurring in the sectors of Energy, Agriculture, Waste and Industrial Processes and Product Use (IPPU).

An assessment was done for all the sectors for the mitigation measures/actions that occurred from the reference period of 2015. As stated in the First Biennial Update Report (2020), these measures are divided into two categories: (i)Mitigation Actions with GHG Impacts and (ii) Mitigation Actions without GHG Impacts.

From the assessment of the implemented mitigation actions that are presented, these options were used to develop the GHG emissions scenarios (Biennial Update Report, 2020). Additional mitigation options were also developed from a Technology Needs Assessment that was developed in 2017 and is the basis for the suggested options. These mitigation options are divided and explained by each sector, where some are broken down into mitigation options that can be undertaken by the subsectors.

An initiative that is geared towards making extensive strides in emissions reduction is the development of a Low Emission Development Strategy (LEDS). The LEDS is planned to be a strategy and action plan that will assist Belize in the development of a sustainable low-carbon economy, while prioritizing positive socio-economic progression. The LEDS will prioritize certain objectives that will achieve socio-economic development, connect low-emission development actions to national and sectoral development plans, as well as linking financial, technological, and capacity needs for the LEDS implementation.

Even though some of the barriers for effective mitigation were covered in the mitigation options section, there are still some barriers that Belize face for full emissions reduction to occur. These include institutional, technological, and social and cultural barriers.

ES.5 Constraints and Gaps, Related Financial, Technical and Capacity Needs

Belize recently reported on its national GHG emissions and removals in the Energy; Industrial Processes and Product Use; Agriculture, Forest, and Other Land Use; and Waste Sectors. Though

improvements have been made, existing limitations and gaps were identified and highlighted in Belize's Fourth Greenhouse Gas Inventory Report.

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

A recent study on Belize's climate finance landscape for the period 2015-2019 showed a total of BZD 454,740,347 was geared to climate investments in the country. Of the 6 sources of financing highlighted, multilateral development banks represented the highest figure with a total of were BZD 179,276,386, representing 39.42% of total climate investments for that period. (Climate Finance Landscape of Belize 2015-2019, 2021).

There is need for greater financing for the country to effectively address the impacts of climate change. In an effort to do this, a Technology Needs Assessment was carried out in 2017 to identify and prioritize technologies and tools that can contribute to adaptation and mitigation goals compatible with national sustainable development goals and priorities.

Expanding national capacity becomes increasingly important under the implementation of the Paris Agreement, whereby the focus on intensified emission reduction efforts will be needed while simultaneously increasing resilience to climate change impacts. There have been several capacity-building initiatives undertaken in several areas during the period 2015-2019.

Public Education and awareness continue to be key in driving national support for climate action, encouraging support for government policies and measures, and influencing positive change in habits. Belize continues to make strides in educating the populace on climate related issues through both public and private sector initiatives, with significant progress achieved through the Marine Conservation and Climate Adaptation Project (MCCAP).

1 National Circumstances

1.1 Geography

Belize, bordered on the east by the Caribbean Sea, on the north and north-west by Mexico, and on the west and south by Guatemala, is a part of both Central America and the Caribbean. Figure 1.1 provides a visual representation of Belize's geographical location. It is the only English-speaking country of the seven countries that make up Central America. It lies between 15°45' and 18°30' north latitude, and 87°30' and 89°15' west longitude and its national territory is made up of 46,620 sq. km (18,000 sq. miles). Of this, the land area is approximately 22,967 sq. km (8,867 sq. miles) which includes 280 km of coastal land. Belize is highly forested, with more than 50% of the mainland covered with forests, and the remaining land consisting mainly of agriculture, arable land, and human settlements. The mainland makes up 95% of the national territory with the remaining 5% contributed by over 1,060 small islands and cayes (National Meteorological Service, n.d.).

Figure 1.1 Belize's Geographical Location

Source: https://geology.com/world/belize-satellite-image.shtml

1.2 Ecology & Environment

Belize's two main ecosystems are the marine and the terrestrial ecosystem. Broadleaf and pine forests make up the terrestrial ecosystem along with several lakes and rivers that run throughout the country. Meanwhile, the country's marine ecosystem includes open ocean, coral reefs, and seagrass beds.

Belize is known to have the largest barrier reef in the northern hemisphere and the second largest in the world. The Belize Barrier Reef Reserve Systems is a UNESCO World Heritage site and is important as it provides a habitat for several threatened marine species. Belize is also known for its pre-Columbian Maya archaeological sites, namely Xunantunich, Altun Ha, and Caracol, etc. There are also several protected areas in the country covering about 36% of Belize's land surface (Cherrington et al., 2010).

1.3 Climate

Belize only has two seasons which are wet (rainy) and dry. The wet season runs through June to November alongside the Atlantic hurricane season. About 60% of annual precipitation occurs during the wet season which begins in the south and moves up north where a subtropical climate occurs with an annual rainfall of 1500 mm (60 inches). Southward, the climate is more tropical, and experiences annual rainfall increases up to 3800 mm (150 inches) (National Meteorological Service,

n.d.). There is a cool transition period where rainfall declines and about 12 cold fronts cross the country (National Meteorological Service, n.d.). This occurs from November to February and is known to introduce the true dry season which goes through to April.

Average maximum temperatures for Belize are approximately 85°F (29.5°C) while average minimum temperatures range in the low 70s (F°) (20°C). Daytime temperature range is greater inland while along the coast it is cooler due to sea breezes. Belize's mountainous regions are also cooler as it experiences a 5°F (-15 °C) fall in temperature per 1000ft. Humidity for the country hovers around 80% throughout the year but is lower during the dry season (National Meteorological Service, n.d.).

Since Belize is bordered on the east by the Caribbean Sea, which is a part of the Atlantic Basin, it is affected by the Atlantic hurricane season. The country's geographical location makes it especially vulnerable to tropical cyclones. Belize City, the former capital, was destroyed twice by hurricanes in the 20th century. Hurricanes can affect any part of the country but are more frequent in the north (National Meteorological Service, n.d.).

1.4 Population

According to the Statistical Institute of Belize (SIB), as of 2019 the estimated midyear population was 408,487 persons. Their estimates show majority residing in rural areas with the rural population being about 225,824 persons and the urban population being approximately 182,663 persons. **Table 1.1** presents this information along with other categories of distribution. Belize's population growth rate remains at an annual average rate of 2.65% (Statistical Institute of Belize, 2020). The country's fertility rate is 22.2% and mortality rate is 3.6%. Belize's average life expectancy is 70 years: 68 for males and 73 for females (Statistical Institute of Belize, n.d.).

Table 1.1 Population Distribution

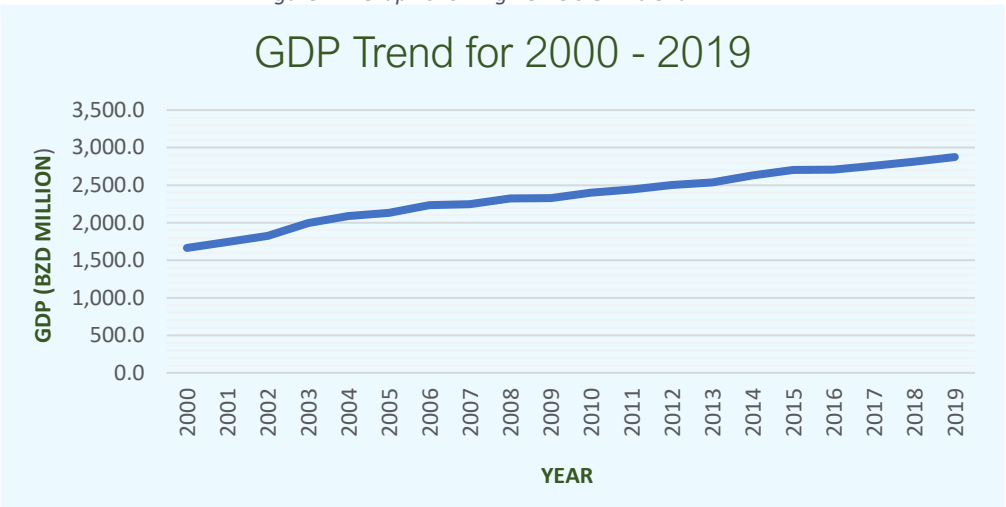
Population by Area	
Urban	182663
Rural	225824
Population by District	
Corozal	49,446
Orange Walk	52,550
Belize	124,096
Cayo	99,118
Stann Creek	44,720
Toledo	38,557
Population by Gender	
Male	204,247
Females	204,240
Total Population	408,487
Total Population Density	46 sq. m

**Data received from Statistical Institute of Belize, 2019*

1.5 Economy

In 2019, Belize's GDP at market prices was 2,886.4 million Belize dollars (USD $1443.2 million) and its GDP per capita at market prices was 7,066.09 million Belize dollars (USD $3,533.05 million) (SIB, 2019). The GDP for 2019 increased by 4.72% when compared to that for 2017 which was 2,756.3 million Belize dollars. Belize's GDP trend can be observed in **Figure 1.2**.

Figure 1.2 Graph showing Belize's GDP trend



**Data received from the Statistical Institute of Belize, 2021*

The country's economic profile is divided into primary, secondary, and tertiary industries. **Table 1.2** shows the three industries and their contributing sectors. As is the usual trend, the tertiary industry was the highest contributing industry. The agriculture and tourism sector are the two main sectors that contribute to the majority of Belize's GDP. In Belize, agriculture is driven by sugar, citrus and bananas contributing the most in that order. The tertiary industry has several sectors that overall represents the tourism sector that contributes greatly to Belize's GDP.

Table 1.2 Economic industries and their contributing sectors (in BZD million)

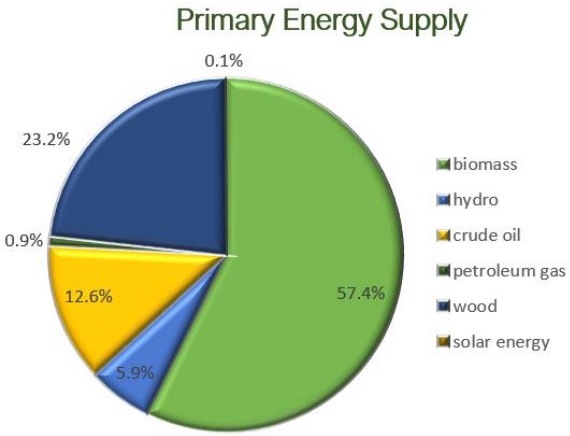
Primary Industries		
Agriculture, hunting and forestry		237.0
Fishing		27.7
Mining and quarrying		10.0
	Total	274.6
Secondary Industries		
Manufacturing		171.6
Electricity and water supply		114.6
Construction		98.4
	Total	384.6
Tertiary Industries		
Transport and communication		242.2
Government services		341.4
Hotels and restaurants		122.2
Wholesale and retail		583.5
Financial intermediation		258.7
Real estate, renting and business services		244.1
Community, social and personal services		153.0
	Total	1945.2

*Data received from the Statistical Institute of Belize, 2021

1.6 Energy

Belize's energy profile is categorized into two groups: (i) primary energy supply (indigenous non-renewable and renewable energy) and (ii) secondary energy supply (mostly imported petroleum products and imported electricity). The primary energy supply consists of biomass (57.4%), hydro (5.9%), crude oil (12.6%), petroleum gas (0.9%), wood (23.2%) and solar energy (0.1%) (2019 Annual Energy Report, Energy Unit). **Figure 1.3** shows the shares that make up the primary energy supply. Belize's four hydropower plants that supply renewable power (and their capacity) are the Mollejon Hydroelectric Plant (25.2 MW), the Vaca Hydroelectric Plant (19 MW), the Chalillo Hydro Dam (7 MW) and Hydro Maya Limited (3.3 MW). As for biomass, BELCOGEN (13.5MW) and Santander Sugar Energy Ltd (8 MW) are the two sugar mill cogeneration plants that use sugar cane bagasse for both facility generation and national grid exports. There is one agency in Belize who supplies solar energy to the national grid, and this is the Japan International Cooperation Agency which has a capacity of 0.3 MW.

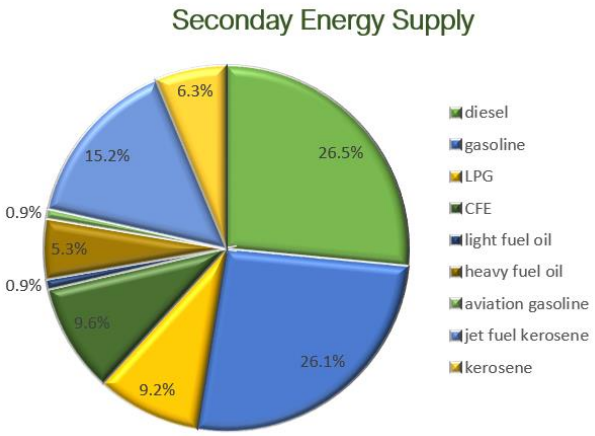
Figure 1.3 Share of primary energy supply



**Data received from the 2019 Annual Energy Report, Energy Unit*

The secondary energy supply (**Figure 1.4***)* is contributed by diesel (26.5%), gasoline (26.1%), LPG (9.2%), CFE (9.6%), light fuel oil (0.9%), heavy fuel oil (5.3%), aviation gasoline (0.9%), jet fuel kerosene (15.2%) and kerosene (6.3%) (2019 Annual Energy Report, Energy Unit). Majority of this secondary energy is imported into the country including electricity from the interconnection with Mexico's Comisión Federal de Energía (CFE) whose capacity is 55 MW (2019 Annual Energy Report, Energy Unit).

Figure 1.4 Share of secondary energy supply



**Data received from the 2019 Annual Energy Report, Energy Unit*

The Belize Electricity Limited (BEL) is the entity responsible for distributing electricity throughout the country. According to their 2019 Annual Report, BEL's national electricity grid connects all major municipalities and extended services to 17 communities in 2019. The electricity grid utilizes hydroelectricity, biomass, petroleum, and solar energy as well as imported energy from Mexico. This report also states that renewable sources accounted for 58.6% of in-country generated supply in 2019 and that Belize remains the number one renewable electricity producer in the Caribbean and number two in the entire North and Central America. The mean electricity rate increased in 2019 after adjustments were made to electricity tariffs. Therefore, since 2017, it increased from 37.51 cents to 41.38 cents per kWh and a total of 690.77 GWh of electricity was produced in 2019 (2019 Annual Energy Report, Energy Unit).

Belize Natural Energy (BNE) is Belize's only oil producer. As of 2019, BNE was extracting 713.3 barrels of crude oil per day which contributes to a decreasing trend over the past years where in 2010 they were extracting 4,130 barrels per day (2019 Annual Energy Report, Energy Unit). Since Belize has no local refineries, PUMA Energy Limited is the sole importer of all refined oil products. Gasoline holds the largest share of imported oil product at 28,452,399 US gallons followed by diesel at 25,950,855 US gallons in 2019 (2019 Annual Energy Report, Energy Unit).

1.7 Transport

In Belize, the transport sector is managed by two entities who each have their own responsibilities. These are the Department of Transport under the Ministry of Public Utilities, Energy and Logistics and the Ministry of Infrastructure Development and Housing (formerly known as the Ministry of Works). The Department of Transport manages and establishes the policies and guidelines with which that road users must abide. The ministry of Infrastructure Development and Housing oversees the physical provision and maintenance of roads, highways, and waterways.

The transport system in Belize is made up of three modes which are road, sea, and air. The road system is made up of primary (highways) (601km), secondary (1,831 km) and lower-class roads (10,675 km) totalling to 13,000 km (CNTMP, 2018). According to the Comprehensive National Transportation Master Plan, public transport accounts for 34.6 % of average daily trips and is expected to increase to 41% by 2025. It could be noteworthy to mention that most of the public transport buses in Belize are old school buses imported from the USA with an average age of 25 years and about 80% are diesel.

Belize's two main commercial seaports are called the Port of Belize and the Port of Big Creek. The port of Belize is the primary cargo entry port for containers and manufactured consumer products as well as fuel import. This port, located in Belize City, has the capacity to accommodate one-149 m vessel and is also used for transporting domestic cargo by barge to and from the cayes. The Port of Big Creek is located in the south of Belize and is used to export bananas and other agricultural products as well as crude oil. It can accommodate bulk carriers to a carrying capacity of 13,000 t (CNTMP, 2018).

Belize has one international airport named the Phillip Goldson International Airport (PGIA), five aerodromes with 5 paved runways and 41 with unpaved runways. There are two registered domestic air carriers namely Tropic Air and Maya Island Air. The Belize Airport Authority regulates the country's airstrips with the use of the Civil Aviation Act of 2000.

The Comprehensive National Transportation Master Plan (CNTMP) was developed in 2018 to aid in facilitating strategic sector planning and more efficient and effective transport of people and freight within the country, and between Belize and its main trading partners.

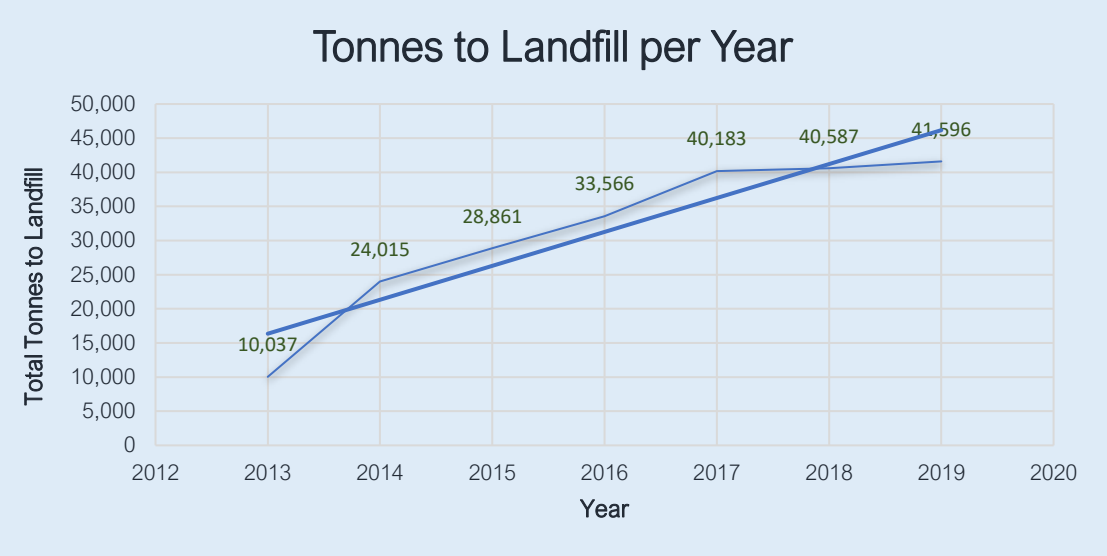
1.8 Waste

Waste in Belize is categorized as non-hazardous waste i.e., municipal solid waste (MSW), hazardous waste, difficult waste, and inert waste. About 70% of non-hazardous or MSW is collected through an organized collection service while hazardous waste follows stricter protocols as outlined in the Basel

Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal to which Belize ratified in 1997 (SWMPSP, 2015). Difficult waste, such as slaughterhouse waste or condemned foodstuff, does not necessarily pose major health or environmental risks but nevertheless is handled and disposed of separately from MSW. Inert waste refers to waste that does not undergo physical, chemical, or biological transformations and affects other matter it comes into contact with.

The Belize Solid Waste Management Authority (BSWaMA) is responsible for the safe and environmentally sound management of solid waste in Belize. This Authority oversees five transfer stations, and one sanitary landfill named the Regional Sanitary Landfill. This is located on a parcel of land of 370 acres and according to the BSWaMA's website, it is the final disposal location for waste generating from municipalities in the Western Corridor of Belize. Figure 1.5 shows the increase of total tonnes the landfill has received annually. Tonnes to landfill has remained relatively constant since 2017 with only a 3.3% increase to 2019.

Figure 1.5 Tonnes to landfill per year (2013 - 2019)



**Data received from the Statistical Institute of Belize*

1.9 Agriculture

The agriculture and food sector is one of the greatest contributors to the Belizean economy. Contributing approximately $590 million annually to economic output, agriculture represents 80% of domestic exports, and this sector directly employs 17.9% of the Belizean population (Ministry of Agriculture, 2018). The sector is comprised of a large-scale commercial sector, traditional small-scale farms, and the traditional export sector for sugar, banana, and citrus (CARDI, n.d.). In 2019, the primary agriculture output value at producer's price was $518,298,545.82 Belize dollars (Ministry of Agriculture, 2020).

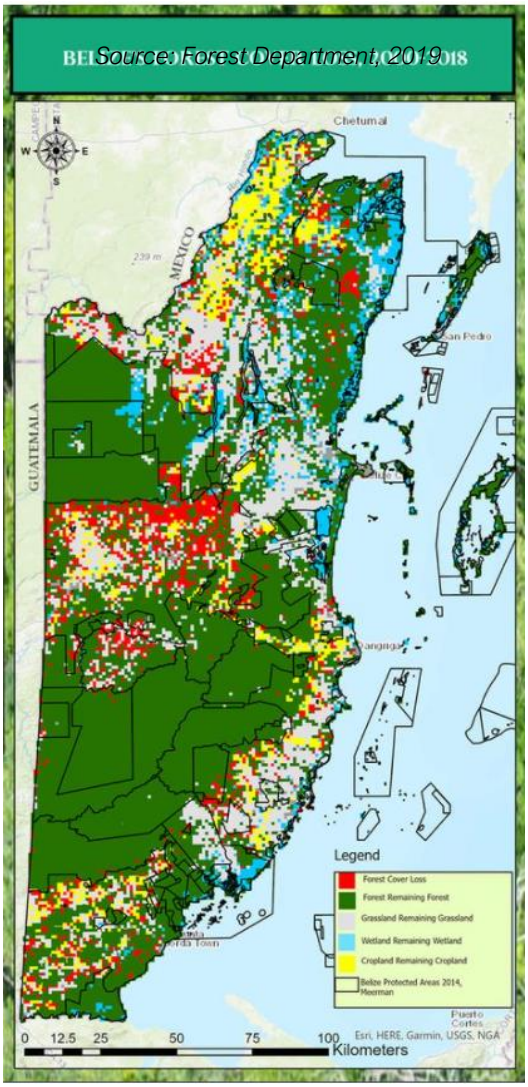
Agriculture is distributed throughout the country with sugarcane being more concentrated in the north and citrus in the south. Several production systems are used such as shifting cultivation processes and fully mechanized operations varying on what is being farmed and whether they are small or large-scale farmers. Semi-mechanized practices are another system used in larger crop industries such as

sugarcane, citrus, banana, beans, and vegetables. Other crops such as corn and rice are grown using mechanized practices and mainly used by large-scale Mennonite farmers. Agroforestry practices, relatively recent, also exist mostly in southern Belize for cacao-based and other rotational crop products. Belize has developed and finalized an Agroforestry Policy in 2020 to further facilitate the implementation of agroforestry practices in the country. Currently, Belize has a revised National Agriculture and Food Policy (2015 – 2030) which aims to provide an environment that is conducive to increasing production and productivity, promoting investment, and encouraging private sector involvement in agribusiness enterprises in a manner that ensures competitiveness, quality production, trade, and sustainability.

1.10 Forestry

Belize is home to various forest types including broadleaf forests, which is the most common, pine forests, mangroves, and mixed forests. The country's forest system is quite diverse despite being mostly dominated by broadleaf forests. It also comprises of other vegetation, water/wetlands, agriculture, and urban/industrialized areas (National Forest Policy, 2015). Recent studies show Belize's total forest cover to be around 61.75% with a deforestation rate of 9712 ha per annum or 5.56% forest cover loss per year as of 2018 (Forest Department, 2019). Figure 1.6 provides a visual representation of the country's forest cover loss for 2000 – 2018. According to the Forest Department Strategic Action Plan, 40% or 1.36 million acres of Belize's forested area is under protected area status with the remaining 60% consisting of either private or public lands which are not directly managed for forestry purposes. It further states that 65% or 884,000 acres of the publicly owned and managed forests are set aside for timber production and the remaining areas are managed for non-extractive purposes.

Figure 1.6 Belize's Forest Cover Loss 2000 - 2018



Source: Forest Department, 2019

1.11 Climate Change Management

The National Climate Change Policy, Strategy and Action Plan, developed and approved in 2015, is the guiding instrument in Belize that guides 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.

Presently, the Belize National Climate Change Committee (BNCCC) is the leading strategic entity responsible for the endorsement of major climate change related activities, policies and plans and therefore holistically responsible for mainstreaming climate change into the broader national development agenda. The BNCCC is chaired by the *MSDCCDRM* and is made up of representatives from related governmental bodies, private sector and civil society and academia (NCCPSAP, 2015). There are two subcommittees under the BNCCC, the Technical Subcommittee and Climate Finance Subcommittee, who provides technical guidance on adaptation and mitigation efforts, and provides oversight of delivery of climate change financing and areas of economic expansion, respectively.

The National Climate Change Office (NCCO), under the Ministry of Sustainable Development, Climate Change and Disaster Risk Management, functions as the Secretariat. The MSDCCDRM houses the UNFCCC Focal point, whereby NCCO takes the leading role in ensuring preparation and submission of major national reports such as NCs, BURs and NIRs for review and endorsement at the committee level before final endorsement by the Cabinet.

The Government of Belize remains committed to strategically combating climate change in an effort to protect its people, natural resources, and economy against the detrimental impacts that have and can result from climate change. Therefore, besides the NCCPSAP, Belize has other national documents that presents its commitments and showcases its efforts in staying true to these promises. These include the Nationally Determined Contributions (2016), the GHG Mitigation Assessment and National Mitigation Strategy (2019), a National Climate Resilient Investment Plan, and other national sectoral plans.

2 National Greenhouse Gas Inventory

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 2012, 2015, 2017, 2018 and 2019 were conducted and sought to capture new sources and sinks in addition to those described in the initial, second and third national communications that might have arisen because of recent developments in the country.

2.1 Methodology

The National Climate Change Office and staff of government departments were stakeholders in the process to collect and validate activity data for the inventory. The recommendations from the peer review exercise were shared with data collectors to provide additional guidance to their work.

2.2 Energy

2.2.1 Sector Background

Belize has made considerable advances in the usage of alternative energy sources such as biomass and hydro power, but petroleum-based fuels are still the main sources of energy as is described in this report through the analysis of fuel importation and usage. The generation of electricity saw slight increases in the usage of petroleum fuels combined with the continual use of hydro power, biomass and the importation of electricity from neighboring Mexico. As the economy continued to grow, the transport sector increased the use of petroleum fuels such as gasoline (premium, regular, and aviation), diesel and kerosene.

The local aviation transport sector, once considered insignificant in relation to greenhouse gas emissions reporting, has started to show an increase in petroleum fuel usage. This can be tied to the usage of fuel by the domestic airlines, but this is supplemented by the increased number of international airlines landing in Belize. The fuel usage by international airlines is described under international bunkers. Lastly, fugitive emissions from natural gas flaring from Belize's small oil and gas industry were not estimated due to data limitations.

2.2.2 Results of GHG emissions and removals

Table 2.1 presents some details of the emissions generated through activities within the Energy sector, the transport sub-sector, and other subsectors which include the residential sector. As depicted, emissions from the sector have continuously increased from 2012 to 2019. The transport subsector contributes the highest number of emissions in the form of carbon dioxide. It should also be noted that consumption of Petroleum fuels increased within the Transport sub-sector although the values for land and marine showed slight decreases in 2017. Compared to carbon dioxide, methane and nitrous oxides are emitted in trace amounts.

Biomass continued to be a major contributor in the mix for electricity production in Belize. Studies have noted that biomass for residential consumption is also increasing as a source of CO2 emissions, indicating that the use of wood for residential energy (cooking) is increasing. Continually increasing cost of kerosene and propane/butane is probably influencing the increased use of firewood for cooking.

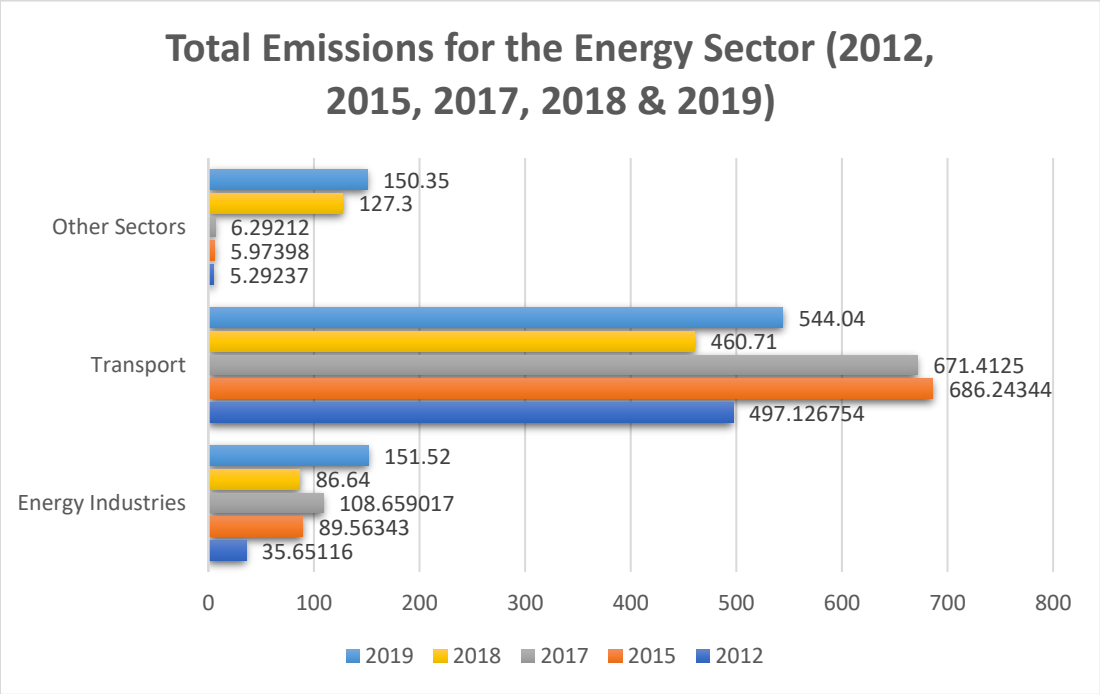
It was observed that consumption of Petroleum fuels increased within the Transport sub-sector although the values for land and marine showed slight decreases in 2017 (**Table 2.1**). The table further shows that CO2 emissions by residential use of biomass continue to increase.

Table 2.1 Summary of Energy Sector GHG Emissions for 2012, 2015, 2017, 2018 and 2019 (Gg $CO_{2\,eq}$)

Subsector	2012			2015			2017			2018			2019		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Overall Total	538.07			781.36			786.36			674.63			845.92		
Energy Industries	27.856	0.017	0.116	80.189	0.043	0.064	96.998	0.051	0.015	75.32	4.34	6.96	139.09	4.76	7.68
Transport	529.455	0.4813	7.17	715.307	0.6803	10.1121	732.21	6.553	9.7871	451.21	2.95	6.55	532.99	3.26	7.79
Others (residential)	78.61	4.42	0.870	88.73	4.992	0.982	93.451	5.257	1.035	122.02	4.45	0.80	144.78	4.69	0.88

Figure 2.1 substantiates the fact that the transport sub-sector was the most significant source of GHG emissions during the entire period. Throughout the study period, emissions from the Transport and Energy generation sub-sector have taken a steady increase, highlighting the increasing energy demand, as well as increased vehicle use. The emissions due to biomass use for "Other", residential cook stoves, are significantly less than other energy uses, and indicate a steady trend throughout the study period.

Figure 2.1 Emissions for Energy Subsectors (GG $CO_{2\,eq}$)



2.2.3 Analysis of results

Petroleum fuels import increased since 2012. The electricity generation subsector saw a slight increase in the use of petroleum fuels. The usage of renewable resources along with the importation of electricity from Mexico mitigated greater greenhouse gases emissions for electricity generation. The largest increase of petroleum fuel usage for the same study period was in the transport sub-sector which increased the greenhouse gases emissions between 2012 and 2019. The increase in petroleum fuel usage was for land, maritime and air transportation. However, there was a decrease in petroleum products usage and emissions for the transport subsector in 2017.

The fuel usage for national aviation has now become significant compared to the last national report which categorized it as insignificant. There was a large increase in aviation fuel which was used by international flights arriving in Belize. The greenhouse emissions for international aviation were reported under the caption of international bunkers and not accounted in national total.

Biomass usage for industrial and domestic energy production continued to increase as an alternative to petroleum products. Biomass is primarily used in the generation of energy by utilizing sugarcane bagasse from the sugar industry. There has been an increase in the use of Biomass for the past few years, especially with the addition of Santander Sugar Energy Ltd. producing electricity for the national grid. The increase of biomass usage also increased the greenhouse gases emissions. However, the sugarcane plants that are used as biomass capture nearly the equivalent amount of CO2 through photosynthesis which contributes to removal of CO2 generated from the combustion of this biomass. For this reason, CO2 emissions from biomass combustion are not included in the national total, however non-CO2 emissions are.

2.3 Industrial processes and product use

2.3.1 Sector Background

Industrialization in Belize is advancing at a slow pace being somewhat limited by energy and labour costs. Activities which release greenhouse gas emissions within the Industrial Processes and other Product Use Sectors occur within a narrow range. There are very few of the sub-sectors displaying any reasonable level of activity to be estimated, these being lime production and road paving with asphalt in the Mineral Products subsector, and the production of beer, wine, and spirits, production of meat, fish, poultry, production of bread, and production of animal feed in the Food and Drink production sub-sector.

Activities within this sector resulting in GHG emissions include industrial processes such as fermentation, limekiln and dolomite 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 Compounds (NMVOC). Limekilns produce quantities of CO2 as the rocks are burned and converted to calcium oxide. Liming applications, for citrus and sugarcane, using crushed calcite or dolomitic limestone do not produce measurable 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.

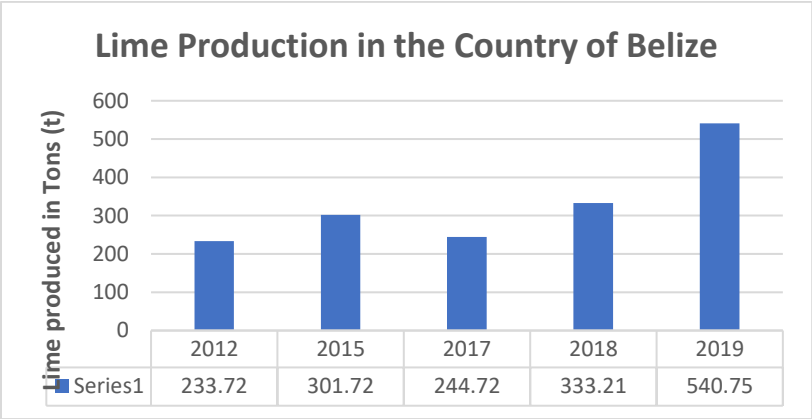
Also accounted for in the IPPU sector are GHG emissions used in products such as refrigerators, foams and aerosols. The estimation of GHG emissions from non-energy sources is often difficult because they are widespread and diverse. The difficulties in the allocation of GHG emissions between

fuel combustion and industrial processes arise when by-product fuels or waste gases are transferred from the manufacturing site and combusted elsewhere in different activities.

Lime production has increased over the years and is one of the main sources of CO_2 emission in this sector, of which there are two types of lime that are produced in Belize (see Figure 2.2 and

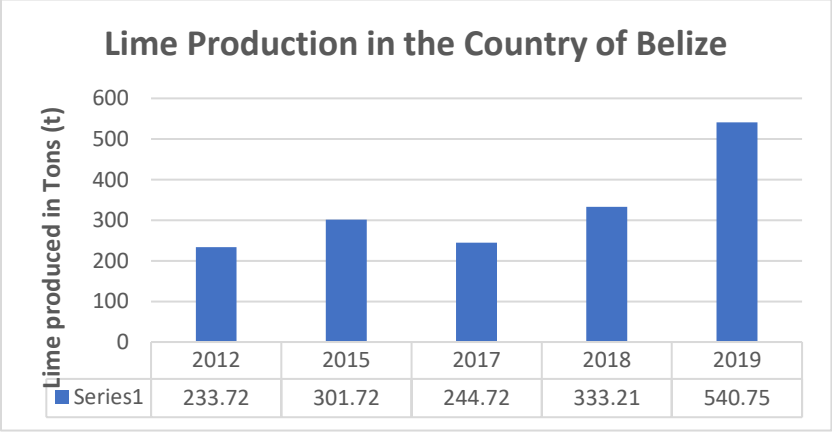
Figure 2.3). These are white lime (calcium oxide) and dolomite lime (calcium magnesium carbonate). Calcium oxide production is found primarily along the Hummingbird Highway within the Cayo District. The major users of burnt or quick lime (CaO) are the shrimp industry, citrus industry, sugar production, and more recently the coconut industry. There is a recent surge in coconut plantations. In the latter two, it is used to alter the soil pH. Consumption of this product fluctuated during the study period, partly as a result of what was happening in the shrimp industry. The shrimp industry has been plagued by diseases, and competition from production in other parts of the world, affecting the local demand for the lime treatment of the ponds.

Figure 2.2 White Lime (Calcium Carbonate) Production



Asphalt, another important source, was imported and used in Belize for repairing old roads and surfacing new roads. Since only 30% of the primary roads are surfaced, there is the continual need for improvement (See figure 2.3). Asphalt usage varies from year to year especially when repair, new road surfacing or building projects are implemented.

Figure 2.3 Asphalt Importation 2010 - 2019



Data on refrigerants was obtained from the Department of the Environment (DOE). Previous inventories had required that alcohol, beverage, and bread production be reported separately. These activities are now grouped into one sub-sector. There were three distilleries and one brewery, for alcohol and beverage production, which were in operation throughout the study period. The Customs Department, which is the source of the data, makes regular monitoring inspections of these facilities. During these inspections the amount of liquor produced is measured and tapped off. The holding tank is closed, and a Customs Department seal placed on it. This seal should be in place for the next inspection.

Table 2.2 Activities within the Industrial Processes and Product Use Sector in Belize

Greenhouse Gas Source Categories in the IPPU Sector	Status
A. Mineral Products	
1. Cement Production	Not occurring
2. Lime Production	Present
3. Limestone and Dolomite Use	present
6. Road Paving with Asphalt	Present
B. Chemical Industry	Not occurring
C. Metal Production	Not occurring
D. Other Production	
1. Food and Drink	
production of beer, wine, spirits	Present
production of meat, fish, poultry	Present
production of bread	Present
production of animal feed	Present
E. Consumption of Halocarbons and Sulphur Hexafluoride	Not present
1. Refrigeration and Air Conditioning Equipment	Present

2.3.2 Results of GHG emissions and removals

The data shows that emissions from the industrial sector continue to be released from the same sources as those for the previous inventories. Indications are that industrial activities continue to increase slowly as Belize's economic development progresses.

Table 2.3 summarizes the emissions from the activity areas for the reference years under study. The results obtained for the study period indicated that overall emissions from the IPPU sector have shown slow increase between 2012 and 2015 and remained relatively consistent between 2015, 2017 and 2018, with a slight drop in 2019.

The current inventory results show that only two areas are significant sources of GHGs in the IPPU sector in Belize. These are product uses as substitutes for ozone depleting substances, and mineral production. Mineral production includes lime production and use of asphalt for paving. Emissions from food and drink processing include the production of liquor, bread, processed meats, sugar and animal feeds. Based on the available data, the software revealed negligible levels of emissions. Similar results of negligible emissions (in some cases displaying as "zero" through software calculation) were obtained from the estimations of emissions from bread production.

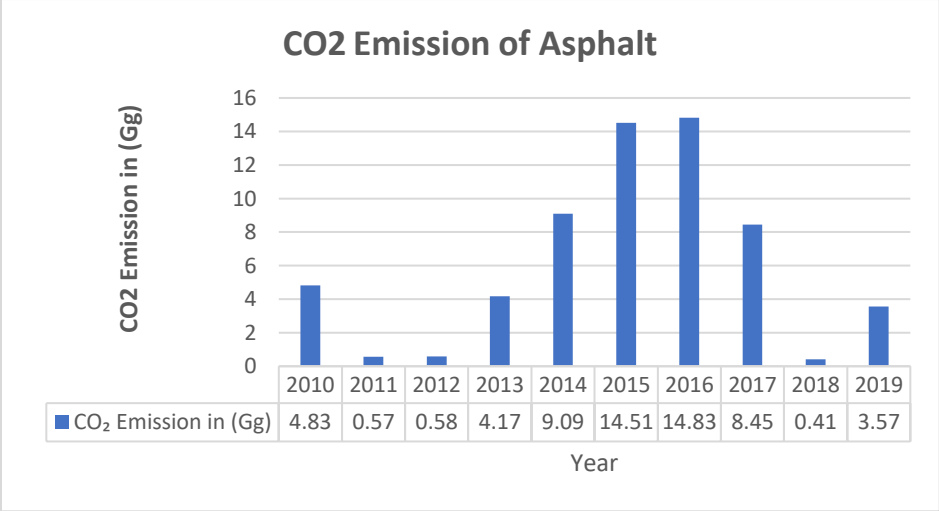
Table 2.3 Summary of GHG emissions from the IPPU sector - 2012, 2015, 2017, 2018 and 2019 (Gg $CO_{2\,eq}$)

Category	Subcategory	GHG Produced	2012 (Gg)	2015 (Gg)	2017 (Gg)	2018 (Gg)	2019 (Gg)
Mineral Industry	Lime and dolomite production	CO_2	1.6	1.02	0.55	2.2	2.9
Non-energy Products from Fuel	Road paving with asphalt	CO_2	0.58	14.51	8.45	0.42	3.57
Product Uses as Substitutes for Ozone Depleting Substances	Refrigerant use CH2FCF3 (Mobile and Stationary)	HFC ($CO_{2\,eq}$)	29.91	40.86	35.08	51.17	33.1
Others – Food and beverages	Use of wheat	CO_2	100.62	140.54	141.26	142.06	124.72
Total		All gases (Gg $CO_{2\,eq}$)	132.71	196.84	185.34	195.85	164.29

The data shows that emissions from the IPPU sector continue to be released from the same sources as those for the previous inventories. The main gas released from this sector in any appreciable quantity was carbon dioxide; with the results of the calculations showing a net decrease in CO2 emissions by the end of the study period. Total Emissions of the gas (carbon dioxide) increased slightly between 2012 and 2015, and then declined between 2015 and 2017. The decrease continued in 2018 and 2019.

Emissions from the road paving sub-category increased between 2012 and 2016 but decreased between 2016 and 2018. There is also a slight rise of emissions in 2019 (See **Figure 2.4**). This trend suggests that road paving activities increased considerably between 2012 and 2016, but marginally declined between 2015 and 2019.

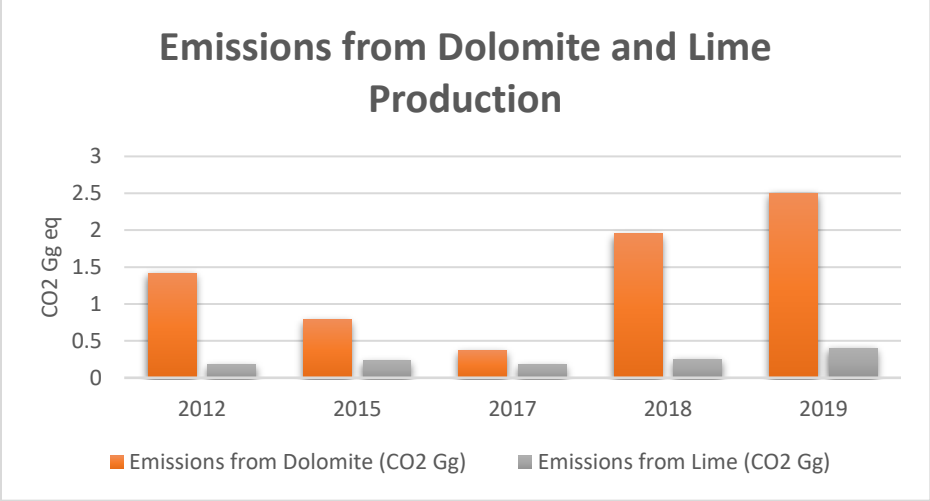
Figure 2.4 Emissions from road paving activities using asphalt



Emissions from refrigerants also showed a decrease between 2012 and 2017 but increased between 2017 to 2019. CO2 emissions from lime and dolomite production decreased slightly between 2012 and 2015, then declined further between 2015 and 2017. As rise in emissions from this source

occurred in 2018 and 2019 (See Figure 2.5). The former decline in the emissions is likely due to the decreased consumption/production of the lime brought by lower demand in the shrimp and citrus industries. The shrimp industry in Belize, like a number of other nations, has recently been negatively impacted by diseases resulting in closure of some of the ponds. The citrus industry has been affected by the disease citrus greening, resulting in rehabilitation of some of the orchards, as a result requiring lower applications of lime.

Figure 2.5 Emissions from dolomite and lime production



2.3.3 Analysis of results

The inventory estimates the primary emissions from the sector are from HFCs followed by CO2, mostly from refrigerant use in stationary and mobile sources, and lime production which involves the heating of limestone rocks in kilns over a three-day period. GHG emissions were also derived from food and beverage production, and road paving with asphalt.

The inventory also shows that the source of emissions from the IPPU sector remains the same as in earlier inventories. Increasing refrigerant use caused emissions to increase considerably between 2012 to 2019. This can be attributed to the increase in the number of vehicles present in the country, as well as buildings being equipped with air conditioning units.

There was a net decrease in CO2 emissions by the end of the study period. Total emissions of CO2 gas increased slightly between 2012 and 2015, and then declined between 2015 to 2018. Afterwards, there was a slight increase in 2019. This is mainly attributed to emissions from lime production, reflecting the decreased consumption/production of the lime brought by lower demand in the shrimp and citrus industries.

2.4 Agriculture, Forestry and Other Land Uses

2.4.1 Sector Background

2.4.1.1 Agriculture

Agriculture remains one of the main pillars of the Belizean economy. The vast majority of the rural population and the livelihood of the rural communities are also dependent on the environment through farming and forestry activities. A census of farms in Belize in 2003 indicated that 24% of farms have less than 5 acres, 33% between 5 and 20 acres, and 74% of farms in the country is below 50 acres2.

Toledo District has one fourth of all farms in Belize and the highest level of concentration of small farms (77% below 20 acres). Orange Walk is next with 22% of farms and Corozal with 21%. The farming population of approximately 11,000 farmers operates on about 5% of the agricultural land area. Small farmers account for more than 75% of the farming population. A large percentage of these small farms produce primary export crops such as sugar, bananas, and citrus, while others concentrate on domestic food crops, viz., rice, corn, beans, root crops and vegetables.

Agriculture in Belize is characterized by three main sub-sectors: a) a fairly well-organized traditional export sector for sugar, banana, citrus, and marine products, b) a more traditional, small-scale farm sector, producing food mainly for local consumption, and c) a large-scale commercial sector.

Liming is a practice conducted in the citrus and banana industries to reduce the acidity of the soils in southern Belize. Currently liming is done using either limestone or dolomite. Additionally, dolomite is also used in aquaculture applications.

Rice management. Rice production is grown under three systems in Belize, namely: Milpa or upland rice, mechanized and irrigated. Mechanized rice production uses farming equipment but is rain-fed instead of being irrigated mechanically. In flood irrigation between 15-30 cm of water is applied to the field and only one crop harvested per annum.

Livestock and manure management. The animal waste management system most common in Belize is the open range and paddock systems where the nitrogen from animal waste is considered as fertilizer. Most of the livestock herds are reared on natural range except for dairy cattle, some feedlots and poultry.

Some dairy farmers and beef feedlot farmers would apply manure directly to the fields. In poultry, manure management is based on the use of litter which is left in ambient temperature and used after a couple of months. This is also used as soil amendment in the rural areas such as Springfield and Barton Creek where the Mennonite farmers produce vegetables. However, poultry manure cannot be applied immediately to plants due to its high Nitrogen content that “burns” the plant. Poultry manure needs to be aged or composted before use.

Field burning is a practice that is normally used in the traditional Milpa system and in other production systems. However, in the mechanized systems of production the crop residue is normally incorporated and is especially done in crops such as the legumes to add nitrogen to the soil, especially where they are in rotation with grain cereals.

2.4.1.2 Forestry and Other Land Uses

Belize is endowed with vast and unique tropical forests that are also habitat to unique biodiversity of global significance. Most of the country and the entire coastal area consist of low-lying plains. Belize is known for its abundant natural resources and vast array of ecotypes especially with respect to water and biodiversity. Belize hosts more than 150 species of mammals, 540 species of birds, 151 species of amphibians and reptiles, nearly 600 species of freshwater and marine fish, and 3,408 species of vascular plants. In fact, Belize has the highest forest cover in both Central America and the Caribbean, including the largest intact blocks of forests in Central America, namely the Selva Maya and the Maya Mountain Massif.

Forest conservation has, historically, been a major priority for Belize. This is evidenced by the country's extensive protected areas system. The Protected Areas of Belize have evolved over the last few decades from being considered primarily as a resource bank, typically for forestry, to become a complex network of large and small "enclaves" having a diversity of purposes and under a variety of management regimes, some more effective than others, reflecting changing conservation attitudes, as has the scope and direction of the various agencies responsible for their administration.

The country has 44% (1.22 million hectares) of its land and sea resources protected under a variety of management structures: 769,093 ha of terrestrial reserves, 159,030 ha of marine reserves, and a further 128,535 ha protected through 'officially recognized' private conservation initiatives. Belize has 102 protected areas (PAs) representing 22.6% of its national territory (land and marine). These include 19 Forest Reserves, 17 National Parks, 3 Nature Reserves, 7 Wildlife sanctuaries, 5 Natural Monuments, 9 Archeological Reserves, 8 Private Reserves, 8 Marines Reserves, 13 Spawning Sites, 6 Public Reserves, and 7 Bird sanctuaries. The terrestrial PAs cover 34.9% of the total land surface, while the marine reserves cover 10.6% of the country's marine area.

These forests also provide sustenance for a majority of the population. Unfortunately, the forests have been under increasing pressures from land conversion and degradation activities. Belize's biodiversity is exposed to various direct anthropogenic and natural threats both within and outside of the Protected Areas (PAs). Over the last five decades the forest cover in Belize had steadily decreased due in general, to the expansion of unsustainable economic activities, such as large-scale and slash and burn agriculture, aquaculture, illegal logging, unsustainable logging, encroachment, forest/bush fires and other uncontrolled conversion of forest to intense anthropogenic land uses and extensive damages from climate related hurricanes and storms. These include unregulated development of urban and coastal areas and the rising pollution from cruise ship tourism leading to the degradation of mangroves and coral reefs and deforestation and unsustainable extraction of non-timber forest products in hotspot areas.

In 2010, hurricane damage led to extensive forest areas being destroyed leaving much debris that accumulated and dried up to form fuel. Consequently, during the 2011 dry season, Belize experienced some of the most extensive forest fires all over the country. The large fire in the Broadleaf Forest was in Central Belize, with was mostly in the Belize and Cayo District, some south of Orange Walk District. These fires and other forest degradation are leading to loss of biodiversity and emissions of GHGs into the atmosphere and contributing to further climate change.

2.4.2 Results of GHG Emissions and Removals

2.4.2.1 Agriculture Results and Analysis

The results of the estimations of the GHG emissions from the AFOLU sector suggest that the emissions from the agriculture sector vary depending on the annual crop and livestock production (See Table 2.4Error! Reference source not found.). Methane emissions from livestock demonstrated a trend of constant increase over the study period. On the other hand, emissions from rice production remained almost constant over the same period. This is probably related to the level of production maintained by the Mennonite farmers who are the major commercial producers. They produce in order to satisfy the national local demand as there is no export of this commodity. Rice consumption has not increased rapidly and might even be affected by clandestine imports. Observations also

suggest that the trends in local production also respond to the global markets for these commodities in any given year.

Agriculture residue burning is linked to the volume of sugarcane harvested and milled. The lower level of emissions estimated for 2012 could therefore reflect a lower volume of sugar cane processed by the factory in that year. Otherwise, the GHG emissions from this source appear to remain almost constant. Biomass continued to be a major contributor in the mix for energy generation in Belize. For the reference years, main emitters from this sector include CH_4 from enteric fermentation, direct N_2O emissions from managed soils, and CH_4 from manure management.

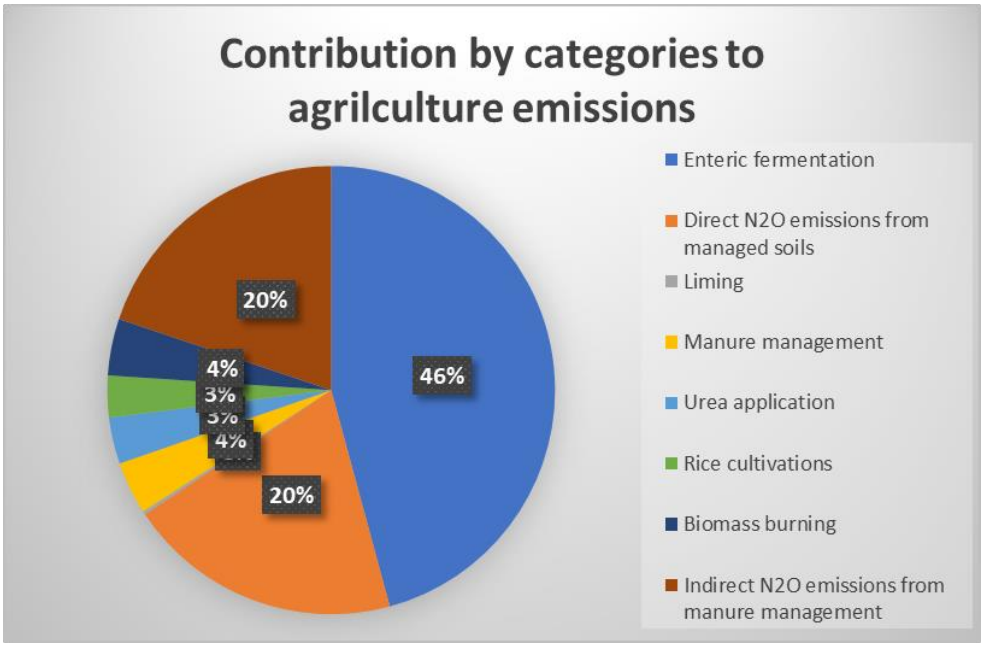
Table 2.4 Agriculture Emissions and Removals from Sector Sources (Gg CO2 eq)

Category code	Source Category	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019
			Gg $CO_{2\,eq}$									
Total Emissions Agriculture		**12.81**	**74.00**	**119.73**	**111.66**	**145.29**	**184.54**	**207.04**	**232.07**	**292.91**	**340.14**	**336.41**
3.A	Livestock	74.51	50.33	71.26	75.33	98.40	121.63	131.65	138.85	176.87	298.74	303.67
3.A.1	Enteric fermentation	68.64	47.89	66.44	72.36	94.63	117.30	122.23	128.43	162.24	273.94	293.01
3.A.2	Manure management			5.92	2.97	3.76	4.32	9.42	10.42	14.63	25.44	10.66
3.C	Aggregate sources and non-CO_2 emissions sources on land (Agriculture)	12.81	7.4	47.37	36.33	46.89	62.87	75.39	93.22	116.04	41.4	32.74
3.C.1	Biomass burning (Agriculture)	NE	NE	12.1	1.21	NE	4.67	7.74	12.79	15.75	17.92	17.94
3.C.2	Liming	2.54	3.67	4.39	5.31	4.89	4.27	0.94	1.01	0.30		
3.C.3	Urea application	9.37	1.40	1.26	1.52	2.10	4.30	4.47	12.92	12.33	16.85	9.09
3.C.4	Direct N_2O emissions from managed soils	40.67	19.06	22.94	22.61	34.69	41.83	51.33	54.42	70.34	NE	NE
3.C.5	Indirect N_2O emissions from managed soils	3.88	0.34	4.42	0.61	1.31	1.40	7.01	7.90	11.78	NE	NE
3.C.6	Indirect N_2O emissions from manure management	3.88	0.34	4.42	0.61	1.31	1.40	7.01	7.90	11.78	NE	NE
3.C.7	Rice cultivations	0.90	2.33	4.42	0.61	13.06	1.40	7.01	7.90	11.78	6.63	6.01

The data shows a gradual increase in emissions over the assessed period, during which it can be observed that the major contributor to emissions in the agriculture sector is livestock mainly through enteric fermentation, followed by agriculture biomass burning, and manure management. Furthermore, **Figure 2.6** below illustrates the main categories from which these emissions are coming from. Enteric fermentation accounts for 46% of the emissions from agriculture on an annual average over the study period, 2012-2019. N2O emissions from managed soils and manure management account for 20% each, followed by biomass burning and manure management at approximately 4% respectively. Rice cultivation and Urea Application both account for 3% of emissions in the sector.

Figure 2.6: Major Contributors of emissions in the Agriculture Sector

Figure 2.6 Major contributors of emissions in the agriculture sector



2.4.2.2 Forestry and Other Land Uses Results and Analysis

Highly accurate activity data for Forestry and Other Land Use sector was derived from the Collect Earth image visualization tool to obtain spatially explicit annual data of land use and land use change for time series of 2000-2017. For this inventory, emissions and removals are shown for the reference years and the recalculated years (1994-2019), and year by year data on FOLU emissions and removals can be seen in **Figure 2.7**.

The Forest and Other Land Use sub-sector as shown in **Table 2.5** shows a generalized increase in land-based emissions (subcategory 3B, Land) from 1994 to 1997. However, for the time 2000 onward the generalized trend is one of fluctuating decreases and increases which can be attributed to natural disturbances, and in some instances attributed to the change in land use.

Table 2.5 Summary of emissions and removals from the AFOLU sector, 1994 - 2019 (t $CO_{2\,eq}$)

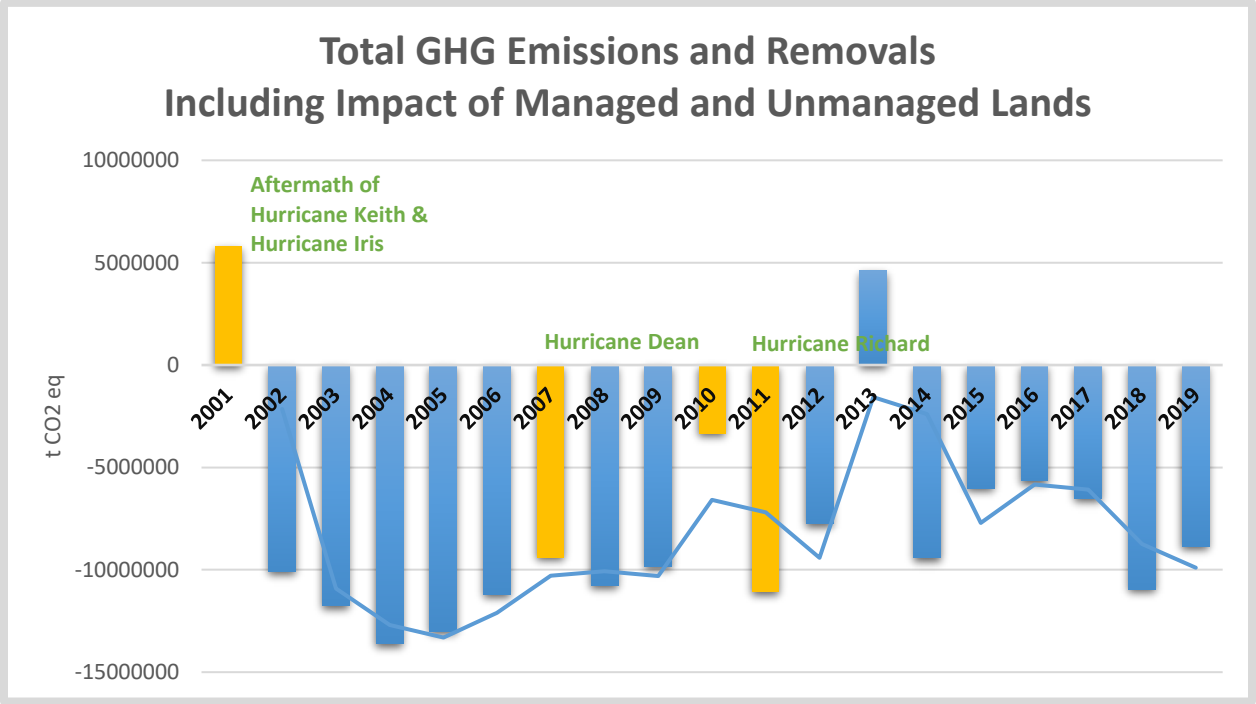
IPCC Source Category		Gases	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019
3	Agriculture, Forestry, & Other Land Use		-14,487,769	-14,064,481	-13,556,533	-11,759,601	-11,194,244	-9,831,423	-7,750,743	-6,006,895	-6,522,514	-10,607,516	-8,512,217
3.A	Livestock	CH_4 & N_2O	74,511	50,332	72,361	75,329.19	98,391.60	121,627.34	131,649.02	138,852.58	176,868.43	298,740	303,670
3.A.1	Enteric fermentation	CH_4	68,641	47,886	66,439	72,359	94,630	117,300	122,230	128,430	162,640	273,290	293,010
3.A.2	Manure management	CH_4 & N_2O	5,871	2,446	5,922	2,970	3,761	4,325	9,421	10,424	14,626	25,440	10,660
3.B	Land (remaining and conversions to)	CO_2	-14,575,091	-14,122,213	-13,669,335	-11,889,519	-11,367,202	-10,051,670	-7,990,701	-6,246,620	-6,825,458	-10,952,068	-8,848,627
3.B.1	Forest Land	CO_2	*	*	-12,355,614	-14,575,305	-14,249,679	-14,040,096	-13,250,304	-12,289,920	-10,935,231	-12,848,257	-13,578,633
3.B.2	Cropland	CO_2	*	*	-243,756	1,538,304	1,806,318	2,435,765	3,666,414	4,487,448	2,878,143	1,862,436	2,086,031
3.B.3	Grassland	CO_2	*	*	-1,074,237	1,143,210	1,299,575	1,596,834	1,802,387	1,596,464	1,239,398	58,829	2,947,288
3.B.4	Wetlands	CO_2	*	*	0	0	-198,339	0	-198,339	0	0	0	-291,987
3.B.5	Settlements	CO_2	*	*	4,272	4,272	-25,077	-44,173	-10,859	-40,612	-7,768	-7,768	-11,328
3.B.6	Other Land	CO_2	*	*	0	0	0	0	0	0	0	0	0
3.C	Aggregate Sources & Non-CO2 Emissions Sources on Land	CO_2, CH_4 & N_2O	12810	7400	79,622	65,533	74,807	92,423	106,666	124,394	160,576	45,822	32,740

3.C.1	Emissions from biomass burning (Land F, G)	CH_4 & N_2O in $CO_{2\,eq}$	*	*	43142	15,541	27,934	29,555	31,280	31,175	44,446	4422	NE
3.C.1	Emissions from biomass burning (Agriculture)	CH_4 & N_2O in $CO_{2\,eq}$		NE	1210.08	1,210.07	NE	4,668.85	7736.01	12,791.95	15,752.65	17,920	17,640
3.C.2	Liming	CO_2	2540	3670	4390	5,310	4,890	4270	940	1010	300	NE	NE
3.C.3	Urea application	CO_2	9370	1400	1263.80	15,175.60	2,098.07	4,295.87	4470.29	12,917.57	12,328.54	16,850	9,090
3.C.4	Direct N2O emissions from managed soils	N_2O	NE	NE	22937.47	22,612.25	34,686.78	41831.38	51328.08	54,420.82	70,430.25	NE	NE
3.C.5	Indirect N2O emissions from manure management	N_2O	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3.C.6	Indirect N2O emissions from manure management	N_2O	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3.C.7	Rice cultivations	CH_4	900	2330	4418.56	611.07	1306.56	1397.22	7013.66	7901.56	11777.24	6,630	6,010
3.C.8	Other		NE	NE	2260.47	5,072.80	3892.20	6,404.58	3898.44	4,176.90	5,541.35	NE	NE
3.D	Other		0	0	-39,181	-10,944	-241	6,197	1,643	-23522	-34,500	NE	NE
3.D.1	Harvested wood products	CO_2	NE	NE	-39,181	-10,944	-241	6,197	1,643	-23522	-34,500	NE	NE

2.4.2.2.1 Land Use Changes in Forests

In reviewing the overall impact of forests and land use change on total emissions and removals, **Figure 2.7** shows the cyclical behavior of increasing and decreasing absorption of CO2. This is largely due to recurring hurricanes that impact national forests, with the most impactful hurricane events highlighted in the graph. Usually in the year of a large-scale hurricane, emissions increase, followed by a period of recovery (increased removals).

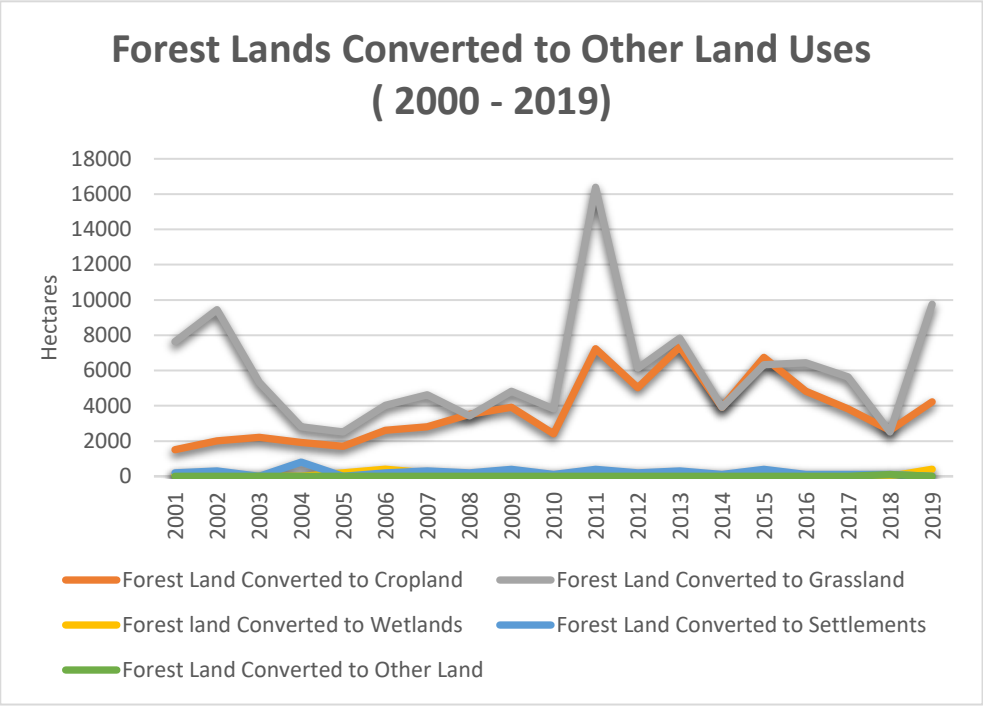
Figure 2.7 Total emissions and removals in Belize (including managed and unmanaged lands) (million t $CO_{2\,eq}$)



Land use change conversions are visually represented in **Figure 2.8**. Cropland (food crops) and Grassland (livestock pastures) were the major drivers of Forest conversion, with Grassland being the most significant contributor on average for the four reference years. While the forest conversions might have been initiated by natural phenomenon (hurricane events), the continuing changes were mainly caused as farmers and landowners took advantage of the loss of forest cover to convert the land to other uses, such as farms, pastures, or otherwise.

There was a major spike in emissions in 2011 when an estimated area of 16,386 ha of forest were converted to Grassland. This was due to Hurricane Richard, which hit the country in 2010 and damaged large areas of forests. Large open patches of almost severely destroyed forests were converted to grasslands because of this incident. It is also noted that in the years 2001, 2002, and 2003, there were major conversions of Forest lands to Grasslands. This particular period of conversion was due to thousands of hectares of forested lands in the Mountain Pine Ridge and Coastal Plains area being affected by the southern pine bark beetle pest infestation that impacted the country between 1999 and 2001.

Figure 2.8 Forest lands converted to other land uses (2000 - 2019)

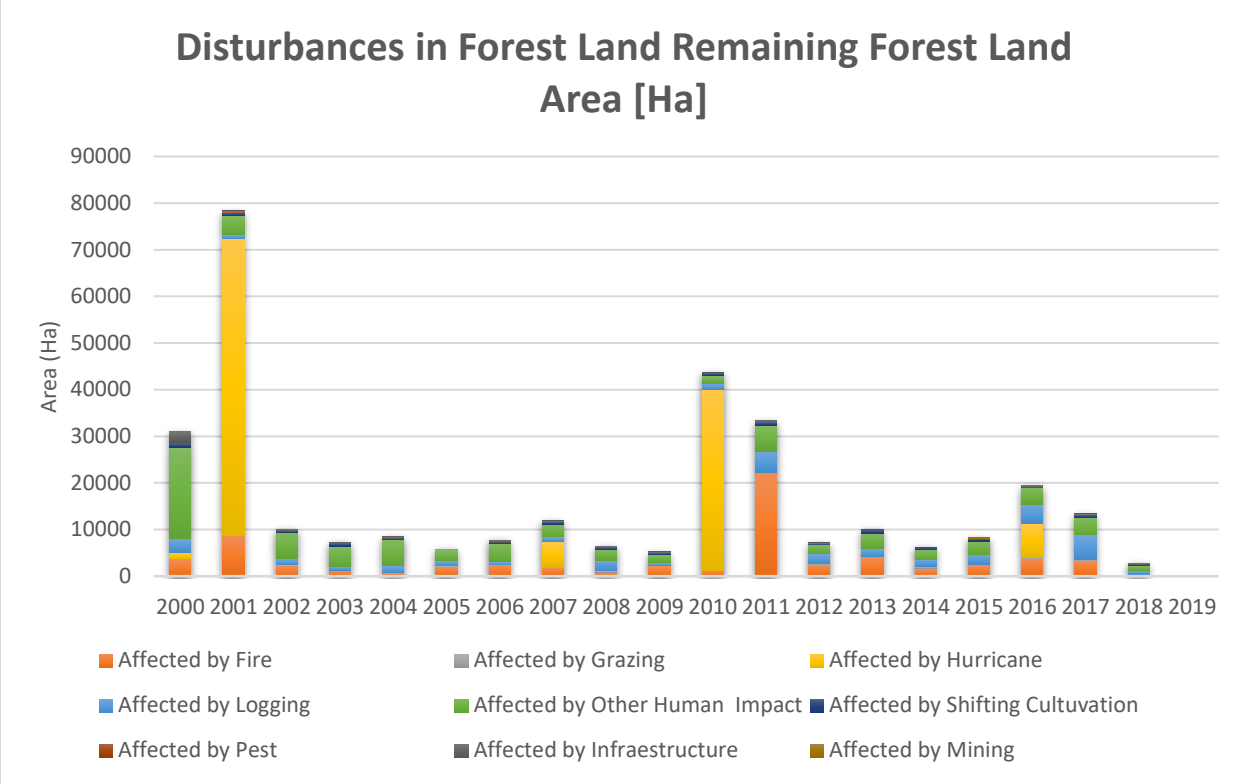


The more recent forest conversion to cropland after 2010 is believed to be because of Hurricane Richard. Some of the forested areas that were affected by the hurricane were turned into agricultural lands in the mid-western part of the country. This activity seemed to have caused a continuing trend of the conversion of forest lands for crops during the years that followed. Examination of the data for forest conversions for the reference years of 2012, 2015, 2017 and 2019 revealed that both Cropland and Grassland were major drivers for forest conversions.

2.4.2.2.2 Forrest Disturbances

As for the disturbances occurring in national forests that were not converted to other land uses, it can be noted in **Figure 2.9**, that hurricanes have impacted forests sink capabilities, and commonly lead to other disturbance types such as fire, logging activities, conversion to pasture, and cultivation. For the years 2001 and 2010, there were significant disturbances noted in areas that did not have a land conversion but still were affected by Hurricane Iris (2001) and Hurricane Richard (2010) showing once more the significance of the occurrence of hurricanes over the years.

Figure 2.9 Disturbances in forest land remaining forest land area (Ha)



Belize like most countries in the Latin American region shows that one of the major sources of greenhouse gas emissions is deforestation. Increases in land degradation and increased utilization of land with less productive potential coupled with the present rate of population increase all contribute to greater forest conversion.

2.5 Waste

2.5.1 Sector Background

The Solid Waste Management Authority (SWAMA) and its Board are charged with the responsibility of handling all matters pertaining to and conducive to the management of solid waste in Belize. Existing service areas are primarily areas being served by the municipalities (Town and City Councils). The Western Corridor is served by waste disposal services including waste management at the National Sanitary Landfill that presently serves Belize City and the communities along the George Price Highway Corridor. This landfill receives daily garbage waste from transfer stations in San Ignacio, San Pedro, Caye Caulker, Burrell Boom and Belize City.

Solid Waste: The SWAMA has commissioned several investigations and reports in relation to solid waste management. One such investigation was a waste characterization study of the major population centers of the Western Corridor that was carried out in 2011. The study estimated the waste production rate and waste characterization of several municipalities including San Ignacio/Santa Elena, Belize City, San Pedro and Caye Caulker. This study determined that the rate of solid waste coming from the domestic sector was estimated at 1.07 kg or 2.36 pounds per capita per day (Hydroplan for Solid Waste Management Authority, May 2011). This same study also

determined that residential waste amounts to 63.8% of all municipal waste produced in the corridor, while waste from the business/commercial sector accounts for 31.8% and the industrial sector produces 4.5% of waste.

Liquid waste includes domestic and industrial wastewater, although data about both is limited in availability. Domestic wastewater data was obtained from Belize Water Services Limited (BWSL) generated through official surveys of the population served by septic tank systems, latrines, and open disposal, was entered using the Tier 2 approach.

Industrial Solid Waste. Both the citrus and the shrimp industry utilize some level of anaerobic treatment in ponds, and therefore, the volume of this effluent was categorized as managed anaerobic, and the volume of the bagasse from the sugar cane as uncategorized waste.

Biological Treatment of Solid Waste. Citrus peels and other solid waste from this industry are mostly re-used after treatment for organic fertilizer. The remaining waste is composted (and accounted for in "Biological treatment of solid waste". Due to processing for fertilizer, volumes are now low. Shrimp farming also produces some waste in the form of shrimp heads with effluent that are treated by burying and is also accounted for in "Biological treatment of solid waste". However, due to the decline of the shrimp industry as a result of challenges such as virus infestations over the past years, the waste from the sector is minimal.

2.5.2 Waste Sector Results

Table 2.6 below shows the total emissions of all gases emitted (Gg CO2 eq) from the Waste sector for the current inventory for the four reference years. The combined results for all sectors show a total of 16.365 Gg CO2 eq of methane in 2012, and generally increases to 17.392 Gg in 2019. Carbon dioxide, attributable to open burning of waste, was estimated at 0.054 Gg CO2 eq in 2012, increasing to 0.057 Gg CO2eq in 2015, 0.072 Gg CO2 eq in 2017, 0.087 Gg CO2 eq in 2018 and 0.126 Gg CO2 eq in 2019. Total Nitrous oxide emissions increased from 6.31 Gg in 2012 to 9.72 Gg in 2017 and further increasing to 10.46 Gg in 2019. The majority of these N2O emissions are attributed to wastewater (and a small fraction to open burning).

Table 2.6 Total greenhouse gas emissions from the waste sector (Gg $CO_{2\,eq}$)

Sector	Gas	2012	2015	2017	2018	2019
4 - Waste	*Gg CO_2 eq*	*Gg CO_2 eq*	*Gg CO_2 eq*	*Gg CO_2 eq*	*Gg CO_2 eq*	*Gg CO_2 eq*
Total	All gases	22.729	19.8648	26.81298	28.40178	27.83278
4.A - Solid Waste Disposal	CH_4	0.023	0.023	0.054	0.085	0.166
4.B - Biological Treatment of Solid Waste	CH_4	0	0	2.86755	2.89855	2.92855
	N_2O	0	0	2.53983	2.55283	2.56583
4.C - Incineration and Open Burning of Waste	CO_2	0.054	0.0568	0.0716	0.0864	0.1264
	CH_4	0.122	0.128	0.128	0.134	0.130
	N_2O	0.035	0.036	0.036	0.034	0.036
4.D - Wastewater Treatment and Discharge	CH_4	16.22	12.839	13.974	15.109	14.168
	N_2O	6.275	6.782	7.142	7.502	7.862

2.5.3 Analysis of results

The Waste sector inventory has been facilitated by the recent solid waste studies, including waste characterization and waste composition studies commissioned by the Solid Waste Management Authority. These studies have led to the availability of improved quality of data.

The results indicate that there is a significant improvement in solid waste data management that is useful for inventory exercises. Additional studies are required if waste generation data are to be applied by region (western corridor, northern and southern corridors), or for each town and city.

There is an overall trend of increasing emissions across all the subsectors. Emissions from wastewater discharge represent the majority of emissions in the waste sector. For industrial liquid waste sub-sector, there is no formal registration or estimation of liquid waste generated within the industrial sector (including both large industries like banana, and smaller ones like shrimp). Some data is available from the citrus and sugar industries. This source of data is important because it is noted that the waste-water sector is increasingly becoming of greater significance in greenhouse gas emissions. Even with the limited data available about this source of greenhouse gas emissions, the total emissions from the waste sector increased significantly with the input of the wastewater sector data over the study period.

2.6 Summary of National GHG Profile

In 1994 when Belize prepared and submitted its initial national greenhouse gas inventory to the UNFCCC the estimated population stood at 201,677 persons, with a growth rate of 2.03 % per annum, and population density of 8.78 persons per square kilometre. These parameters had changed to 332,960 people in 2012 with a growth rate of 2.32 % and population density of 16.66 persons/km2; then to a population estimate of 375,769 in 2017. That year the growth rate was determined to be 2.00 % with a population density of 16.31 persons/km2. During this period, Belize experienced some economic growth, which was largely driven by agriculture and tourism. It is possible that these areas of economic development have influenced the trend displayed in the country's greenhouse gas emissions. The two sectors contributing significantly to the GHG emissions continue to be AFOLU and Energy.

With Belize being a largely service oriented country with an expanding tourism industry, Belize is able to offer residents and visitors terrestrial and marine experiences. This has probably helped to stimulate growth in the transport sector in the expansion in the public and private sector vehicle fleet, the local maritime ferries, and the local aviation fleet. This has resulted in continuing increases in emissions from the Transport sub-sector even while the emissions from energy generation are not increasing as rapidly even with an increased energy demand by the growing population. The mitigation effect in the Energy sector is produced by the increasing utilization of renewable energy sources in the energy generation mix.

The net GHG emissions and removals for the recalculated period, estimated with and without the FOLU removals, are presented graphically in **Figure 2.10** and **Figure 2.11** below. As shown in **Figure 2.10**, the AFOLU sector has sequestered between 6,000 to 12,000 Gg CO2 eq from 1994 to 2019. Sequestration from this sector continues to help Belize to maintain the status of being a net sink. During the aforementioned period, emissions from the waste and IPPU sectors continued to be relatively stable, while emissions are dominated by the energy sector, which includes the transport

subsector. The impact of the AFOLU sector is shown again in **Figure 2.11** where a spike in emissions is observed when removals from this sector is not considered.

Figure 2.10 Trend of Belize's net emissions and removals including forestry and other land uses (Gg $CO_{2\,eq}$)

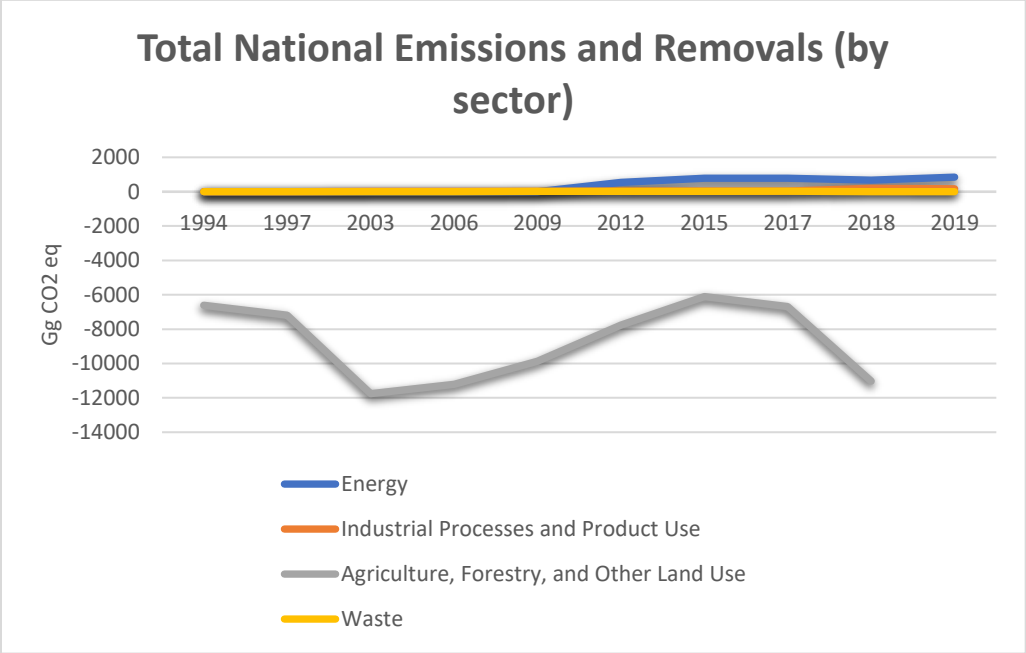
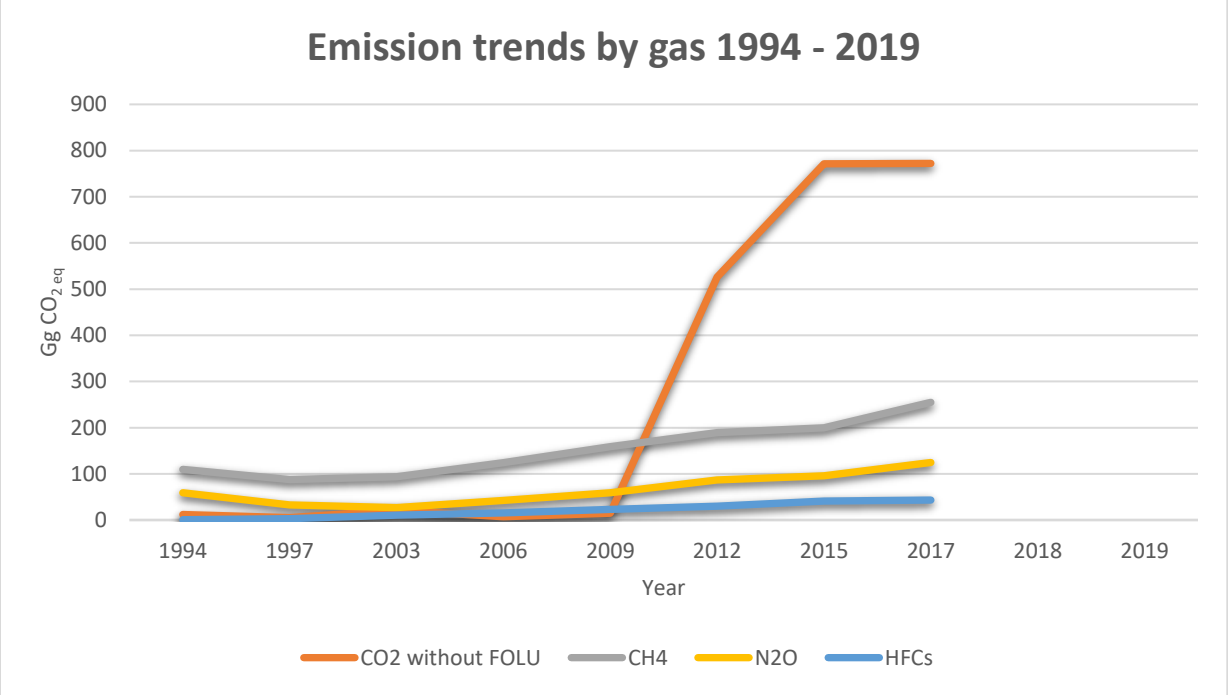


Figure 2.11 Trend of Belize's emissions by gas, 1994 - 2019, without FOLU (Gg $CO_{2\ eq}$)



Within the AFOLU sector, land conversion from forested land to other uses (croplands and grasslands) displayed the greatest influence on sector emissions; this is most likely due to the continued expansion in agriculture, in the most recent cases to grassland (pastures) and cropland at the cost of the natural forests. It is noted that not all of this change is man-caused, since natural phenomena like hurricanes and insect infestation have been the precursor of the change and forest disturbance. Hurricane impact across the mid-western section of the country and the pine bark beetle infestation have left their mark on the broadleaf and pine forests, respectively.

The observed increases in the emission trends in the Energy sector corresponded to some increases in the imports of petroleum fuels since 2012. This was because of increases in the consumption of petroleum fuels for electricity generation, and in the transport sub-sector. Local aviation has also expanded, as has the vehicular and sea-going fleets. Both public transportation and numbers of privately-owned vehicles continue to increase. Charter boats and commuter ferries are also on the increase as the tourism industry grows. Biomass usage for industrial and domestic energy production continued to increase as an alternative to petroleum products, thus somewhat tempering the impact of emissions from this sector.

Biomass is primarily used in the generation of energy for the sugar industry, and additional conversions are sold to the national grid. There was an increase in the use of this fuel late in the study period due to another company, Santander Sugar Energy Ltd., coming on stream and producing electricity for the national grid. The increase of biomass also increased the greenhouse gases emissions from this source, but this is largely recycled by the additional biomass being cultivated. Solar powered energy is increasing for domestic application, but also for applications like street lighting, and public service buildings. Noteworthy in the transport sub-sector, is the unavailability of

disaggregated fuel type data preceding 2010. National data collection mandate was formalized in 2012 under the Energy Unit.

The Industrial sector continues to display slow growth. The trends in GHG emissions displayed by the IPPU sector were the result of increased refrigerants use with the large number of new buildings constructed, along with the noticeable growth in the number of air-conditioning service facilities for vehicles. The tourism industry probably contributed to the use of refrigerants in both accommodations and transportation. Further, there was a general decrease in production and application of lime in the agriculture sectors, and slow growth in the production of beer, spirits, and bread. Beer, spirits, and bread are primarily for local consumption, so are probably apace with population growth. During the study period, there were a few road-improvement projects underway in the municipalities, but these were mostly completed by building reinforced concrete roads. The cement was imported, so no discernible levels of GHG emissions could be attributed to this particular activity. However, there was some highway rehabilitation using asphalt. Road paving activities using asphalt appeared to fluctuate somewhat with levels of emissions in 2017 being lower than in 2015. The construction industry was busy across the study period with the building of private homes, expansion of resorts on the cayes, some public building construction like schools and office buildings, etc. Many of these were being equipped with air-conditioning.

The most noticeable trend in the Agriculture, Forest, and Other Land Use sector is continuing increases by all the gases in all the sub-sectors. While the national forests continued to remove CO2 allowing Belize to be a net sink of overall emissions, this function is diminishing as the process of deforestation and forest conversion continued. It is also noted that the current inventory revealed that the greatest causes of GHG emissions in this sector were due to land conversions to grasslands and croplands. Enteric fermentation emissions from the agriculture sub-sector increased as the livestock populations increased, although some of the emissions in this sector were from land preparation for crop cultivation.

The emissions within the Waste Sector show some small changes over the study period, this being due to the fact that some data for wastewater disposal and treatment was accessed and introduced to the estimates. This sector also displayed some fluctuations in emissions across the study period with some decline in 2015 but increasing again in 2017. The level of GHG emissions was almost flat across the three reference years, this most likely due to the construction of the managed landfill at mile 23 on the George Price Highway. The improved management of solid waste resulting from the construction and use of the managed landfill and the waste transfer station infrastructure, reinforced by law enforcement has resulted in great reduction in open burning of solid wastes. Greenhouse Gas emissions from this sector have been reduced compared to the period between 1997 and 2007 even with the inclusion of wastewater emissions. Future inventories of this sector may demonstrate that the Methane emissions from wastewater treatment have more impact on national emissions as the data collection improves.

3 Adaptation Information and Measures

Belize's geographic location and low-lying coastal areas leave it highly susceptible to the impacts of a changing climate, which is one of the greatest threats to its sustainable development. Belize is also economically dependent on its natural resources and the associated ecosystem services provided, magnifying the impending vulnerabilities to be faced as a result of climatic changes. Given current climate projections for the region and Belize, impacts will be exacerbated and have highly noticeable effects on Belize's society and environment. Changes in the intensity, distribution, and frequency of extreme weather events, such as storms and hurricanes, sea-level rise (SLR), increased sea surface temperature, ocean acidification, coral bleaching, drought, wildfires, and changes in crop production are some of the impacts of climate change that Belize expects to face. A 2014 assessment categorized Belize's vulnerability index to climate change as extremely high, ranking 9th on the list of 38 other countries in Latin America and the Caribbean (CAF, 2014).

Adapting to climate change and variability poses a great challenge for Belize. Most sectors, including water, agriculture, tourism, and health, are all vulnerable to climate change. While Belize has made many advancements in improving national capacity to monitor, mitigate and adapt to climate change, many gaps and obstacles still exist. For example, developing adaptation plans and implementing adaptation measures and solutions require high up-front investments, which do not exist nationally. The country also lacks the technical expertise to plan for climate change effectively. Thus, implementing adaptation actions is often not prioritized due to limited financial and technical capacity and resources.

This chapter discusses different aspects of adaptation, especially as it relates to the economically, environmentally, and socially vital sectors of Belize. The information for this chapter was provided by two methods of data collection via (1) a climate change survey and (2) a vulnerability and adaptation assessment. The climate change survey was conducted to obtain and present the adaptation activities being undertaken at a national level and discuss what capacities exist related to responding and preparing for the future impacts of climate change. This allowed the observation of the measures in place that contribute to strengthening the country's resilience and adaptive capacity to deal with the negative consequences, moderate harm, or take advantage of opportunities that arise.

The vulnerability and adaptation assessment was conducted to produce an Integrated Vulnerability and Adaptation Assessment for the Coastal Zone, Water, Agriculture and Fisheries Sectors in Central Belize and South-Central Belize. The results of this contributed in different ways to the preparation of this chapter. Furthermore, it identified the vulnerabilities of different hazards to the different sectors considering various impacts and factors.

3.1 Climate Change Survey

3.1.1 Objective

Responding effectively to the threats and hazards of climate change requires changes in planning, regulation, and financing to prepare for any future challenges or opportunities. An essential task in effective planning requires the involvement of stakeholders in climate change strategies and the design of responses to increase resilience. Their involvement is vital in the tracking of adaptation actions to avoid duplication, improve coordination and cooperation among different entities and to know their level of preparedness to climate change.

This information was obtained via a survey that allowed stakeholders to share information on their level of awareness on climate adaptation, document the current status of adaptation activities in their organizations and the obstacles they face, track changes in adaptation activities over time, and make recommendations based on the findings of the analysed adaptation actions.

3.1.2 Methodology

A list was first created of all stakeholders involved in climate change activities and then narrowed down to those most relevant in terms of adaptation planning and implementation. The list, which comprised of government, public and private organizations, was developed based on previous collaboration with the National Climate Change Office (the national entity responsible for climate action in Belize), and those believed to be influential in their field without prior collaboration.

A survey was developed and shared with the stakeholders to assess the awareness and knowledge of stakeholders about adaptation, the nature, and extent of adaptation activities, and to track future changes in activities. The survey (Annex 1) included 22 questions, using both multiple-choice and open-ended questions. The online survey was shared with 80 stakeholder organizations in total, of which 32 responded to the survey, a 40% response rate. The full list of respondents can be found in Annex 2.

It is noteworthy to mention that the sample chosen does not represent all organizations in Belize, nor was it intended to. Rather, the sample was chosen to include a diversity of relevant organizations in climate change adaptation. Although the organizations that have responded may not represent the entire country, it provides valuable information for analysing the current level of adaptation within the country and potential areas for improvement. The survey will also be carried out on a recurrent basis every two years, which will allow for better tracking of adaptation actions and planning.

3.1.3 Summary of findings

The results of the survey have been grouped into three general categories in order to do an analysis: understanding climate change, adapting to climate change, and drivers & obstacles to climate change adaptation.

Understanding Climate Change

Many of Belize's entities are informed about climate change to some level which is accurate as many of them have been involved in the implementation of climate change activities. The majority of them are also in agreement that climate change poses a serious problem for Belize and are aware of the impacts that comes with it, such as droughts, flooding, temperature increase, to name a few. Most recently, Belize experienced a drought in 2019 which extended into 2020. Flooding events also occurred due to Hurricane Eta and Iota. In the past, drought conditions have been experienced in different parts of the country in 2015, 2016, and 2018.

Most entities or organizations are aware of how their work ties in the response to climate change. Many organizations have priority areas that are directly linked to climate change while other organizations don't have any. However, their priorities are nevertheless intrinsically linked as they focus on environmental conservation and/or resource management. A variety of priority areas that

exists from different organizations include renewable energy, sustainable management of environment and natural resources, and promoting sustainable and smart agricultural practices. Priority areas also included increasing awareness & knowledge and capacity building; informing policy development and plans; improved research and education; project management with climate change focus; product and livelihood diversification; sustainable tourism management' sustainable businesses, and social/community work.

Lacking is the certainty of potential impacts, risks or vulnerabilities to future climatic changes that may affect different organizations, increasing their exposure to negative consequences of natural hazards. If organizations or entities assessed these potential impacts, risks, or vulnerabilities, they would take an essential step to reduce being negatively affected by natural hazards. For this purpose, assessments are necessary and one that many organizations should adopt and implement as part of their adaptation planning process. However, it is understood that a lack of resources and finances makes this difficult, and often, some sort of analysis may have been done but unfortunately, nothing formal.

Adapting to Climate Change

Many organizations or entities in Belize are at different stages of planning and execution as it relates to adaption actions. Most do not have a policy or plan to address climate change. While the plan may be integrated within goals, it is not specifically targeted. For instance, the Development Finance Corporation (DFC) has a Climate Change Policy and Environmental Policy to manage climate change impacts to their institution and loans/projects they oversee. Some policies or plans concerning climate change adaptation include the National Fisheries Policy, Strategy and Action Plan, the Integrated Coastal Zone Management Plan and Guidelines, National Biodiversity Strategy and Action Plan. There are several reasons why organizations do not have such a policy or plan in place. These include lack of funding, no preliminary assessment or baseline data available to formulate such a policy or plan, and lack of technical expertise. Another reason is that it is not a priority, or climate change adaptation is already integrated into existing policies or plans.

Collaboration among different entities is essential in carrying out climate change activities, as no sector works in isolation. Collaboration is crucial so that stakeholders can assess gaps, share risks, and make better use of available resources. Through collaboration efforts, stakeholders can achieve beneficial outcomes for adaptation. Conversely, lack of collaboration may lead to maladaptation because the actions will not match the risks. Luckily, in Belize, most entities collaborate with others to ensure effective planning and implementation of climate change actions.

Most partnerships share similar or common goals and targets and draw upon the expertise and knowledge of other institutions. These partnerships or collaborations provide support where some of them co-manage protected areas or projects. Some organizations have collaborated through the formation of programs or projects for which funding is provided to them.

Many organizations are aware of the importance of addressing climate change through adaptation efforts to plan, prepare for or manage the projected impacts of climate change. As a result, many have prioritized climate change adaptation in their organization's agenda to some level. This is

supported by the work carried out as many of it is directly linked to actions that can help address climate change, and they are directly affected by the impacts of climate change.

For most, the organization's strategy or mandate prompts their professional involvement in adaptation planning. For others, it is the opportunity to provide community support as funding becomes available, or as a local climate action plan is developed or updated.

Most organizations within Belize are within the planning stages of adaptation, which involves developing a way forward, assessing options to prepare for and decrease vulnerabilities and risks to climate change, and increasing their organization's resilience. Fewer are within the implementation phase, meaning they have completed their planning and implemented the identified adaptation solutions and monitored their effects. Other organizations are still focusing on knowledge building, i.e., trying to gather information and knowledge to understand the potential impacts of climate change and vulnerabilities.

There are different adaptation measures that organizations are currently planning or involved in, which are directly linked to the goals and targets of their organization but also climate change. The most common measure that organizations are involved in is capacity building. Many work on increasing knowledge and awareness as well. Others conduct activities related to managing natural resources, whether forest, coastal or other ecosystems, climate- smart agriculture, and water management. A full list of adaptation activities can be found in Annex 3.

Several types of adaptation activities revolve around ensuring the sustainable use and management of natural resources. As a nation, Belize is highly dependent on its natural resources and the services it provides. Hence, most activities are directly or indirectly linked to natural resource management. However, based on the frequency of activities related to capacity building and increasing knowledge and awareness, it is recognized that partnerships are of key importance. Sharing experiences, and increasing knowledge, skills, and awareness is vital to effectively and fully carry out climate actions that stakeholders intend to pursue.

Drivers and Obstacles to Climate Change Adaptation

It is clear that various entities have started the process of adaptation in Belize by incorporating climate change into existing strategies or plans, gathering knowledge and planning for adaptation. However, it is highly important to identify what barriers they have faced or could potentially face and the drivers for efficient adaptation planning. An essential aspect of informing policies and plans related to climate change adaptation relies on understanding the drivers and obstacles to develop solutions to overcome these obstacles.

Given the nature of organizations' work, many agree that climate change will affect their activities from a socioeconomic standpoint. This includes the availability of resources, changes in livelihoods, sustainability of businesses/markets, changes to ecosystem integrity or functions, impacts to urban/development planning, and development of policies and strategic plans.

It is necessary to identify the main drivers and barriers to climate change adaptation so as to ensure efficient adaptation planning and implementation. The main drivers and barriers to climate change

adaptation within Belize identified are a lack of human/financial resources, a need to increase education and awareness about climate change, limited collaboration between stakeholders, and a lack of political will to integrate climate change adaptation into planning and implementation.

At a national level, the main drivers to adapt to the effects of climate change are related to increasing socio-economic resilience, mostly related to income generation and livelihoods; ensuring sustainable management of resources and productive sectors; and increasing knowledge and awareness.

At an organizational level, the main obstacles faced as they become aware of or involved in adaptation planning include insufficient human and financial resources, insufficient technical expertise to analyse and utilize relevant information. Other obstacles include the need for technical staff versed in climate change and increased staff or human resources to carry out all tasks required to reach goals, which may not need direct expertise in climate change.

It was imperative to distinguish between what may be considered national barriers versus those at the organizational level. For example, some organizations are already implementing adaptation activities but could be facing hurdles in implementation, while others are still in the planning stages and may not have the adequate capacity to plan for adaptation.

As a developing nation, there is an urgent need for Belize to strengthen its immediate and long-term ability to access climate finance for adaptation to plan effective adaptation activities and build resilience. To effectively access financing for climate change adaptation, stakeholders require an understanding of the national circumstances, the national adaptation landscape, and knowledge of key conditions to access various sources of finance. With that knowledge they can prepare and present adaptation projects which are fundable. On the other hand, without the proper knowledge and knowing what funding agencies require, stakeholders may know what is needed but not be able to present it to meet requirements of funders. Hence, it is crucial to build capacity in adaptation planning and funding requirements to access finance and build resilience.

3.1.4 Discussion of the Survey

The Adaptation Chapter was developed based on findings of a survey distributed among a range of national organizations and entities. It offered baseline information for adaptation planning. It also assisted in showing that what organizations need most to increase planning for adaptation is increased knowledge and capacities, technical support, and finance. Access to human and financial resources are The most significant barriers to planning and implementing adaptation actions. Most organizations see the need to increase capacity for planning because while they may know the importance of climate change adaptation, stakeholders fall short in planning and accessing finance needed to build resilience.

Many organizations that represent the country are well informed about climate change and its effects and impacts and are aware that it poses a serious threat to our country. This is reinforced by the nature of work different organizations carry out. Their work may not directly target climate change at times, but they do provide co-benefits, such as the management of protected areas or ensuring energy efficiency. However, that formal assessment of their vulnerabilities or risks to climate change is still lacking, whether due to insufficient resources or finances or it not being given priority as yet.

Even without a formal assessment of vulnerability or risks, most organizations have already commenced the adaptation planning process, which is evident by the many existing collaborations with other entities. Establishing collaborations is crucial for adaptation planning to ensure the best use of limited resources.

Organizations recognize the importance of addressing climate change through adaptation efforts and planning, preparing for, or managing the projected impacts of climate change, and have prioritized this within their organization's agenda. Many organizations are affected by climate change and carry out activities directly and indirectly linked to adaptation. Consequently, many of them are professionally involved in some form, whether due to an organizational level strategy or mandate within their entity, in providing community support to increase resilience when funding becomes available. Organizations are also involved in the development or updating of a local climate action plan or activities.

The highest frequency of activities can revolve around the management of natural resources or the services they provide. Many organizations are also involved in capacity building and knowledge or awareness-raising initiatives. From the activities described, it can be deduced that while many organizations understand the gravity of climate change impacts and realize the importance of planning for adaptation, much improvement is still needed. Not many organizations have assessed vulnerabilities to climate change, so it is difficult to assess the level of adaptation or specific activities needed for sectors to decrease such vulnerabilities. As a result, it is then difficult to prioritize what assets are needed to build resilience. Without the proper baseline assessments in place, it is not easy to analyse whether the adaptation activities have actually built resilience as they should.

Some organizations see climate change as having socio-economic effects on the dynamics of their work and lead to challenges in that regard. Others see it as affecting the way both urban and development planning is done which affects the different ecosystems they manage. Hence, it can be deduced that most organizations are concerned with the socio-economic and environmental impacts of climate change. This may be due to recent events where the productive sectors of Belize have been drastically impacted by natural events, such as flooding that occurred recently. For example, the 2020 hurricane season, and 2020 drought adversely affected the agriculture sector, leading to drastic changes in the economy, impacting vulnerable ecosystems and sectors, as Belize is highly dependent on its natural resources and services.

The main barrier identified in climate change adaptation in Belize is limited resources, whether human or financial resources. At the same time, the main drivers identified were the need to increase socio-economic resilience and diversify livelihoods and ensure the sustainable management of natural resources and productive sectors. This shows a consensus view that socio-economic and environmental factors are key concerns of stakeholders. Obstacles faced in becoming aware of or involved in the adaptation process professionally, again, were directly linked to limited funding, limited technical expertise to use and analyse relevant information, and limited human resources or staff to carry out required tasks.

The results suggest a consensus on the need to increase human and financial resources to plan for adaptation and increase resilience effectively. Without the appropriate skills, knowledge, and expertise, access to finance is not possible, as funding agencies have specific requirements that need to be met. Organizations need to explore and analyse their hazards, vulnerabilities, and risks, look at different options to decrease them, and develop solutions. With the correct information in place, stakeholders have better opportunities to access financing and funds, and prioritize and plan for the favoured or most desirable options and implement them. Stakeholders require access to finance and human resources, as well as increased capacity and training to be able to integrate more adaptation planning into their organizations. Climate change adaptation requires mobilizing a significant amount of funding to implement adaptation measures in a wide range of sectors and increasing technical expertise in adaptation planning.

3.2 Vulnerability and Adaptation Assessment

A Vulnerability and Adaptation Assessment was conducted in 2019 for the following sectors: coastal zone, water, agriculture, and fisheries, in Central Belize and South-Central Belize.

3.2.1 Methodology of the V&A Assessment

With a focus on specific sites located in Central Belize and South-Central Belize, the scope of the assessment was to assess the vulnerability of human and natural systems to climatic impacts and based on these results, propose ways to address this vulnerability through adaptation measures and strategies. The assessment covered four sectors, namely, coastal zone, water, agriculture, and fisheries, and proposed adaptation measures and strategies tailored to the specific situation on the ground.

Within this study, an effort was made to collect and integrate sex-disaggregated data and gender-related information concerning the sector to understand gender differences and gaps. This study focused on hydro meteorological hazards, a phenomenon of atmospheric, hydrological, or oceanographic nature that is aggravated by climate change. Beyond the hazards, the study looked into the specific effects of these hazards linked to climate change and the impact they cause -- and can potentially cause -- on people, ecosystems, and assets. Each of the nine types of hazards is assessed per sector and according to the corresponding sensitivity identified for four elements: Social, Infrastructure, Economic, and Natural Systems. The impacts of these hazards in the above-mentioned 'systems' had been assessed according to relevance and available data with the aim to derive the system's sensitivity.

The Vulnerability and Adaptation Assessment focuses on two rectangular sites. It is estimated that 150,000 people live within the project's polygons in Central and South-Central Belize. **Table 3.1** presents the main characteristics of both sites:

Table 3.1 Main characteristics of Sites A and B

	Site A	Site B
District	Most of Belize District, parts of Orange Walk and Cayo Districts	Stann Creek, Cayo, Toledo Districts
Size	980,000 ha	880,000 ha
Land area	Tropical rain forests; abundant water bodies, mostly coastal wetlands. 53% located offshore, encompasses many islands and part of the Belize Barrier Reef	Tropical rain forests, majority of land area is protected; several rivers crossing the site; water bodies present in coastal zone including wetland and mangroves. 63% is marine sea
Major Settlements	Belize City	Placencia, Mango Creek

The hazards considered in this study are illustrated in Table 3.2 according to each sector:

Table 3.2 Hazards considered in the study

Sector	Hazards				
Coastal	Ocean acidification/ warming	Sea level rise	Storm frequency/ intensity	Coastal erosion	
Water	Fluvial and pluvial flooding	Water availability			
Agriculture	Water availability	Temperature rise	Storm frequency/ intensity	Saltwater intrusion	Precipitation change
Fisheries	Ocean acidification/ warming	Sea level rise	Storm frequency/ intensity		

3.2.2 Coastal Zone Sector

For the purpose of this study, the coastal zone is assumed to be all mainland up to 4 kilometres from the coastline, and all marine territory up to 80 kilometres from the coastline. As listed in table 2, the hazards assessed for this sector are ocean acidification and warming, sea- level rise, coastal erosion, and increase of storm frequency/intensity. In accordance with the methodology previously discussed, vulnerability is mapped for four different elements: social, infrastructure, economic and natural systems.

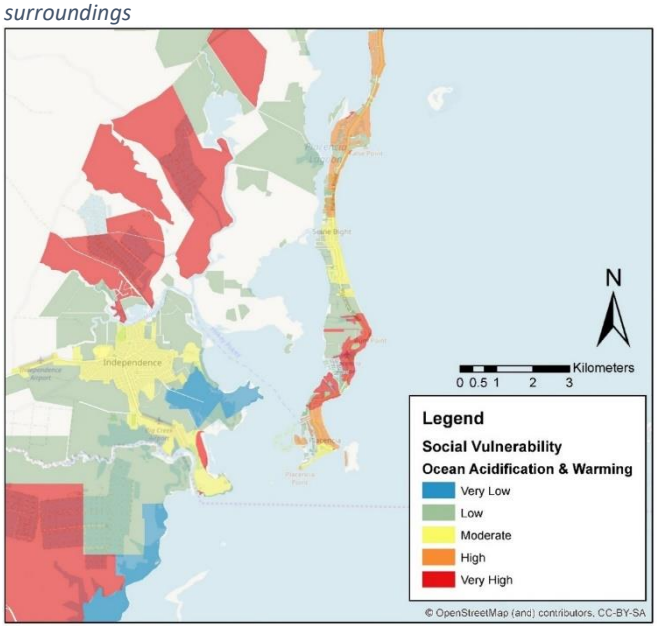
Ocean acidification

Exposure and sensitivity analysis

Ocean chemistry is changing as a result of higher carbon dioxide concentrations in the air. Oceans absorb around 33% of carbon dioxide in the atmosphere causing ocean acidification (Integrated V&A Assessment, 2019). As a result, the natural system's elements, such as mangroves, seagrass beds, and coral reefs are directly affected by ocean acidification. The impact on ecosystems in the coastal zone sector is valuable to the tourism industry, particularly in the case of coral reefs and the fishing industry. Tourism is the focus of this section.

Initially, ocean acidification positively affects mangroves and seagrass species resulting in an increase in productivity. (Integrated V&A Assessment, 2019). However, not all responses to elevated atmospheric CO_2 are positive; it is dependent on the species type and their ecosystems, with some expected to thrive while others decline (Integrated V&A Assessment, 2019). Potential negative effects on mangroves and seagrass are nonetheless extended to coral reefs. Seagrasses, mangroves, and coral reefs have a chain-like functioning ecosystem. Mangroves filter water coming from mainland and going to the sea creating shorelines; seagrasses collect sediments creating nurseries for fish before they migrate to coral reefs; coral reefs receive beneficial nutrients from seagrass beds (Integrated V&A Assessment, 2019).

Figure 3.1 Social vulnerability map of the Placencia Peninsula and surroundings



Social vulnerability

Social exposure to ocean acidification & warming is given by the degradation of natural systems that attract tourism and create lifelines for society. Social sensitivity is given by the demographic attributes of electoral sub-districts. Mapped social vulnerability for study sites A and B show the highest social vulnerability for areas destined to aquaculture, both around Belize City and the Placencia peninsula, and electoral sub-districts with higher percentages of the working-age population, mainly in the Placencia peninsula and urban areas in the cayes. **Figure 3.1** shows the social vulnerability map

zoomed to the Placencia peninsula and the city of Independence in study area B, where aquafarms and tourist-laden districts in the southern tip of the peninsula result in Very High vulnerability.

Economic vulnerability

Economic exposure analysed for ocean acidification and warming is primarily focused on tourism activities. However, different data sources provide a broad view of all tourism activities in the coastal zone. Mapped economic vulnerability (**Figure 3.3**) for study sites A and B show a *Moderate* to *Very High* vulnerability for coral reefs in the cayes.

Figure 3.3 Economic vulnerability map to ocean acidification and warming of Belize City and the coastal zone of Belize City focused on tourism

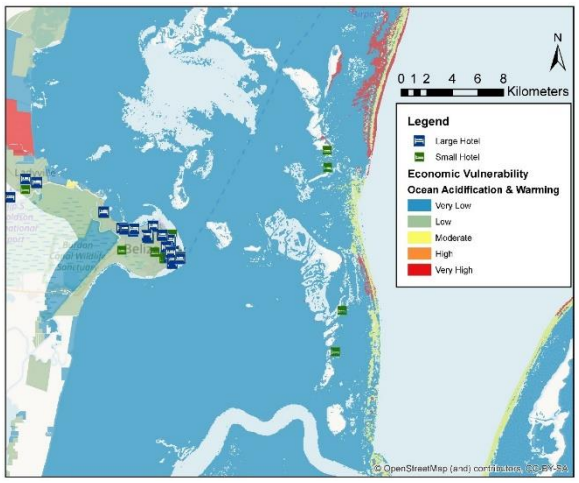
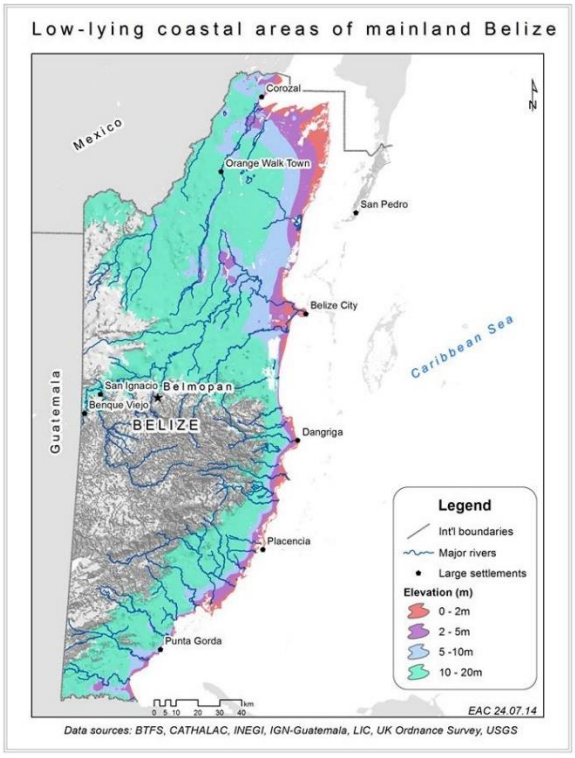


Figure 3.2 Low-lying coastal areas of Belize exposed to sea level rise



Natural systems vulnerability

Natural systems are affected first-hand by ocean acidification & warming. Mangroves, seagrass beds, coral reefs, and fish are thus directly exposed, given that their entire environmental conditions are changing as a result of this hazard. While some ecosystems initially benefit from this hazard, such as seagrass beds, coral reefs degrade and experience bleaching due to ocean acidification and warming; fish and other marine animals also experience habitat loss due to corrosive upwelling resulting from ocean acidification (Integrated V&A Assessment, 2019).

Fertilization, larval development, growth, and survival of intertidal wetland biota will also be affected as the impacts of ocean acidification and warming will affect wetlands which are habitats for macroinvertebrates, such as molluscs and crabs, and vertebrates, such as fish and potentially birds(Integrated V&A Assessment, 2019).

Sea Level Rise

Exposure and sensitivity analysis

The Coastal Zone is inherently exposed to the impact of sea-level rise. The main effects of this hazard are translated to coastal flooding of low-lying areas close to the sea. **Figure 3.2** shows the low-lying

coastal areas of Belize and elevations reaches, giving an idea of areas exposed to the effects of sea level rise.

To properly map vulnerability of exposed areas, the Digital Terrain Model (DTM) of Belize is used. The DTM available of Belize to analyse the effects of a higher sea level have a resolution of 30 meters. Given the relatively low resolution of the DTM for this purpose, a sea level rise of 5 meters is assumed to delineate the exposure to this hazard instead of the scenario RCP8.5, which amounts to a global sea level rise of 0.52-0.92 meter (Integrated V&A Assessment, 2019). Sea level rise is expected to affect the coastline settlements and natural systems as the shoreline retreats. Urban areas located in low-lying areas are prone to flood, while intertidal wetlands face potential extinction if inland migration is not possible. Intertidal wetlands will be forced to depend on their ability to move inland if sedimentation cannot keep pace with sea-level rise, however, their ability to do this can be impacted by topography limitations or barriers put in place to prevent flooding (Integrated V&A Assessment, 2019).

A social sensitivity indicator of 5 (*Very High*) is assigned to the residential urban land use in the coastal zone considering the permanent damage this hazard is prone to induce.

Social vulnerability

Settlements in low-lying areas of Belize give rise to social exposure. Therefore, social sensitivity indicators are provided to all classes of land use in the coastal zone, with higher sensitivity given to urban areas. The sensitivity is then weighted considering different factors related to sea-level rise.

The areas with highest vulnerability levels lie primarily in coastal areas, such as Belize City and Ladyville on Site A. On site B, the beach front of the Placencia peninsula and a considerate portion of Monkey River Town on the Monkey River's estuary would end up under water with serious social consequences for the inhabitants.

Vegetated areas and wetlands exposed to this hazard show the lowest social vulnerability values given the limited effect this hazard has on the well-being of populated areas. Agriculture and semi-urban areas show high social vulnerability given the first's social importance in providing food and the latter's innate exposure to social well-being. Aquaculture land cover scores a *Low* social vulnerability given its limited effect, mostly economical, on the coastal zone inhabitants' well-being.

Infrastructure vulnerability

To analyse the infrastructural vulnerability of Belize to sea level rise, all roads, airports, and any structure of general importance are assigned a sensitivity factor to this hazard.

Important highways on Site A in and around Belize City are exposed to this hazard and have the highest infrastructure vulnerability. These include tracks of the George Price Highway and even the Burrel Boom cut-off. This is also the case for Belize City's municipal airport and exposed areas of the Philip Goldson International Airport. High and Moderate infrastructure vulnerability are observed across the roads and avenues in Belize City which are exposed to this hazard.

On Site B, some parts of the Placencia Road on the Placencia peninsula are exposed to this hazard and show High infrastructure vulnerability. Nonetheless, most of the peninsula and all of

Independence, including airports in the area, are not directly exposed to sea level rise and thus, show no vulnerability to this hazard.

Economic vulnerability

Economic exposure to sea-level rise is given by economic activities in low-lying coastal areas of Belize. For the Coastal Zone, the focus for economic vulnerability is tourism as well as ordinary economic activities. Economic sensitivity is assigned using land use for the coast as well as point of interest.

Given its exposure to sea-level rise, the coral reefs will experience the highest economic vulnerability given their exposure to this hazard and the touristic value these have in Belize. The economic impact of deteriorated natural systems will directly affect large and small hotels in Belize's beach fronts and the Atolls. *High* economic vulnerability is observed in urban areas on the coastal zone and patch and back reefs, while the reefs' crests show *Very High* economic vulnerability. Sea-grass beds have little touristic value and thus show a *Very Low* economic vulnerability to this hazard.

Natural systems vulnerability

Analysis of vulnerability of natural systems to sea level rise is given mainly by the coastal zone's marine habitats, which are directly exposed, and coastal land use exposed to this hazard. Natural systems sensitivity indicators are thus assigned using marine habitats' geographical information and coastal land use. In addition, the location of nesting sites for crocodiles, manatees, sea turtles and dolphins are shown within natural systems that may or may not have high vulnerability values for this hazard.

Highest vulnerability of natural systems in regards of sea level rise are observed in the whole coral reef systems present in the Atolls as well as on the edge of the sea grass beds on Belize's coastal zone. See grass beds show a *Moderate* vulnerability while exposed wetlands inland show *High* vulnerability to this hazard.

Coastal Erosion

Exposure and sensitivity analysis

Coastal erosion removes material from beaches, dunes, cliffs, or coastal wetlands, mainly due to strong winds, high tides, and storm surge conditions. The effects of coastal erosion go from mild, like loss of beaches, to severe, like removing considerable masses of ground where infrastructure can be present. The empirical Bruun rule (which predicts a retraction of the shoreline up to 200 times the sea level rise) is used to determine the coastal areas directly exposed to erosion in Belize (Integrated V&A Assessment, 2019). In this case, all the low-lying areas of the coast are considered exposed to this hazard. This area is represented by the geographically referenced dataset of coastal land use.

Social vulnerability

Social vulnerability to coastal erosion refers mostly to urban areas and livelihoods affected by this hazard. In that sense, the combination of exposure with sensitivity indicators yields social vulnerability. Points of interest (non-residential buildings) exercising activities in education, healthcare, waterworks, telecom, state, leisure, commerce, and finances are subject to social vulnerability to coastal erosion.

Social vulnerability to coastal erosion uses the coastal land use and aggregated points of interest on the coastal zone. The highest vulnerability values are found in urban settlements, such as Belize City and Ladyville on Site A, and the Placencia Peninsula on Site B. Exposed areas in the coastal zone destined for aquaculture and agriculture have the lower vulnerability, Moderate and Low, respectively. Vegetated areas and wetlands exposed to this hazard have the lowest social vulnerability values.

Infrastructure vulnerability

Infrastructure is directly affected by coastal erosion. In fact, the effects of coastal erosion are the most tangible for this component in comparison with other elements. For instance, the transportation infrastructure, such as roads and airports on the coast, is the most affected, all of which have been given a sensitivity indicator of 5 (*Very High*). Residential, commercial, institutional, industrial, and residential areas are also directly affected if exposed.

Economic vulnerability

Economic vulnerability to coastal erosion of the coastal zone is focused on the disruption of economic activities related to commerce, tourism, and oil production. In that sense, points of interest (buildings) exercising activities in tourism, commerce, finances, leisure, and services are subject to economic vulnerability to coastal erosion.

Similar to the case with infrastructure vulnerability to coastal erosion, urban areas show the highest economic vulnerability to this hazard in Site A and Site B, namely Belize City and the Placencia peninsula. The economic vulnerability maps show, however, also the effect of coastal erosion in marine habitats with economic value to tourism activities. Consequently, coral reef systems affected by sedimentation due to coastal erosion have economic vulnerability values ranging from *Low*, for reefs not directly exposed to sedimentation, to *High* for back reef pavements approaching the edge of Belize's seagrass beds, which directly receive sediment from the coastal zone.

Natural systems vulnerability

The vulnerability of natural systems in the face of coastal erosion has an evident and a less evident aspect. The exposed mainland, combined with the sensitivity of coastal land use, yields the most vulnerable natural systems in Belize's coastline. Nonetheless, marine habitat is also affected by movements of sediment due to coastal erosion.

Seagrass beds, present underwater almost throughout Belize's coastline, are negatively impacted by layers of sediment as a consequence of coastal erosion. Coral reefs, more particularly back reefs facing Belize's coastline, also experience a degree of degradation and loss due to turbidity and sediment suspension.

Tropical Storms/Hurricanes

Exposure and sensitivity analysis

Sensitivity indicators are given using Belize's land cover map. Each land cover class gets a sensitivity indicator per sensitivity component. Additionally, Points of interest (non-residential buildings) are included in this analysis. However, the aggregation of classes is performed per component.

Therefore, the sensitivity indicators per aggregated class for this hazard are given in the following components subsections, except for natural systems.

Infrastructure sensitivity is considered for roads and airports. The road dataset of Belize comprises from footways and cycleways to all main highways. Therefore, sensitivity indicators are given according to road class for infrastructure sensitivity to storms and economics.

Economic and natural systems sensitivity is not limited to land cover classes. A more detailed dataset of marine habitat is available and is thus better suited for the sensitivity analysis of natural systems under water. Marine habitat is taken, therefore, into account for the vulnerabilities of the economic and natural systems.

Social vulnerability

Belize's population living on the coastline faces the yearly threat of hurricane season in the Atlantic Ocean and the Caribbean. Tropical storms and hurricanes often ravage coastal settlements with dire and lasting effects on population. Coastal flooding due to a category 5 hurricane exposes a vast area of the coastal zone to this hazard.

In addition to the urban sprawl and social sensitivity according to electoral sub-districts, Points of interest (non-residential buildings) exercising activities in education, healthcare, waterworks, telecom, state, leisure, commerce, and finances are also subject to social vulnerability to tropical storms and hurricanes.

Infrastructure vulnerability

In analysing infrastructure vulnerability to tropical storms and hurricanes, all roads, airports, and any structure of general importance, are assigned a sensitivity indicator. In addition, all structures exposed to flooding due to a category 5 hurricane are vulnerable to tropical storms/hurricanes. Sensitivity indicators give the magnitude according to the type of structure involved.

In addition to the sensitivity analysis given for the roads network, points of interest (non-residential buildings) exercising activities in education, healthcare, waterworks, telecom, state, tourism, leisure, commerce, and finances are also subject to infrastructure vulnerability to tropical storms and hurricanes.

The use of aggregated points of interest for determining infrastructure vulnerability to tropical storms and hurricanes allows adding detail to the vulnerability maps. For example, leisure areas, such as Marion Jones Sports Complex in northern Belize City, have a *Low* social vulnerability while Saint John's College Campus (Education) has a *High* social vulnerability. Also, critical highways, such as the George Price Highway, have *Very High* vulnerability while secondary roads show a Moderate vulnerability.

Economic vulnerability

Economic vulnerability of the coastal zone to tropical storms and hurricanes is focused on the disruption of economic activities related to commerce, tourism, and oil production. In that sense,

points of interest (non-residential buildings) exercising activities in tourism, commerce, finances, leisure, and services are subject to economic vulnerability to tropical storms and hurricanes.

Natural systems vulnerability

Natural systems on Belize's coastline and underwater are exposed to the effects of tropical storms and hurricanes and the increase in intensity and frequency of these due to climate change trends. Breakage and uprooting of mangroves and changes in soil elevation and peat collapse lead to mangrove degradation and losses. As a result, the habitat for aquatic biota is affected, and ecosystem services are lost. Similarly, coral reefs experience breakage and dislodgement during these extreme weather events, where reduced salinity and increased turbidity lead to coral degradation and losses. Seagrass beds also face destruction due to turbidity and sediment transport leading to the elimination of specific species and/or reduced recovery capacity.

The vulnerability of natural systems to tropical storms and hurricanes, and the prospect of increasing frequency of these events, shows the highest values for marine habitats in Belize Barrier Reef. The reef on the edge of the seagrass beds and the atolls are in the majority red- coloured, meaning *Very High* vulnerability. Conversely, the seagrass beds, which cover a vast area of Belize's marine habitats, show *Moderate* vulnerability.

3.2.3 Water Sector

Inland flooding

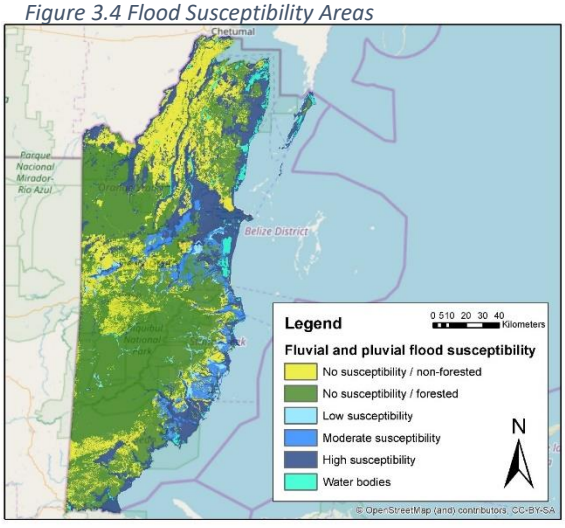
Exposure and sensitivity analysis

In 2014, flood susceptibility maps were prepared for the Belize National Emergency Organization (NEMO) by the Water Centre for the Humid Tropics of Latin America and the Caribbean (CATHALAC), based on previous estimates, settlement, and land cover maps.

Figure 3.4 shows flood susceptible and non-susceptible areas. For the purpose of this study, all areas that experience any level of susceptibility are considered areas exposed to this hazard.

Social sensitivity indicators from 1 to 5 (1: very low sensitivity, 2: low sensitivity, 3: moderate sensitivity, 4: high sensitivity, and 5: very high sensitivity) are assigned according to a curve obtained from sensitivity scores resulting for all electoral sub-districts.

Figure 3.4 Flood Susceptibility Areas



Ordered by sensitivity scores from low to high, the range for each sensitivity indicator is established, and each electoral sub-district is assigned with a sensitivity indicator accordingly.

Social vulnerability

Social vulnerability to inland flooding is given by the combination of exposed areas, as pictured in **Figure 3.4**, and the social sensitivity in demographic and land cover terms. In addition to the urban sprawl and social sensitivity according to electoral subdistricts, Points of interest (non-residential buildings) exercising activities

in education, healthcare, waterworks, telecom, state, leisure, commerce, and finances are also subject to social vulnerability to inland flooding.

The highest vulnerability values are found in urban areas. Nonetheless, large swathes of agricultural land are exposed to this hazard and present a High social vulnerability due to their role in provided food and thus well-being to Belize's population.

Infrastructure vulnerability

To analyse the infrastructural vulnerability of Belize to inland flooding, all roads, as well as airports and any structure of general importance, are assigned a sensitivity indicator to this hazard. As such, all structures exposed to inland flooding yield a vulnerability to this hazard. Sensitivity indicators are assigned according to the type of structure involved.

In addition to the sensitivity analysis given for the roads network, points of interest (non-residential buildings), exercising activities in education, healthcare, waterworks, telecom, state, tourism, leisure, commerce, and finances are also subject to infrastructure vulnerability to inland flooding.

Economic vulnerability

Economic vulnerability to inland flooding is focused on the disruption of economic activities related to commerce, tourism, and oil production. Points of interest (non-residential buildings) exercising activities in tourism, commerce, finances, leisure, and services are subject to economic vulnerability to inland flooding. Oil wells, airports, the road network, and hotels exposed to this hazard are also considered.

The use of aggregated points of interest for determining economic vulnerability to inland flooding allows adding detail to the vulnerability maps. For example, important highways, such as the Southern highway in Site B, have Very High vulnerability. At the same time, secondary roads show a Moderate vulnerability, and less important roads show Very Low vulnerability. Figure 44 shows a portion of Site B, with a focus inland from the Placencia peninsula.

The road network and GPD oil wells and hotels exposed to this hazard are drawn in this economic vulnerability map. The highest vulnerability values observed correspond to agricultural lands susceptible to fluvial and pluvial flooding.

Natural systems vulnerability

Vulnerability of natural systems to inland flooding is given by the exposure to this hazard, as pictured in Figure 45, and sensitivity indicators assigned for land cover classes, as listed in Table 31.

Mangroves initially benefit from flooding events by growing in area and biodiversity. However, dieback after an extreme flood has receded, affects regeneration. Consequently, mangroves and littoral forests which are exposed to hazard show a High vulnerability to inland flooding. Figure 45 shows the natural systems' vulnerability to inland flooding map for Site A. Broad-leaved forests show Moderate vulnerability. At the same time, lowland savannahs have a Low vulnerability given their natural flood plain function.

Water availability

Exposure and sensitivity analysis

Water availability, or more precisely lack thereof, is a general hazard to which the whole territory of Belize is exposed as it is dependent on precipitation patterns and the hydrological cycle. In Belize, water supply and wastewater services are provided by different entities, namely the Belize Water Services Limited (BWS) for urban areas and the Village Water Boards (VWBs) in rural areas.

BWS serves approximately 59% of Belize's population with 12 water distribution systems and 3 sewerage systems (Belize City, Belmopan, and San Pedro Town). Despite this, wastewater collection and treatment are limited as the wastewater collection system only connects 21% of the urban population (Integrated V&A Assessment, 2019).

BWS uses watersheds and rivers for water collection, namely the Belize River, North Stann Creek River, and wells along the bank of the Macal River. Deforestation threatens the degradation of watersheds and water quality in aquifers. The Integrated V&A Assessment quoted that it is estimated that about a tenth of Belize's territory presents forest degradation. Climate change trends tend to exacerbate the extremes in a way that wet periods are becoming wetter and dry periods are becoming drier. In that sense, during dry periods, low water availability is expected to increasingly become a problem.

Social vulnerability

Water supply for urban areas, for example, is fed by reservoirs in mountainous areas. A reduced water availability scenario in catchments feeding the reservoir will thus have a direct social impact in urban areas located far away. The same applies to agricultural lands, which need water to produce food.

Figure 3.5 shows the social vulnerability to water availability for a portion of Site A, with the highest vulnerability observed in and around urban areas and on agricultural lands. Natural habitats also show a social vulnerability to this hazard, given the value of their ecosystem services to the well-being of Belize's inhabitants.

Economic vulnerability

Similar to the importance of water for all life processes, water is also crucial for economic activities. Lack of water can severely impact crops and cause considerable economic losses. The economic vulnerability analysis focuses on tourism activities with large and small hotels directly affected by lack of water.

Points of interest (non-residential buildings) exercising activities in tourism, commerce, finances, leisure, and services are also subject to economic vulnerability to water availability.

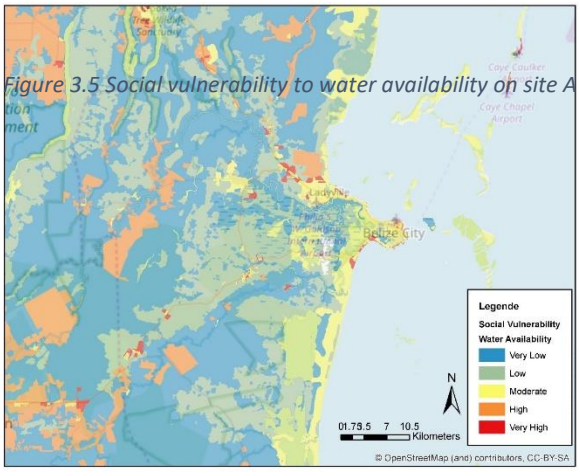


Figure 3.5 Social vulnerability to water availability on site A

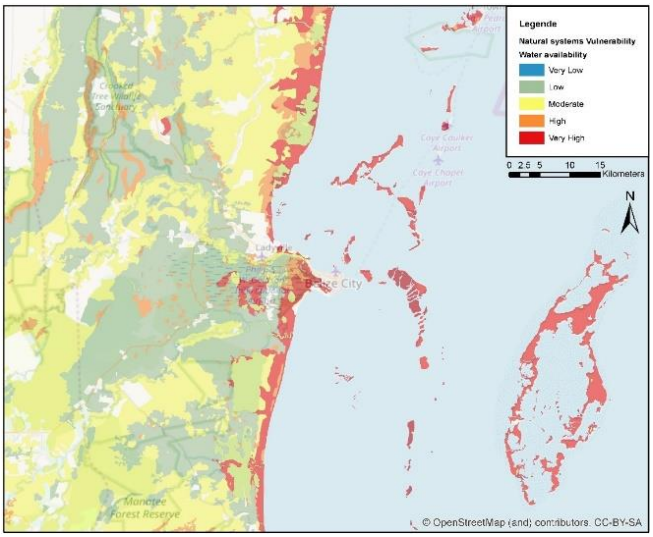
Natural systems vulnerability

Vulnerability of natural systems to water availability is given by the exposure to this hazard, which comprises the whole territory of Belize, and sensitivity indicators assigned for land cover classes.

Mangroves experience decreased photosynthesis, higher salinity, and changes in species composition, which lead to mangrove degradation and, eventually, loss. In addition, the quality of freshwater may also decline due to more saline water intrusion.

Figure 3.6 shows the natural systems' vulnerability to this hazard, where mangroves and littoral forests show the highest vulnerability. This is also the case for natural systems present in Belize's atolls.

Figure 3.6 Natural systems vulnerability to water availability on site A



Lowland broad-leaved forests show a *Moderate* vulnerability while savannahs have *Low* vulnerability to this hazard.

3.2.4 Agriculture Sector

The analysis of the agriculture sector focused on six of the most critical crops vis-à-vis their share in export: sugarcane, citrus, and bananas, and food security: maize, beans, rice. The economic component was the one analysed as it is the most significant. The remaining components are relevant indirectly, i.e., as following from the economic component.

Temperature rise

Exposure and sensitivity analysis

Fluctuations in temperature play a major role in agricultural production. The temperature rise trend is a general hazard to which the whole territory of Belize is exposed in similar scope because of the relatively small geographical size of the country.

Climate change trends tend to exacerbate the extremes so that seasonal patterns are disturbed and, in turn, drastically affect the agriculture sector. In addition, the changing conditions for aquaculture and crop growth, including seasons' length, contribute to more frequent occurrence of extreme weather events that encourage the recurrence of pests and diseases affecting Belize's agriculture sector and its productivity.

Economic vulnerability

As mentioned above, stable temperature conditions are essential for the growth of crops. However, as these are expected to change, new, more resilient varieties of crops need to be introduced to reduce the effect of temperature rise on agricultural productivity. In addition, temperature rise, together with precipitation change, through evapotranspiration and decreased water availability can and is already leading to droughts. This can severely impact crops and cause considerable economic losses.

The analysis focuses on agricultural activities, i.e., different crop types and aquaculture present in the areas of interest. It is assumed that all of them are exposed to temperature rise to a similar extent. The crops are characterized with different levels of sensitivity to this hazard as the decrease in yields varies for different crop types. Subsistence farming of maize and beans is particularly vulnerable, reaching nearly 14-20% decrease in productivity depending on the scenario.

Precipitation change

Exposure and sensitivity analysis

Change in precipitation patterns due to climate change trends is a hazard to agricultural production in the entire country. However, due to the geographic size of Belize, it is assumed that the impact will be quite similar in the project's areas of interest, as they don't include the Maya Mountains range located in the South. Therefore, it is assumed that agricultural lands in project sites are exposed to this hazard to a similar extent.

Climate change also exacerbates existing trends in precipitation, making dry season at more considerable risk to droughts and wet season with more frequent flood occurrences. Thus, especially during dry periods, low water availability for agriculture is expected to become a problem that increasingly jeopardizes agricultural productivity.

Economic vulnerability

Disturbance in precipitation patterns and excessive rainfall can lead to fluvial and pluvial flooding, particularly dangerous to smallholder farming near water bodies. Therefore, this aspect of the increase in precipitation has to be considered while assessing crops' sensitivity.

On the other hand, drought following temperature rise and insufficient precipitation in the dry season poses an equally serious threat to agricultural productivity in Belize. Recent and ongoing drought events in the country showed full magnitude of the problem, especially severe in case of smallholder farmers, whose adaptive capacity is limited and who have no access to irrigation, entirely relying on regular precipitation. Sugarcane farming is also highly exposed to both flooding and droughts, as it primarily relies on precipitation water.

Water availability

Exposure and sensitivity analysis

Water availability is a hazard to which the entire area of Belize is exposed, not excluding agricultural areas. Belizean economy relies on domestic agriculture production both for export and subsistence. Both types of agricultural production are heavily dependent on rain-fed water, the latter being characterized by almost no irrigation systems present. Given climate change trends affecting precipitation patterns resulting in low water availability will increasingly become a significant problem that will impact agricultural productivity in Belize.

Economic vulnerability

As earlier indicated, a decrease in water availability can severely impact yields and cause considerable economic losses. This, in turn, translates to decreased supply on domestic food

products market and subsequently increased prices for produce, making the more vulnerable, more disadvantaged unable to purchase the needed resource.

Tropical storms and hurricanes

Exposure and sensitivity analysis

An increase in frequency and intensity of storms and hurricanes will directly and adversely affect the agriculture activities exposed to this hazard. It will also exacerbate the impact of other hazards such as a change in precipitation patterns and saltwater intrusion.

An increase in the frequency of storms and hurricanes will increase pest incidence and new diseases. In a study by the UN Office for Disaster Risk Reduction (UNDRR) for Belize, it is asserted that flooding resulting from occurrence of extreme weather events has a very high damaging potential. The 2003 National Food & Agriculture Policy Document, which covers the period 2002-2020, mentions that Hurricane Keith, Tropical Storm Chantal, and Hurricane Iris caused together more than US$200 million in damages to the agricultural sector in Belize.

Economic vulnerability

The impact of this hazards on agricultural activities determines the economic vulnerability of agriculture sector to tropical storms and hurricanes. Smallholder farming will be particularly affected in terms of productivity, as family farmers usually lack the financial capacity to invest in adaptation measures and quicker recovery after storm events. In cases where they have acquired these newer infrastructures and technologies, increased frequency of storms and increase storm intensity will continue to disenfranchise the smaller producers. On the other hand, sugarcane planting is particularly vulnerable to stronger Tropic Cyclone events.

Although most farming activities are located outside of the zone impacted by the storms and hurricanes (both within project sites, as well as overall in the entire country), the aquaculture sector is highly sensitive due to its location near the coast.

Saltwater intrusion

Exposure and sensitivity analysis

The exposure to saltwater intrusion in the Belizean coastal zone is still limited, although it can increase due to sea-level rise and precipitation change. Most of the agricultural activities in Belize other than aquaculture are located inland. Nevertheless, projected increased storm surges threaten several areas that as a result could experience inundation with saltwater and destroy crops (Integrated V&A Assessment, 2019). Aquaculture is highly exposed due to its location on the coast.

The full extent of the coast's exposure to tropical storms, together with data regarding precipitation change, were used to estimate the exposure of agricultural activities to saltwater intrusion.

Economic vulnerability

The economic vulnerability of the agriculture sector to saltwater intrusion is determined by the impact of this hazard on agricultural activities. Aquaculture will be particularly affected in terms of its productivity, as it is located on the coast. This can lead to an impact on the domestic seafood market and an increase in prices.

3.2.5 Fisheries Sector

Ocean acidification and warming

Exposure and sensitivity analysis

All marine habitats present in the coastal and marine zone of Belize are exposed to ocean acidification and warming. Marine organisms use chemical concentrations in the ocean to guide their life processes, such as predator/prey presence, routing, and mating. The Integrated V&A assessment stated that several studies show that ocean acidification disrupts neurological functions affecting these processes.

In the case of Belize and the Mesoamerican reef ecosystem, the queen conch and the spiny lobster could be affected by ocean acidification during their long larval stages of 8-10 months (Integrated V&A Assessment, 2019). These effects are expected to be felt to a greater degree if one considers the capacity of the country to respond to this hazard and the consequences it brings along.

The Integrated V&A Assessment stated that according to the Belize Fisheries Department, fisheries rank 4th in income earnings while it provides 3,210 jobs, including aquaculture. Consequently, social sensitivity indicators for ocean acidification and warming give a higher weight factor to working-age population, considering the economic and employment dependence of Belize's population on fisheries and aquaculture.

The V&A further stated that the Caribbean spiny lobster, Panulirus argus, is the most important fishery in Belize, and although it is considered stable with earnings reaching $16.85 million, no additional effort is recommended. It continued with saying that the effects of ocean acidification and warming have been proven to alter the spiny lobster's chemosensory-driven sheltering behaviour, which may have stark consequences for its populations in the future. Additionally, the V&A observed that commercial fishing for lobster is practiced chiefly in shallow waters (5-15m) within the reef lagoon directly in front of Belize's coast, with more experienced fishers venturing to the fore reef.

The effects of ocean acidification on bonefish, Albula vulpes, were studied by Piersiak et al, as stated within the Integrated V&A Assessment, by adding CO_2 and thus decreasing the pH of water until fish lost equilibrium. This phenomenon occurs when the fish turns upside down and cannot turn back again. Results showed that bonefish lose equilibrium at a pH lower than 7 with a tolerance level as low as 6.16. Since the decrease in pH calculated under RCP 8.5 of around 0.30 for ocean water that has a pH of 8.1-8.2, it is evident that bonefish is not directly threatened by ocean acidification.

The assumption is made that bonefish will tend to migrate away from deteriorating environments. However, Permit and Tarpon fish species in Belize are affected mainly through temperature changes, which alter their migration routes in the case of tarpon. Nonetheless, it is the effects of this hazard on their ecosystems and habitats that exerts pressure on their subsistence. Moreover, both tarpon and permit are considered game fish, also called sport fishing or fishing for pleasure or competition in contrast to commercial fishing.

Social vulnerability

Social vulnerability to ocean acidification and warming for the fisheries sector is determined almost entirely by the populations economic end employment dependency. The Integrated V&A Assessment stated that Belize's food dependency on fish & seafood accounts for less than 1% of the country's

dietary energy supply while, as previously stated, fisheries rank 4th in income earnings and provides 3,210 jobs, including aquaculture.

The georeferenced results show areas with high vulnerability on coastal settlements. Almost the entire Placencia peninsula is covered by the highest vulnerability, with the only middle part, between Placencia Lagoon and the southern tip the peninsula, showing moderate vulnerability. Several aquaculture complexes are located north and south of Independence, on the coast directly west of Placencia peninsula. Given the touristic nature of economic activities in the Placencia peninsula, one must be careful in interpreting these cartographic results. The higher ratio of working-age population in the Placencia peninsula is likely to be related to touristic activities, while Independence town's economy may depend more on the nearby aquafarms.

Other areas showing high social vulnerability to these hazards include the northern areas of Belize City, north-eastern areas of Corozal Town in northern Belize, and the whole Consejo settlement in the furthermost northern village close to the Mexico border on Belize's coast.

Economic vulnerability

Economic activities related to fisheries and aquaculture are analysed according to available data regarding economically relevant species. Spiny lobsters, the queen conch, and bonefish are the most significant, while tarpon and permit are mainly fished for recreation. Given the impact of ocean acidification and warming on ecosystems and the dependence of marine species on these, marine habitats are used to determine the economic vulnerability of the fisheries sector. Conch, bonefish, permit, and tarpon habitats are located cartographically, and the potential economic damage gives their marine habitats sensitivity. Therefore, the deterioration of these habitats could impact the fisheries sector.

Shallow water in front of Belize's coastline between the barrier reef and the mainland, as well as the entire length of the barrier reef, which extends about 300 km from north to south along the coast, is the primary ground for lobster fishing. These areas are subject thus to *high* or *very high* economic vulnerability. In addition, Queen conch habitats can be found along the reef and are clearly demarcated in the economic vulnerability maps for this hazard.

The highest vulnerability is observed in the coral reef systems. Nonetheless, the seagrass bed habitats show *High* vulnerability. This map locates the habitats of bonefish, conch, permit, and tarpon. These are all located in areas with *High* to *Very High* vulnerability emphasizing their economic relevance for Belize's fisheries sector.

Sea level rise

Exposure and sensitivity analysis

Concerns related to sea- level rise for the fisheries sector are mostly focused on sensitive coastal ecosystems such as mangroves, seagrass beds, and coral reefs which are critical for the survival of marine fish species. Areas most exposed to this hazard in Belize are along the mainland, where fringing mangroves grow and the cayes. Many species of reef fish and nursery habitats are found within mangroves, therefore, the sensitivity of mangrove systems to rising sea levels is also subject to changes in freshwater input and the rate of sedimentation (Integrated V&A Assessment 2019).

Aquaculture is also exposed to this hazard as aquafarms near the coast can experience changes in various water quality parameters, migration routes, and nutrient supply for hatchery production. Hence, loss of land and mangroves due to rising sea levels are the primary causes affecting aquaculture production (Integrated V&A Assessment).

Given the effects of sea-level rise for the fisheries sector and available demographic data, social sensitivity and resulting vulnerability are similar to ocean acidification and warming.

Coral reefs and seagrass beds are the main habitats for the nursery of commercially significant marine species such as lobster and conch. These ecosystems are expected to withstand the 1-meter increase in sea level predicted for 2100 (Integrated V&A Assessment, 2019). Nonetheless, the adverse effects of sea- level rise on corals depend on the rate of increasing water levels.

Economic vulnerability

Very high economic vulnerability to sea- level rise results for all the cayes and coastal mangroves in Belize. All land surrounding the Turneffe Atoll shows very high economic vulnerability to sea- level rise as habitats for hatchery and nurseries of commercially valuable marine species facing environmental changes.

Tropical storms/hurricanes

Exposure and sensitivity analysis

An increase in intensity and frequency of tropical storms and hurricanes is expected to have considerable detrimental consequences for the fisheries sector as habitats are directly exposed to this hazard. Shallow water natural habitats are already susceptible to storm surges, such as coral reefs and seagrass beds. Greater damage caused by more intense storms combined with more frequent such events leaves little room for recovery of these natural systems, which in turn sustain a variety of commercially valuable marine species.

The aquaculture industry would see an increase in storm related damage, which can cause pond damage and levee breaches for shrimp farmers. However, the V&A stated that the passage of Hurricane Iris in 2001 left very little damage to aquaculture infrastructure in Belize, which lowers the severity of climate change impacts expectations for this industry.

Coral reefs and seagrass beds are considered to be amongst the most productive ecosystems in the world. Both are vital hatchery and nursery grounds for a number of important commercial marine species. Unfortunately, coral reefs are exposed to mechanical damage due to violent storm surges threatening their survival. Seagrass beds are also essential feeding grounds for Marine Turtle, Manatee, and dozens of marine bird species. Increased frequency of Category 4 and 5 hurricanes could cause long-lasting turbidity within seagrass beds severely affecting them (Integrated V&A Assessment, 2019). Coral reefs and seagrass beds also stabilize coastal sediments, capture, and recycle nutrients, and reduce wave energy. The V&A stated that in Belize, as much as 50% of the spiny lobster and 40% of conch production are from seagrass beds which equates to some USD$5 million annually. Economic vulnerability

Economic vulnerability to tropical storms and hurricanes in Belize for the fisheries sector is determined by the impact of this hazard on marine habitats and land cover classes. Belize's reef lagoon, where vast quantities of seagrass beds are present, shows economic vulnerability ranging from moderate in the northern parts of the coastline to high and very high further south. The cayes and atolls fall mostly under Very High vulnerability for underwater marine habitats and High for overland areas.

Shallow water in front of Belize's coastline between the barrier reef and the mainland, as well as the entire length of the barrier reef, which extends about 300 km from north to south along the coast, is the primary ground for lobster fishing. These areas are subject to high or very high economic vulnerability. Queen conch habitats can be found along the reef and are clearly demarcated in the economic vulnerability maps for this hazard.

3.3 Recommended Adaptation Measures

3.3.1 Coastal Zone Sector

Box 3.1 Proposed measures for the coastal sector

Proposed priority adaptation measures in Coastal Sector
EBA: Active planting and maintenance of mangrove stands as a natural sea wall
Ecosystem-based Adaptation (EbA) is priority measure for implementation in the Coastal Zone. EbA is also typically considered a no-regret adaptation measure – It can be easily and successfully implemented in the Belizean context (given the natural habitats that the country harbours). EbA is already being implemented on a pilot basis through a World Bank Adaptation-funded project, namely MCCAP. This project is under the responsibility of the Fisheries Department and the Protected Areas Conservation Trust (PACT). In this manner, Belize is also making great strides towards determining the costs and the effectiveness of EbA as an adaptation strategy. The conservation of both coral reefs and mangroves would fall under the EbA typology. The former is covered under Fisheries. In the context of the Coastal Sector, mangroves are the typical focus of EbA measures. They provide a natural line of defence against coastal erosion, extreme weather events, storm surge, and sea- level rise. Well-conserved mangroves will also help local people build resilience, to the extent that the ecosystem is an essential source of construction wood, food, fibre and possibly medicine. The conservation and restoration of mangrove areas, especially in areas of very high vulnerability to climatic hazards that will affect the coastal zone, can bring about a significant decrease in the economic vulnerability of these areas and therefore should be prioritized as an adaptation measure.
Sea walls
Remodelling of existing seawalls can accommodate the sea level rise and increasing wave height during extreme weather events. This measure, however, requires a more detailed viability analysis, as the cost of construction of new walls and remodelling of existing ones is high and has to be carefully assessed – not to mention EIA studies and other pre-feasibility studies.
Managed retreat
In areas of very high vulnerability to coastal erosion (in the context of this assessment, especially applicable to certain infrastructure (including in Belize City) and natural systems), managed realignment of the shore should be considered. However, this measure is an expensive engineering undertaking, and the Government of Belize is advised to conduct a detailed CBA to assess its feasibility.
Migration out of low-lying areas
The government of Belize could consider migrating populations located in the coastal zone who are severely vulnerable to impacts of extreme weather events, sea-level rise resulting in flooding, and coastal erosion. In site A, Belize city and Ladyville are severely vulnerable most hazards, would be the most important areas of interest. In site B, the Placencia Peninsula, Independence, and Mango Creek, and aquaculture should be prioritized. Replacing or remodelling several infrastructures could be considered. The removal of

Proposed priority adaptation measures in Coastal Sector
these objects and parts of the aforementioned areas has to be carefully assessed further. All retreat processes are generally gradual and complicated also because some of these areas of very high vulnerability are tourist destinations.
Integrate Disaster Risk Management in the Coastal Zone to Adaptation Planning
In the 2016 Integrated Coastal Zone Management Plan, the government of Belize recognized that Disaster Risk Management should include climate change impacts. Therefore, the government should ensure cooperation between NEMO and other relevant governmental and private entities to accelerate this inclusion process for all relevant sectors, including coastal sector.

Box 3.2 Proposed policy measures to support adaptation for the coastal sector

Policy and legislation change for adaptation in Coastal Sector + Institutional collaboration & Finance

Strengthen the implementation of all of Component 4 elements/activities and measures of the 2016 ICZMP, which focuses on climate change adaptation. This is the **top priority policy adaptation measure** for the Coastal Zone Sector – regardless of whether it would be classified as a baseline or additional measure from a climate finance point of view.

Strengthen the implementation of other key actions foreseen in the 2016 ICZMP, namely in the remainder of the Plan's Components – and measures that can facilitate or enable climate change adaptation measures. More specifically, these should be priorities:

- Research & Monitoring of the coastal zone
- Protected Area Management (on the coastal zone)
- Mangrove protection
- Coastal Habitat & Species Conservation
- Fisheries management
- Coastal Area Planning & Development
- Beach & Shoreline Management
- Marine Pollution Control
- Disaster Risk Management
- Education, Awareness & Communication
- Sustainable Coastal Economies
- Collaboration in Enforcement & Monitoring
- Capacity Building

Maintenance and consequent development and strengthening of Early Warning Systems for the Coastal Zone, using appropriate technology, including securing technology transfer programs for the purpose.

Complete the revision of the National Land Use Policy and Integrated Framework for Land Resources Development which can guide both public and private sectors in land use zoning in the Coastal Zone.

Enforce the recently approved 'Protection of Mangrove Regulations' to reduce the removal of mangroves, which affects fisheries' habitat.

Ensure collaboration with **NEMO, City, Town and Village Councils, the Ministry of Works** on the management of floodwaters, with MCCAP responsible for the management of protected areas; with the **Fisheries Department** and the CZMAI responsible for all matters concerning halieutic resources as a coastal resource; as well as with several other entities, whose collaboration framework has been masterfully described in the 2016 ICZM Plan (Tourism, Mining, local government).

Consider and address gender inequalities in a much more systematic way in the management of coastal resources. Women have a primordial role in mainstreaming resilience into the implementation of the 2016 ICZM Plan and in adaptation measures within the Coastal Sector.

Leverage funding for implementing the 2016 ICZMP in full, and within a realistic time frame, including tapping into climate finance as an additionality for the purpose.

3.3.2 Water Sector

Box 3.3 Proposed measures for the water sector

Proposed priority adaptation measures in Water Sector
Water recycling/reuse
Water recycling and reuse is the most viable option for reducing vulnerability to water availability in natural systems, for human use but especially in agriculture, which has very high exposure to water deficits and droughts. Therefore, improving water recycling is the best way to ensure sufficient water is available to the population living within the boundaries of the sites but primarily to avoid crop scarcity. Water reuse can be improved through various interventions such as investments in infrastructure, training, and capacity building. It should be considered that the population of Belize is distributed across the country, with majority of people living outside of Belmopan and Belize City. The Belize Water Services (BWS) and the Hydrology Unit, together with other relevant government bodies, especially at the lower administrative level (community – Village Water Boards), are strongly encouraged to work on viable solutions for improving water treatment and reuse.
Monitoring and Early Warning System
Monitoring and Early Warning System should be a number one priority for providing information about the availability of water, forecasting, and providing warnings against floods and droughts. This is in line with the 2016 Integrated Coastal Zone Management Plan, which emphasizes the important role of monitoring activities, especially in connection with climate change-related hazards. In the water sector, monitoring of inland flooding risk and water availability should focus mainly in mangrove areas, agricultural and cultivated land, and urban areas. The system could additionally foresee incorporating early warning against impact of extreme weather events on water resources. The Belize Water Services, the Hydrology Unit, and Village Water Boards are advised to assess how the aforementioned monitoring activities can be incorporated into an existing framework.
Temporary or permanent retreat from areas at risk of flooding
The government of Belize could consider remodelling or moving several objects of infrastructure, including certain parts of roads and the Sir Barry Bowen Municipal Airport. In addition, agricultural activities could be gradually moved to areas where the risk of inland flooding is less severe. Some parts of urban areas could be considered candidates for retreat. However, they should be carefully assessed further as all retreat processes are generally gradual and complicated.
Storm Water Management
This measure should be for the most engineered solutions, and EbA – the latter when green areas are used for assisting with excess storm water collection in peak-times e.g. If EbA is the measure of choice, natural systems can be used for collecting of storm water and managing the influx by promoting water infiltration into the ground. Under EbA, the ecologically important areas must remain protected.
Water conservation practices, including water harvest, storage, temporal transfer, and efficient use of rainfall water
Water conservation implies using water efficiently to reduce unnecessary water usage. It mostly includes engineered solutions and may refer to commercial, agricultural and/or household applications.

Proposed priority adaptation measures in Water Sector
For places with pre-existing water stress of high usage, water conservation practices will require a more robust application of adaptation measures. This measure can be implemented well with water trading.

Box 3.4 Proposed policy measures to support adaptation in the water sector

Policy and legislation change for adaptation in Water Sector + Institutional collaboration & Finance
Implement the National Integrated Water Resources Management Policy (2008) and the National Integrated Water Resources Act (2011), including strengthening the enabling aspects in the mentioned frameworks which, promote can facilitate the implementation of proposed adaptation measures further up. **Strengthen, as much as possible through regulations a 'climate sensitive' and 'climate smart' management of water resources** (i.e., tending towards Adaptive-IWRM). **Develop the management frameworks for the water sector based on evidence and data**, preferably geographically-based data, that relates to adaptation or facilitates the implementation of adaptation actions – **Strengthen the implementation of cross-sectoral and integrated adaptation measures** through collaborative implementation frameworks with other sectors – e.g., Measure #12) Water conservation practices, including water harvest, storage, temporal transfer, and efficient use of rainfall water. **Integrate DRM in the management of the Water Sector, particularly for the management of flood and storm waters.** **Leverage funding to implement adaptation measures** in the Water Sector, including a realistic time frame for implementation and clear responsibilities across entities. **Tap into climate finance** as an additionality for the purpose of funding implementation of the new frameworks for the Water Sector. **Fully consider gender inequalities in the Water Sector**, even though they may not be fully apparent in a context such as Belize.

3.3.3 Agriculture Sector

Box 3.5 Proposed measures for the agriculture sector

Proposed priority adaptation measures in Agriculture Sector
Climate- Smart Agriculture, including the development of new varieties of crops, Intercropping of adapted varieties of species
To a certain extent, Belize is already implementing climate-smart agriculture. However, the scale is not sufficient to ensure a broader transformation into the sector. Therefore, the focus is on strengthening or scaling up the current CSA Project implemented by the Ministry of Agriculture. Regardless, **the impact of climate change in agriculture will be significant and adaptation a necessity.** Increasing crops' resilience to changing precipitation patterns and changes in temperature both by conventional breeding and by genetic modifications of the crops is part and parcel of a broader strategy for CSA. While adapted and resilient seeds provide a strong basis for implementing CSA, an on-farm context of resilience needs to be understood, including market parameters, and access to specialized agronomic knowledge. In some places, CSA will imply intercropping, while in others, it could mean mulching or terracing. Quite often, it also includes no-till agriculture.

Proposed priority adaptation measures in Agriculture Sector
Therefore, to roll out CSA at scale, **meaningful discussions** involving farmers, policymakers, and technical professionals should occur, given that few people actually know what CSA means for Belize. **A core principle of CSA is that resilience is the first priority. A second one is that CSA is highly contextual.** It depends on the biophysical resources and the level of specialized – and adaptive -- know-how. Therefore, discussions and knowledge sharing should now pave the way for a broader discussion on what climate-smart agriculture will mean for Belize and different localities. This study contains **fine-scale and geo-referenced climate information – in particular of various aspects of vulnerability.** The study should be widely used to make sense of the different strategies for bringing CSA to scale in Belize and for decision-making on land use and CSA techniques.

Box 3.6 Proposed policy measures to support adaptation in the agriculture sector

Policy and legislation change for adaptation in Agricultural Sector + Institutional collaboration & Finance
Strategies recognized to alleviate the hardships resulting from climate change have been recommended by the current policy frameworks for the agricultural sector (namely, in the **National Agriculture and Food Policy of Belize for the period 2015 to 2030)**. The Agriculture and Food Policy does recognize that climate change is no longer a topic of the past, and its effects are already impacting the agriculture sector. Other strategies such as the Agriculture Development Management and Operation Strategy, and the National Adaptation Strategy to Address Climate Change in the Agriculture Sector are critical polices that support improved adaptation to climate change in water resources management, increase biodiversity for agro-ecological balance, and economic sustainability of agriculture productions systems. It is imperative that farmers become better prepared to mitigate against climate change. At the same time, the development of specific rural strategies defining adaptation measures in agriculture is highly recommended. The Climate Smart Agriculture Project being funded by the World Bank and implemented by the Ministry of Agriculture is a start in improving adaptation and leveraging finance to implement CSA at the national scale. **Consider the implementation of measures that focus on subsidized drought assistance.** At the same time, policymakers should keep in mind that when government provides subsidies as an incentive, these always have a trade-off and an opportunity cost – mostly in the form of undesirable market distortions and aggravation of inequalities among social and economic groups. Therefore, **policies involving the subsidized need to be carefully crafted and should be at best a temporary measure.** **Crop insurance is a market-based measure whereby an external entity (the insurer) de-risks the cropping activities in the face of climate change.** If climate-tailored insurance products targeting farmers do not yet exist in Belize, the work at hand would involve sensitizing the insurance industry to the needs of these farmers and the opportunity to make a profit while generating a public good. Other key policy measures recommended for the Agricultural Sector include **the integration of DRM in the management of the risk within the Sector.** Fully consider **gender inequalities i**n the Agricultural Sector, ensuring that every policy, strategy, and action provides a gender-balanced value proposition and that they do not aggravate inequalities. **Base the development of adaptation policies, strategies, and actions within the Agricultural Sector on evidence and data, preferably geographically-based data**, that relates to adaptation or facilitates the implementation of adaptation actions – such as **the on-system data produced by the current study**. **Leverage climate funding for implementing additional adaptation measures,** including **in proposals** a realistic time frame for implementation and clear responsibilities across entities.

3.3.4 Fisheries Sector

Box 3.7 Proposed adaptation measures for the fisheries sector

Proposed priority adaptation measures in Fisheries Sector
Policies reducing non-cc-related stresses
Introducing new policies and enforcing existing ones is the number one priority of no-regret adaptation measures in the fisheries sector. These policies should be aimed primarily at reducing the pressure caused by factors unrelated to climate change, but that exacerbates the impact of cc-related hazards included in this assessment. The policies should put the emphasis on: • Reducing pollution (to the extent that it reduces pressure on the marine ecosystem and its services) • Reducing overfishing and enforcing sustainable fisheries • Shifting livelihoods to decrease pressure and to adapt sources of income vis-à-vis reducing job opportunities in fisheries • Enforcing sustainable tourism • Declaring new conservation areas • The impact of tourism is of particular interest, as it is one of the primary industries of the economy of Belize. Some policies that seek to implement adaptation measures in the Fisheries sector have also contributed to reducing the social and economic vulnerability of fisheries' dependent populations. The reinforcement of measures could, though, be significantly improved. The policies should also target women as one of the most socially and economically vulnerable groups, whose vulnerability to climate change is projected to increase further. They should also be projected considering climate change scenarios, i.e., address non-cc related pressures 'in excess', keeping in mind increasing pressure from cc-related hazards in the future.
Ecosystem-based Adaptation (EbA)
Ecosystem-based Adaptation (EbA) is another no-regret measure of adaptation that can be successfully implemented in the Belizean context. As far as fisheries, the Belizean coral reef and seagrass area should be subjected to improved conservation efforts. Both the reef and the seagrass render various important ecosystem services such as providing habitat for commercial fisheries species, decreasing the impact of hurricanes on fisheries (seagrass). Parts of the reef within the boundaries of the sites are already under conservation, e.g., South Water Caye, but there are several highly vulnerable parts that currently are not under conservation (e.g., part of the reef south from South Water Caye). The government could consider including them in the national chain of protected areas. Another critical ecosystem providing an excellent basis for EBA are mangroves. They are a natural line of defence against extreme weather events and sea-level rise. Their conservation and restoration, especially in areas of very high vulnerability can significantly decrease economic vulnerability and therefore should be prioritized as an essential adaptation measure.
Monitoring and Early Warning System
As pointed out in the 2016 Integrated Coastal Zone Management Plan, monitoring ecosystems' health should be prioritized. The effort foreseen in the plan should also include creating an early warning system for climate change-related hazards. For the fisheries sector, ecosystems' health should apply to coral reefs and aquaculture related to, amongst others, water acidification, pollutants release. and the occurrence of extreme weather events such as hurricanes and storms.
Integrated Disaster Risk Management in Fisheries
In the 2016 Integrated Coastal Zone Management Plan, the government of Belize recognized that disaster risk management should include climate change impacts. Therefore, the government should ensure cooperation between NEMO and other relevant governmental and private entities to accelerate this inclusion for all relevant sectors, including fisheries.
Sea walls construction and remodelling
Remodelling of existing seawalls can accommodate the sea level rise and increasing wave height during extreme weather events. This, however. requires a more detailed CBA analysis, as the cost of construction of new walls is high and has to be carefully assessed.

Box 3.8 Proposed policy measures to support adaption in the fisheries sector

Policy and legislation change for adaptation in Fisheries Sector + Institutional collaboration & Finance

Revision and passage of the Fisheries Resources Bill with help to strengthen the policy and institutional framework for fisheries resources management as it expands the range of species under protection, improves governance framework for marine protected areas, and fines for rule-breaking.

Consider the implementation of conservation measures in the fisheries sector.

Insurance is a market-based measure whereby an external entity (the insurer) de-risks the fisheries activities in the face of climate change. If climate-tailored insurance products targeting fishermen (and women) do not yet exist in Belize, the work at hand would involve sensitizing the insurance industry to the needs of these groups and the opportunity to make a profit while generating a public good.

The integration of DRM in the management of the risk within the Sector.

Fully consider gender inequalities in the Fisheries Sector, ensuring that every policy, strategy, and action provides a gender- balanced value proposition and that they do not aggravate inequalities.

Base the development of adaptation policies, strategies, and actions within the Fisheries Sector on evidence and data, preferably geographically-based data, that relates to adaptation or facilitates the implementation of adaptation actions – such as the on-system data produced by the current study.

Leverage climate funding for implementing additional adaptation measures, including in proposals a realistic time frame for implementation and clear responsibilities across entities.

3.4 Climate Change Adaptation Action Portfolio

Tracking climate change adaptation is crucial to ensure that countries are building resilience to climate change impacts. However, it is recognised that the appraisal of climate change adaptation involves several major challenges, particularly the consideration of uncertainty as it cannot be quantitatively measured, unlike mitigation measures. Therefore, tracking adaptation actions is one of the first steps to ensure that adaptation actions will lead to increased resilience.

Through its Public Sector Investment Programme (PSIP) report, the Government of Belize tracks all projects. Those related to climate change adaptation have been reviewed and included in this portfolio. Additional adaptation activities that are currently being carried out were also gathered from the Climate Adaptation Analysis survey. Both sources help to provide a more comprehensive list of adaptation measures carried out from 2015 to 2019.

PORTFOLIO OF ADAPTATION ACTIONS			
Project/Activity Type	**Cost (USD)**	**Support Area (Adaptation/ Cross-cutting)**	**Implementing Entity**
Agro-ecological Farming of fruits and vegetables within the Selva Maya region (Cayo District)	50,222	Crosscutting	Ministry of Natural Resources (MNR)
Description	To promote sustainable production of fruits and vegetables through the use of agro-ecological practices that will reduce the harmful effects of synthetic fertilizers and pesticides while protecting the natural forest in communities within the Selva Maya region.		
Belize Education Sector Reform Programme II	35,000,000	Adaptation	Ministry of Education and Youth Services

Description	The use of simple reinforced concrete construction will contribute to resilience to natural hazards. On the coast, on the islands and in areas with high risk of flooding, structures will be elevated to high water protection from flooding, tsunamis, and storm surges, with the concrete roofs serving as potential refuges.		
Belize Marine Conservation and Climate Adaptation Project	7,047,979	Adaptation	MAFFESDI/PACT
Description	Implement priority ecosystem-based marine conservation and climate adaptation measures to strengthen the climate resilience of the Belize Barrier Reef System. Expanding Selected MPAs to achieve about 20% of area under protection and creating replenishment zones. Improve management effectiveness by strengthening the legal framework for the MPA network. Increase protection of mangroves, seagrass, and tidal marsh areas.		
Capacity development in the energy sector		Crosscutting	Energy Unit
Description	Energy Planning and Forecasting: to carry out long-term energy and climate adaptation planning to identify policies, investments, and capabilities that are necessary to achieve Government of Belize's objectives in addressing the vulnerabilities in the energy sector.		
Climate Resilient Infrastructure Project (CRIP)	30,303,030	Adaptation	Social Investment Fund (SIF)
Description	To enhance the resilience of road infrastructure against flood risk and impacts of climate change; and to improve the Borrower's capacity to respond promptly and effectively in an eligible crisis or emergency.		
Climate Smart Agriculture		Crosscutting	BEST
Description	Promotion of adaptation measures such as covered structures for agricultural production, use of insurance to cover storm damage to structures, climate resilient seeds and planting material.		
Climate Smart Agriculture		Crosscutting	CARDI
Description	Promotion, research and helping farmers to implement water harvesting, use of drought tolerant variety trials, biofortified crops, cover crops and agro-forestry systems, cover structures, early warning pest and disease app for farmers		
Climate Smart Agriculture		Crosscutting	UB-Central Farm
Description	Moving towards drought tolerant crops, implementing measures to use water resources more efficiently – improved irrigation, water harvesting, energy/protein banks, biopesticides and biofertilizers, IPM and cover crops, CSA training programs.		
Climate Smart Agriculture & Capacity Building		Adaptation	Ya'axche Conservation Trust

Description	Moving and promoting drought tolerant crops, adopting smart agriculture practices such as agroforestry and inga alley cropping, moving away from slash and burn practices, better water resource efficiency, developing early warning fire detection, capacity building for farmers and community members		
Climate Vulnerability Reduction Program (CVRP)	10,000,000	Adaptation	Ministry of Works
Description	Preparation of implementation and monitoring tools and technical studies in the following areas: climate change risk in the tourism sector, disaster risk management governance, climate change adaptation, and framework for a National Climate Risk Information System.		
EcoMicro - BCUL Green Finance for MSMEs in the Agricultural and Fisheries Sectors	600,000	Adaptation	Belize Credit Union League Limited
Description	Focused on providing financing for adaptation technologies and methods to increase the climate resilience of micro, small and medium-sized enterprises in the agricultural and fisheries sectors.		
Ecosystem based adaptation		Adaptation	CZMAI
Description	Use and promotion of ecosystem-based adaptation approaches for coastal protection		
Energy Resilience for Climate Adaptation Project	12,095,959	Adaptation	Belize Electricity Ltd
Description	To enhance resilience of the energy system to adverse weather and climate change impacts through long-term planning and capacity-building for adaptation and implementation of demonstration measures targeting the electricity transmission and distribution networks.		
Financing opportunities for climate change activities		Crosscutting	DFC
Description	Providing climate smart financing for climate smart agriculture, renewable energy & ensuring building codes & environmental laws are adhered to		
Flood Mitigation Infrastructure Program for Belize City	10,750,000	Adaptation	Ministry of Works
Description	Protection of the Belize City's drainage and urban road networks aiming at reducing Belize City's vulnerability to flooding events.		
Formulation of National Agriculture and Food Policy	36,282	Crosscutting	Ministry of Natural Resources (MNRA)
Description	To prepare a final draft National Agriculture and Food Policy for Belize that provides a framework for the sustainable development of the sector and increased socio-economic benefits to Belize.		
Fourth National Communication and First Biennial Update Report to the UNFCCC	1,905,000	Crosscutting	NCCO, MAFFESDI

Description	The Project will seek to assist the country of Belize in meeting reporting requirements under Article 12 of the UNFCCC		
George Price Highway Rehabilitation	28,528,000	Adaptation	Ministry of Works and Transport
Description	To improve the road connectivity by rehabilitating road infrastructure to national standards, decreasing travel time and costs, reducing road fatalities and injuries, and ensuring road accessibility by improving the CC resilience of the corridor. Planning for projected CC impacts and disaster risk planning for impacts associated with current climate variability and the consequences of future CC.		
George Price Highway Rehabilitation Project	34,288,383	Adaptation	Ministry of Works (MOW)
Description	Rehabilitation of the George Price Highway road infrastructure between miles 47.90 in Belmopan and 67.30 in Santa Elena to national standards		
Improving Disaster and Climate Resilience in Sustainable Tourism	707,070	Adaptation	IADB
Description	Mainstreaming disaster and climate resilience in tourism destination planning in Belize, emphasizing ecosystem-based adaptation and risk reduction. The specific objective is to increase the availability of destination-specific risk information, addressing existing and future vulnerabilities, in order to improve risk awareness and knowledge, inform local level tourism plans and the design and feasibility of physical investments.		
Improving Livestock Sector Productivity and Climate Resilience in Belize	884,545	Crosscutting	Belize Livestock Producers Association (BLPA)
Description	To improve the productivity of the livestock sector in Belize through the promotion of pasture intensification and address the low capacity for adaptation to climate change of especially small and medium-sized producers.		
Increasing community capacity		Adaptation	NAVCO
Description	Promoting and building awareness on the conservation and use of water, implementing irrigation systems in crop fields in rural communities		
Intra-ACP GCCA+ Programme in the Caribbean: Enhancing Climate Resilience in CARIFORUM Countries	*12 Million Euros	Adaptation	CCCCC
Description	Regional project that aims to strengthen the Climate Risk Management Framework in the 16 CARIFORUM member countries.		
Japan Caribbean Climate Change Partnership (JCCCP)	1,287,554	Crosscutting	UNDP

Description	Activities in Belize include supporting the development of Belize's National Climate Change Communications Strategy, National Adaption Plan (NAP) and Nationally Appropriate Mitigation Actions (NAMA); and implementing a sustainable agriculture and water resources management pilot project to advance inclusive low-emission, climate-resilient development in Belize.		
Livelihood diversification		Crosscutting	Turneffe Atoll Sustainability Association
Description	Researching and exploring supplementary livelihood options for fisherfolk, in the form of seaweed mariculture		
Managing climate change projects		Crosscutting	UNDP Belize
Description	Providing support, managing programmes/ projects related to climate change adaptation and mitigation, e.g., FNC/BUR project, JCCCP		
National Energy Information System		Crosscutting	Energy Unit
Description	To plan, promote, and effectively manage the production, delivery, and use of energy, and improve access to reliable and time-sensitive information to support energy policy and decision-making processes linked to CC adaptation and mitigation.		
Northern Highway Upgrading - Airport Junction to Haulover Bridge (5th Road - PSW Goldson Hwy Upgrading -Project)	29,719,000	Adaptation	Ministry of Works
Description	Climate adaptation features of the works include higher capacity drainage; river training; and improved bridge freeboard to protect the infrastructure from scour, higher intensity flood events, and sea level rise.		
Paving/Upgrading of the Manatee Road (Coastal Highway Upgrading)	1,150,000 pounds	Adaptation	Ministry of Works
Description	Update feasibility study and prepare preliminary and detailed designs to upgrade the Coastal Highway incorporating CC considerations; identify CC vulnerabilities, assessment of hydrological and hydraulic conditions, Climate Vulnerability Assessment: identifying and evaluating potential effects of CC on the road and the surrounding watersheds and identifying resilience measures to address the identified vulnerabilities		
PROADAPT2 -Proadapt Belize -Increasing Climate Change Resilience and Related Business Opportunities	203,000	Adaptation	Belize Chamber of Commerce and Industry (BCCI)
Description	PROADAPT was created to pilot and support the development of new and innovative methodologies, tools, and business models to help micro, small and medium enterprises (MSMEs) in Latin America and the Caribbean increase their climate resilience and take advantage of related businesses.		

Promotion of climate smart agriculture in sugar industry		Crosscutting	SIRDI
Description	SIRDI provides support and research in climate smart agriculture techniques, such as recommending minimum tillage in land preparation, incorporating fertilizer application, promoting the elimination of the second burning of harvest residues, use of biological agents for pest control, evaluating sugarcane variety to withstand the changes in the climatic conditions, irrigation trials experiment, fertilizer dosage trails.		
Protected Areas Management Initiatives		Adaptation	APAMO
Description	Climate smart, conservation and management programmes and plans implemented for marine and terrestrial habitats, which increases the resiliency within the network of vulnerable Protected Areas and use of solar technologies. Improve adaptation capacity to climate change and climate resilience of the ecosystems in buffer communities. Improved awareness of climate change impacts and mitigation and adaptation measures towards climate resilient ecosystems development in the buffer communities.		
Raising awareness & increasing capacity		Adaptation	TIDE
Description	Carry out activities for reforestation along riverbanks, livelihood diversification opportunities, outreach to increase awareness about climate change, building away from coast and advise on re-location of communities highly impacted by coastal erosion etc.		
San Ignacio/ Santa Elena Bypass Project	29,472,222	Adaptation	Ministry of Works (MOW)
Description	Construction of a bypass road and new all-weather bridge across the Macal River to increase the efficiency of road transportation in and through San Ignacio and Santa Elena. The project also includes activities to determine the extent of vehicle overloading and the accompanying economic and financial impacts.		
Smart Coasts		Adaptation	WWF, CZMAI & partners
Description	Mainstream climate smart principles into Marine Protected Areas Management and coastal development policies in countries bordering the Mesoamerican Reef with a view to improve the adaptive capacities of coastal communities in the region.		
Social Investment Fund III Project	10,000,000	Adaptation	SIF
Description	Provide increased gender-equitable and inclusive access to climate-resilient infrastructure and quality basic social-services for poor and vulnerable communities. The Project comprises small-scale infrastructure works and capacity building for stakeholders.		
Support for climate related projects		Adaptation	SIF

Description	Many SIF sub-projects have civil output to improve the lives of the beneficiaries. Classroom Buildings, Rudimentary Water System, Water distribution network, health centres, polyclinics, and resource centres would all require - adaptation of building codes, individual site's vulnerability to flooding, fire, etc. Other social interventions that are implemented alongside or separately include; training teachers, parents, students, community workers, and other identifiable stakeholders in water conservation, W.A.S.H., to operate and maintain water facilities, equipment and knowledge improvement.		
Support for climate smart agriculture		Adaptation	IICA
Description	Provide support for adaptation planning in the agriculture sector, identifying and implementing climate responsive practices, knowledge management, & support coordination with public and private sectors		
Sustainable Fisheries Management		Adaptation	Fisheries Department
Description	Implementation of effective management of fisheries resources and marine reserves; coral restoration; Planning: Monitoring of fisheries using climate information; early warning system, etc.		
Sustainable Forest and Biodiversity Management		Crosscutting	National Biodiversity Office
Description	Promoting sustainable forest and biodiversity management and use of resources through regulations		
Sustainable Tourism Program II	16,000,000	Crosscutting	Ministry of Tourism and Civil Aviation
Description	Project aims to increase tourism employment, income, and revenues through increased overnight tourism expenditures in the selected destinations while improving sector governance, promoting environmental sustainability, and creating enabling conditions for private sector investment in overnight tourism.		
Technology Needs Assessment for Climate Change Mitigation and Adaptation	166,666	Crosscutting	MAFFESD
Description	To identify and prioritize adaptation and mitigation technologies for Belize and development of a technology action plan		
Urban and Resilience Planning		Adaptation	BAP
Description	Work with Belize City Southside community to build urban resilience and with municipalities/communities on various planning related programs.		
Waste Management		Crosscutting	Solid Waste Management Authority

Description	Closure of open burning of municipal waste, several dump sites have been closed down, transfer facilities have been established and a sanitary landfill is in use.		
Water Management		Crosscutting	Belize Brewing Company Limited
Description	Measures are implemented to use water resources efficiently by recycling, conservation and zero discharge of wastewater		
Water Management		Crosscutting	Friends for Conservation and Development
Description	Promoting the efficient use of water with farmers and at FCD facilities, promotion of the harvesting of rainwater. FCD is developing an internal plan to reduce our carbon foot-printing at the office.		
Water Utility Climate Risk and Vulnerability Assessment	169,696	Adaptation	Belize Water Service (BWS)
Description	Consultancy services for the development of a Climate Risk and Vulnerability Assessment (CRVA) for 3 BWSL systems and formulation of an accompanying adaptation plan of action; and capacity enhancement of the BWSL in conducting CRVAs		

3.5 Conclusion

Adaptation planning is crucial for the sustainable development of societies. As a nation, Belize needs to transition from building awareness to developing and implementing actual plans and strategies. However, from the survey results, it is evident that there is a long road ahead for the adaptation process. The level of awareness in terms of climate change and adaptation is not where it should be, neither is the level of planning and implementation. Only one organization considered itself in the implementation phase of the adaptation process, backed up by the different adaptation activities that were described by stakeholders, as many of the activities are geared towards building knowledge or improving planning or management of resources. However, from responses obtained, it would seem that the sector most advanced in terms of implementation is the agriculture sector, as several organizations have been implementing climate-smart agricultural practices, but there is much room for growth. In addition, many entities incorporate climate adaptation within a broader climate change perspective rather than having actions or plans directed solely at adaptation.

To ensure increased adaptation planning and resilience, adequate human and financial resources are needed. Hence, organizations need to have increased capacities, skills, and tools to access financing. The uncertainties of climate change and the complexities of social and environmental systems emphasize the need for diverse and innovative tools in adaptation planning and implementation. The information and knowledge based on climate change risks and vulnerabilities also need to be increased, as they are essential in developing plans and informing the process and accessing finance.

Most organizations have not assessed their risks or vulnerabilities and do not have a strategy or plan in place for adaptation. Hence, the provision of information about the potential risks and level of vulnerability needs to be formally assessed to strengthen the actions of public and private stakeholders. These will then, in turn, inform decision- making and lead to increased capacity for access to finance. It can also be deduced that if more organizations were to conduct vulnerability and risk assessments, then they would be more likely to plan for adaptation to high vulnerability. With the knowledge in place, then recommendations can be made, and solutions sought after.

Based on the responses, adaptation planning is more likely to occur if knowledge of climate change, in general, is increased, a vulnerability assessment is conducted, expertise in planning is developed, and access to finance is more readily available.

Future Work & Recommendations

It is proposed that the survey be designed to track changes in adaptation activities over time, with a planned reoccurrence of every two years. Thus, the survey results will enable better tracking of activities over a long period.

It may not be easy to contact the same respondents when the survey is conducted again. However, the surveyor will aim to keep the survey as consistent as possible.

The proposed timing of the survey will allow for up-to-date information to be collected to measure progress while also avoiding stakeholder fatigue and allowing any changes to occur.

Tools and capacities for planning need to be increased in communication & collaboration, creating a learning process to transfer knowledge, skills and experiences, enhanced monitoring and evaluation of adaptation planning and actions currently being undertaken to learn and improve on, and finance mechanisms.

Adaptation planning is a dynamic process and is different for all stakeholders, and as such, it should be treated as a learning process, where experiences can be shared and modified.

4 Measures to Mitigate Climate Change

Despite Belize being a Small Island Developing State (SIDS) and a minute contributor to global emissions, there are a multitude of measures that the country nevertheless undertakes to reduce its greenhouse gas emissions. Seeing that the human induced increase of greenhouse gases into the atmosphere is the cause of climate change, understanding what type of GHGs the country is emitting, where the emissions are coming from and in what amount (Greenhouse Gas Inventory) is key for effective mitigation measures. Utilizing this understanding of its emissions, Belize is taking active steps to not only reduce its emissions, but to ensure emission reduction targets are maintained in the future.

4.1 Mitigation Assessment

In 2019, Belize conducted a Mitigation Assessment that assisted with preparing its Fourth National Communication and its first Biennial Update Report. This assessment provided key information such as: the implemented mitigation actions for the country, how those actions affected the different sectors and the identification of other appropriate mitigation options (National Climate Change Office, 2020). These different information groupings were assessed from both the public and private sectors to ensure that mitigation actions were captured from a holistic stance for Belize. As 2015 for the base year of the assessment, the Mitigation Potential measures the amount of long-term GHG emission reductions that can occur at the national level against a baseline (as is the case for National Communications). It is represented in tonnes of carbon dioxide equivalent. This is to ensure that mitigation measures remain in effective continuum for now and the future.

The Mitigation Potential was assessed by looking at two areas:

1. The current GHG emissions profile from the recent GHG inventory (Biennial Update Report, 2020).
2. Potential long-term scenarios for economic development with a focus on population growth and GDP growth (Biennial Update Report, 2020).

GHG Emissions Profile (2019)

The Greenhouse Gas Emissions Profile is an assessment that provides specific data that shows GHG emission levels from the different sectors. Emission Profiles are utilized to make effective mitigation measures where the main structure is the GHG Inventory. The GHG inventory is the actual database that presents detail data of GHG emissions for Belize. The assessment revealed that the Forestry and Other Land Use (FOLU) Sector has the greatest impact in Belize's emissions. This sector, however, acts as a carbon sink and is responsible for Belize removing more GHGs than it is emitting for its historic period. Even though Belize is a net remover, there are still GHG emissions occurring in the sectors of Energy, Agriculture, Waste and Industrial Processes and Product Use (IPPU). Table 4.1 below shows the breakdown of GHG emissions in Belize for the years of 2012, 2015 and 2017 (Biennial Update Report, 2020).

Table 4.1 GHG emission in the historical period (Gg CO2-eq)

Inventory Sector	2012	2015	2017
Energy	546.89	794.58	802.46
IPPU	17.72	44.63	54.16
Agriculture	303.35	292.32	399.37
FOLU	-8,232.46	-5,898.41	-6,714.37
Waste	126.58	133.43	139.08
Total Without FOLU	994.54	1,264.96	1,395.07
Total With FOLU	-7,237.96	-4,633.44	-5,319.33

Utilizing this information is the basis for assessing proper Mitigation Potentials and, thus, undertake effective mitigation measures for the country. The data retrieved from the GHG inventory (presented in Table 4.1) was used to develop the Potential Long-Term scenarios. However, some adjustments had to be made to the information to assess the impacts of these mitigation measures. Box 4.1 below outlines the adjustments that were made (Biennial Update Report, 2020).

Box 4.1 Adjustments made to the GHG inventory to develop GHG emission scenarios

Energy sector:

- Using the most disaggregated activity data provided by the inventory to estimate the GHG emissions using default 2006 IPCC Emission factors
- Splitting the transport aggregated fuel consumption by fuel
- Estimating the GHG emissions from the consumption of charcoal.

IPPU sector:

- Using the AD provided to estimate the GHG emissions using default 2006 IPCC emission factors for lime production and lubricants consumption.
- Estimating the GHG emissions of refrigerant and air conditioning using an IPCC methodology and the data on refrigerant blends provided by the inventory.

Waste sector:

- This sector has been calculated entirely using tier 1 2006 IPCC methodologies using some data (waste generation rates, waste composition, etc.) from the national GHG emissions inventory.

Agriculture, Forestry and Other Land Use (AFOLU):

- The estimate of GHG emissions from forest fires has been moved from FOLU to Agriculture (biomass burning).
- The emissions due to hazards, i.e., hurricane effects on forests, are subtracted from the estimation as non-anthropogenic emission.

Based on the adjustments made in Box 4.1 along with the remaining data from the inventory, the following assumption that can be made is: the limited GHG emissions in energy industries is due to the significant amount of electricity that is imported (37% 2018) in the country. If the electricity was produced in country (which would require fossil fuel generation), the emissions would be significantly higher. (Biennial Update Report, 2020)

For the IPPU sector, based on Box 4.1's adjustments and data from the inventory, it is assumed that even though the IPPU sector does not contribute much to Belize's emissions, Tourism is expected to increase emissions from refrigerants and air conditioning.

For the Waste sector, utilizing the adjustments from Box 4.1, the assumption is that there will be improvements in both solid waste and wastewater management that will allow for better emissions estimation and reductions. It is also assumed that national health will garner additional benefits, as well as there being better standards of living as it relates to waste management and for tourism (Biennial Update Report, 2020).

For the Agriculture, Forestry and Other Land Use sector, based on the adjustments from Box 4.1, these are the assumptions:

1. Primary sources of emissions from this sector are due to livestock and biomass burning for the agriculture sector, where if fires are controlled, emissions can be greatly reduced.
2. The main drivers of emissions are the land use changes of forestlands to grasslands and forestland to croplands. If deforestation and forest degradation are reduced from these two land use changes, so will emissions for the FOLU sector.

4.2 Mitigation Measures and their Expected Impacts

Great strides have been made in understanding Belize's GHG emissions, allowing for effective mitigation measures to ensure emission reduction for the country. These mitigation measures or actions are presented in the form of projects, strategies, action plans or policies, all of which directly or indirectly reduces Belize's GHG emissions. From the 2015 reference period, an assessment was done for the mitigation measures/actions for all the sectors. As stated in the First Biennial Update Report (2020), these measures are divided into two categories:

1. Mitigation Actions with GHG Impacts
2. Mitigation Actions without GHG Impacts

The mitigation actions with GHG impacts are those projects, action plans, policies and strategies that have quantifiable reductions in the greenhouse gas emissions, while mitigation actions without GHG impacts are those that could not be quantified (Biennial Update Report, 2020). The following tables only include those actions from the Energy Sector, AFOLU Sector and Waste Sector.

Table 4.2 Energy sector mitigation actions with GHG impacts (National Climate Change Office, 2020)

Mitigation Action	Timeframe	Specific Objectives	Coverage							Emissions Reduction Potential	Co-Benefits
			Scope	Implementing Entity	Support Entity	Support Type	Gas	Funding Provided	Status		
1. emPOWER Rural Electrification Project - Caribbean Renewable Energy Fund	November 2018 - February 2020	Provide renewable energy solutions to assist Belize in achieving universal energy access.	Community Level (3)	Energy Unit, Ministry of Labour, Local Government, Rural Development, Public Service, Energy & Public Utilities	United Arab Emirates (UAE)	Financial	CO_2	2.3M USD	Ongoing	319 tCO2 eq/year	Access to clean energy to the population of rural villages that currently do not have access to the national grid. Improvement in community livelihood, economic development, increased employment, and quality of jobs.
Description	The emPower Rural Electrification Project plans to install 400kW of solar PV and battery storage in rural villages that currently do not have access to the national grid. These villages are Medina Bank, Golden State, and Indian Creek. This project is in alignment with Belize's Sustainable Energy Action Plan (SEAP), which sets a goal of universal access to energy services by 2030.										
Assumptions	The estimated grid emission factor is 0.218 tCO2/MWh, calculated by splitting the GHG emissions of electricity production (GHG inventory category 1A1) for year 2017 by the MWh produced (data obtained from BEL). The estimation of impact of this policy is made by applying the grid emission factor to the 400kW installed. The value of capacity factor is obtained by multiplying daily isolation hours by 365 days.										
2. ESD-Caraibes (Energy for Sustainable Development in Caribbean Buildings)	April 2014 - Present	Promotion of sustainable energy use in buildings through interventions that constitute energy efficiency applications and renewable energy technologies within the project territories	Project Pilot Territories	Caribbean Community Climate Change Centre (5Cs)	United Nations Environment Programme (UNEP)	Financial	CO_2	988,000 USD	Ongoing	11.79 Gg CO2 Eq by 2033	The reduction of electricity consumption will reduce the need to consume fossil fuels for producing electricity, reducing the GHG emissions, and improving the air quality of the country.
Description	The ESD Project activities, a mix of policy proposals and pilot demonstration, aim to reduce electricity use by 20 per cent from the business as usual (BAU) scenario. Its strategic priority is to reduce greenhouse gas emissions and promote energy efficient technologies and practices in appliances and buildings (households, businesses, and Government). Check http://energyunit.gov.vc/energyunit/index.php/projects1/esd-caraibes and ESD_Caraibes.JPG for more information										
Assumptions	The production of electricity is reduced by 20% and the emissions of category 1A1 Energy industries are reduced accordingly. We assume the 20% reduction is obtained by 2033, and it is obtained progressively by using a linear extrapolation from year 2014.										

3. PALCEE Project: Latin America and the Caribbean Energy Efficiency Programme	July 2017 - August 2018	Promotion of energy conservation measures in southern Belize through a bulb exchange program.	Sub-National	Energy Unit, Ministry of Labor, Local Government, Rural Development, Public Service, Energy & Public Utilities	Latin American Energy Organization (OLADE)	Capacity/ Financial	CO_2	188,000 USD	Completed	28 tCO2 eq/year	LEDs produce a better-quality light, and the useful life of the tube is significantly higher than bulbs. Communities will save money and will have access to a better, more durable light.
Description	Capacity Building in energy audits was given for officers of the public service and agents promoting energy efficiency throughout Belize. The second phase of this program involved the implementation of these recommended energy conservation measures, and the final phase of the program focused on awareness creation of energy efficiency in lighting. This was done via a bulb exchange program to replace inefficient bulbs and tubes with LEDs in low-income households. The bulb and tube exchange program involved trading in incandescent bulbs and compact fluorescent lamp for the more energy efficient light emitting diodes (LEDS). A total of 1,448 LED bulbs and 100 LED tubes were distributed to recipients in Dangriga, Sarawee and Hope Creek. The remaining 300 bulbs were distributed to other residents across the country.										
Assumptions	The estimation of the impact of this policy is made by estimating the impact of the reference technology and applying default assumption from the GAMCO model to obtain the annual emission reduction. The estimated grid emission factor is 0.218 tCO2/MWh, calculated splitting the GHG emissions of electricity production (GHG inventory category 1A1) for year 2017 by the MWh produced (data obtained from BEL). There is no difference between the scenarios, as the evolution of GDP and/or population does not affect this mitigation action.										
4. La Gracia Smart Solar Off-Grid Project	March 2016 - May 2017	Expanded Access of sustainable electricity to rural community, La Gracia, consistent with the Sustainable Energy Action Plan to extend electricity access to villages that remain un-electrified.	Community Level	Energy Unit, Ministry of Labor, Local Government, Rural Development, Public Service, Energy & Public Utilities	Government of Switzerland (90%); Government of Belize and the British High Commission (10%)	Financial	CO_2	400,000 USD	Completed	19 tCO2 eq/year	This mitigation action will enable access to clean energy to the population of rural villages that currently do not have access to the national grid. The population of these areas will see their livelihood improved, and the prospects for the economic development of the area, including higher and better-quality employment, improve.
Description	The La Gracia solar PV system pilot project was the first renewable energy smart off grid system in Belize. A total of 45 buildings including homes, churches, and shops were connected to a 24kW system PV system. The participants were educated on the operation of the system in respect to charging the card, discharging the card on the meter, and verifying their account on the meter. The pilot system is currently serving the community's electricity needs.										
Assumptions	The estimated grid emission factor is 0.218 tCO2/MWh, calculated by splitting the GHG emissions of electricity production (GHG inventory category 1A1) for year 2017 by the MWh produced (data obtained from BEL). The estimation of the impact of this policy is made by applying the grid emission factor to the 24kW installed. The value of capacity factor is obtained by multiplying daily isolation hours by 365 days. There is no difference between the scenarios, as the evolution of GDP and/or population does not affect this mitigation action.										

5. Solar Water Heating NAMA (status: queued)	Aug-17	Implementation of solar heating technology for industrial, commercial, and residential sectors, to reduce GHGs from traditional energy sources	Project Scope	National Climate Change Office	Latin American Energy Organization (OLADE)	Financial/ Capacity	CO_2	N/A	Queued	7.98 Gg CO2 eq by 2033	The co-benefits identified for this mitigation action are the increasing access to affordable clean energy and a positive impact in local employment for the installation and maintenance of solar collectors and storage tanks.
Description	Solar Water Heating NAMA Concept aims to implement the solar heating technology for industrial, commercial, and residential sectors, to reduce the emission of greenhouse gases from the use of fossil fuels for water heating through the installation and use of solar collectors and storage tanks.										
Assumptions	The estimation of impact of this mitigation action was developed in the NAMA concept. This action has not been implemented and its implementation is not foreseen.										
6. Street Light LED's Conversion Project	Nov-18	Reduce energy consumption by converting public streetlights to LEDs	Sub-National	Caribbean Community Climate Change Centre (5Cs) and the Sustainable Development Unit, MAFFESDI	Government of Italy through the Italian Ministry of Environment, Land and Sea (IMELS)	Financial/ Capacity	CO_2	Approx. 3,200,000 USD	Ongoing	184 Gg CO2 eq/ year	LEDs produce a better-quality light, and the useful life of the tube is significantly higher than bulbs. Communities will save money and will have access to a better, more durable light in the streets.
Description	Through the project titled "Reducing the Carbon Footprint of San Ignacio Town and five surrounding villages in the Cayo District", its aim is to replace street lighting with LED fixtures to quantify the benefits to be derived: financial, and the reduction of Greenhouse Gas (GHG) emissions. The project aims to replace 1,000 low- efficiency street lighting fixtures with 1,000 LED fixtures.										
Assumptions	It is expected that the replacements will result in 1.) A significant reduction in energy consumption per lamp from 150 W to 60 W, thus realizing a 60% reduction in energy use. 2.) A reduction of 184 metric tons of CO2 per year. 3.) An annual savings of some US$40,000 that can benefit the communities.										
7. Energy efficiency in the public sector	2020	Stemming from the Sustainable energy action plan, section 2.1. details the decentralization of Government Payment for Electricity.	National	Energy Unit, Ministry of Labor, Local Government, Rural Development, Public Service, Energy & Public Utilities	N/A	Policy	N/A	N/A	Planned	205.18 tCO2 eq/year	The reduction of electricity consumption will reduce the need to consume fossil fuels for producing electricity, reducing the GHG emissions, and improving

Description	Making ministries pay for electricity out of budgets allocated to them by the Ministry of Finance will give them an incentive to be more energy efficient. At present, the bills for all of the ministries' electricity consumption are sent to the Ministry of Finance, which pays them directly without considering any breakdown between ministries. This gives the individual ministries little incentive to be more efficient.										the air quality of the country.
Assumptions	This mitigation action is complementary to mitigation action 2 ESD Caraibes, in which a 20% of electricity consumption is reduced in households, businesses, and the government. The sustainable energy action plan estimates that the "standard energy efficiency measures across the government's building stock could save approximately US$4 million per year on average the cost of the improvement in energy efficiency in US$ 4 million per year average". Despite no information on the energy savings obtained is available, the estimation of this mitigation action is based on this cost. We also assume that the implementation started in 2020.										
8. Expand Access to Electricity Using RE	2020	This action stems from the Sustainable Energy Action Plan on the section "Expand Access to electricity using RE".	National	Energy Unit, Ministry of Labor, Local Government, Rural Development, Public Service, Energy & Public Utilities	N/A	Policy	N/A	N/A	Planned	15.98 Gg CO_2 eq by 2033	This mitigation action will enable access to clean energy to the population of rural villages that currently do not have access to the national grid. The population of these areas will see their livelihood improved, and the prospects for the economic development of the area, including higher and better-quality employment, improve.
Description	The Government wants to extend electricity access to villages that remain un-electrified. In many cases, RE can be a cheaper alternative to grid extension or diesel generation.										
Assumptions	Belize's current electricity system is well-managed and reaches 92% of the country's population. The assumption is that the remaining 8% of population gain access to electricity through renewable systems. The national electricity demand will increase by an analogous percentage and the fuel consumption of fuel for electricity generation will increase accordingly.										
9. European Union 11th EDF National Indicative Programme	2014-2020	Provide energy service for Rural communities, increase energy efficiency in the country and support renewable energy uptake.	Community Scope	Energy Unit, Ministry of Labor, Local Government, Rural Development, Public Service, Energy & Public Utilities	European Union	Financial/ Capacity	N/A	15,525,000 USD	Planned	*See Mitigation action 8*	*See Mitigation action 8.*

Description	This mitigation action (planned) comes from the European Union 11th EDF National Indicative Programme. It is consistent with the Sustainable Energy Action Plan for Belize to expand electricity access to villages that remain electrified and promote large-scale renewable energy. This project aims to further the rural electrification project, support energy efficiency and conduct feasibility studies for different renewable energy systems.										
Assumptions	Same assumptions as mitigation action 8 “Expand access to Electricity using RE”.										
10. Caye Caulker Interconnection Project	September 2018- June 2020	Interconnection of island power distribution to the mainland to remove island reliance on power by diesel generation.	Sub-National	Belize Electricity Limited	Caribbean Development Bank (CDB)	Financial/ Technical	CO_2	7,500,00 USD	Planned	0.2391 Gg CO2 eq by 2033	Linking Caye Caulker to the national grid will benefit the security of supply. The interconnection will ensure the supply of electricity and the reduction pf prices. In turn, this will impact the employment and GDP growth of the country.
Description	Caye Caulker is a high priority load centre as it is not currently connected to the main grid, its load demand is increasing significantly, and the island is powered by diesel generation. The initial assessment of the routes for interconnecting the distribution network on Caye Caulker with the Belize mainland transmission has been completed. BEL appointed Mott MacDonald (MM) to undertake the feasibility study to determine the technical, economic, social, and environmental feasibility of supplying electricity from the main grid. This assessment was completed September 2018. BEL has applied for financing from the Caribbean Development Bank (CDB) to fund the project. The timeline for the procurement of goods, works and consultancy services for the interconnection of Caye Caulker with San Pedro Ambergris Caye is expected for the period March 2019 to June 2020.										
Assumptions	The electricity consumption rate per capita in Caye Caulker is assumed equal to the national total electricity consumption rate. The total MWh consumed in Caye Caulker is calculated with this rate, and the impact of the mitigation actions is estimated as the difference between meeting this demand only with diesel or with the average fuel consumption of the grid (i.e., the grid emission factor). The difference between both estimates is the impact in GHG emissions reduction of the mitigation action. This mitigation action is assumed to have had an impact since 2018.										
11. Build an Efficient and Enabling Utility	2014-2020	This action stems from the Sustainable Energy Action Plan to "build an efficient and enabling utility". It covers an amendment of tariff structure by electricity utility provider to incentivize energy efficiency.	National	Belize Electricity Limited	N/A	Policy	CO_2	N/A	Planned	8.37 Gg CO2 eq by 2033	The co-benefits of this action will be the reduction of energy consumption and the corresponding reduction in GHG and air pollutant emissions.
Description	BEL is a relatively efficient utility compared to its peers. According to the sustainable energy action plan, BEL has started helping its customers be more energy efficient. Building on these strengths, the right rules and incentives need to be in place. This tariff restructure will maximize BEL’s efficiency on the supply side and incentivize BEL to make its customers more efficient.										
Assumptions	Estimate the reduction in consumption over time due to increases in the price of electricity. This assumes that BEL raise its prices to the average of LAC (25 USD cents per Kwh). Electricity consumption and prices data were obtained from the BEL. The median estimates for electricity price elasticity vary depending on the time and sector. Available studies show that the price elasticity for										

	electricity is rigid in the short term, but it increases over time. The price elasticities selected for the study are -0.28 in the short run and – 0.81 in the long run. This assumes a linear increase of the elasticity starting at -0.28.										
12. Arundo Donax-Renewable Bio-Mass Fuel for Belize: Feasibility Study and Funding Proposal Preparation	2018-2019	This mitigation action comes from an Energy Project using Arundo Donax to replace fossil energy in the generation of electrical energy. It is consistent with the Sustainable Energy Action Plan for Belize to prepare resource studies for biomass to further develop Belize's biomass.	Project Scope	Caribbean Community Climate Change Centre (5Cs)	GCF	Financial/ Technical	N/A	739,700 USD	Planned	N/E	
Description	The Arundo Donax Project was initiated to supplement bagasse for energy production to ensure a continuous supply of electricity to BEL annually. The ADP is identified as a suitable fuel crop that can contribute to energy cogeneration throughout the year and assist with the reduction of fossil fuel importation. The Project will be rolled out over four years involving a Compatibility Testing Phase of the technical feasibility of Arundo Donax being burnt in the BELCOGEN boilers, a Field Research Phase of various agronomic parameters, and a Commercial Production Phase.										
Assumptions	This mitigation action increases GHG emissions, as its objective is to reduce importation of electricity and exchange it by national generation. The emission reduction potential has not been estimated, because it is a feasibility study. However, it must be noted that biomass consumption for electricity generation also produces GHG emissions, so this action could increase GHG emissions.										

Table 4.3 Energy sector mitigation actions with no GHG impacts (extracted from the Biennial Update Report, 2020)

Mitigation Action	Timeframe	Specific Objectives	Coverage							Emissions Reduction Potential
			Scope	Implementing Entity	Support Entity	Support Type	Gas	Funding Provided	Status	
13. Belize Sustainable Energy Action Plan	2015	Provides the framework of actions and tasks to overcome the barriers to sustainable energy.	National	Energy Unit, Ministry of Labor, Local Government, Rural Development, Public Service, Energy & Public Utilities	Inter-American Development Bank	Financial	N/A	N/A	Completed	N/E
Description	This Sustainable Energy 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. The Action Plan is structured around six actions that work together to unlock Belize's EE and RE potential.									
14. Cleaner and More Efficient Fuels and Vehicles in Belize - Global Fuel Economy Study	November 2016 – February 2018	Establishment of a baseline for the fuel economy of light duty vehicles that were imported into Belize during 2013 to 2016.	National	Energy Unit, Ministry of Labor, Local Government, Rural Development, Public Service, Energy & Public Utilities	United Nations Environment Programme (UNEP)	Financial	N/A	N/A	Completed	N/E
Description	The study facilitated policy discussions by providing a scientifically-sound assessment of the fuel economy of light duty vehicles that entered Belize's vehicle fleet. Deep knowledge of the starting point will allow legislators to choose the right combination of technology and political instruments necessary to achieve national objectives (Energy and Transportation) in the field of emissions (climate change mitigation), energy security and efficiency.									

15. BEL-USTDA Solar & Wind Feasibility Project	2016-2019	A feasibility study for the development of utility-scale wind and solar power in Belize. The study is for Belize Electricity Limited which seeks to enhance energy security by reducing dependence on imported electricity and displacing fossil-fuel-fired power generation.	Project Scope	Belize Electricity Limited	United States Trade and Development Agency ("USTDA")	Financial/Technical	N/A	N/A	Completed	N/E
Description	BEL signed a Grant Agreement, effective September 30, 2016, with the United States Trade and Development Agency ("USTDA"). Its purpose is to identify potential sites for wind and solar energy development that could accommodate onshore and offshore wind energy projects of 15 MW (and above) and onshore solar energy projects of 5 MW (and above). BEL retained the services of DNV KEMA Renewables, Inc. ("DNV GL") to execute the project. BEL-USTDA has completed six (6) of a fourteen (14) task plan thus far, including the installation of three (3) 60-meter meteorological towers for wind measurement at North San Pedro, Maskall village and Long Caye island, in addition to one SRA solar measurement station at the Philip Goldson Int'l Airport for data collection in the technical analysis									
16. Santander Sugars Energy (SSEL) Limited	Dec-16	Introduction of an additional renewable energy source through biomass cogeneration in the Sugar Industry.	Plant Scope	Santander Sugars Energy Limited (SSEL)	N/A	Technical	N/A	N/A	Completed	N/E
Description	SSEL, a subsidiary of The Santander Sugar Group, signed a Power Purchase Agreement with Belize Electricity Limited to provide clean energy to the electrical grid of Belize. SSEL utilizes bagasse, the by-product of sugar cane, as a renewable power generation source. The energy produced by bagasse at The Santander Sugar Mill is used as a primary fuel source to supply energy to the local consumer electricity grid.									

17. Transport NAMA	2017-2019	The report covers the collection and collation of validated data sets for the identified vehicle categories used for public transportation.	National	National Climate Change Office	Japan-Caribbean Climate Change Partnership (J-CCCP)	Financial/Capacity	2,549,357 BZD	N/A	Completed	N/E
Description	Belize is one of eight countries that received support from the J-CCCP in advancing the process of low-emission risk-resilient development by improving energy security and integrating medium to long-term planning for adaptation to climate change. One of these activities is the preparation of a National Appropriate Mitigation Action (NAMA) in the transport sector of Belize. The NAMA covers the entire country, both urban and rural areas as well as all transport modes (land, domestic air, and domestic sea). The components currently included in the NAMA focus on public transportation.									
18. MOU signed to promote tourism sector uptake of renewable energy & energy efficient technologies in Belize	June 30, 2018	The uptake of Renewable Energy and Energy Efficient (RE/EE) technology in the tourism sector.	National	Ministry of Tourism and Civil Aviation (MTCA)	Development Finance Corporation	Financial	N/A	N/A	Completed	N/E
Description	The Government of Belize has identified RE/EE as a priority area for reducing Belize's energy intensity levels. This is consistent with the Belize's Strategic Development Goals, the National Sustainable Tourism Master Plan (NSTMP) 2012-2030, and the National Tourism Policy 2017-2027. Equally, under its Responsible Tourism Implementation Plan 2018-2022, the MTCA is working towards the uptake of RE/EE technology in the tourism sector. Under the MOU, the MTCA and the Development Finance Corporation (DFC) will Promote a National Campaign for Renewable Energy in the Tourism Sector with the MTCA actively promoting DFC's RE/EE lending product within their planning, product development, promotional programs, and events.									

Table 4.4 AFOLU sector mitigation actions with GHG impacts (extracted from the Biennial Update Report, 2020)

Mitigation Action	Timeframe	Specific Objectives	Coverage							Emissions Reduction Potential	Co-Benefits
			Scope	Implementing Entity	Support Entity	Support Type	Gas	Funding Provided	Status		
1. Socialization and Implementation of Mangrove Act (no trimming)	2018	Reduce losses of mangrove due to housing developments, and in protected areas is an issue in Belize. The Forests (Protection of Mangroves) Regulation was developed and came into force 23rd June 2018 to address this challenge.	National	Forest Department	N/A	Policy	CO2	N/A	Ongoing	22.1 Gg CO2 eq by 2033	Maintaining mangrove ecosystems enable the protection for low-lying coastal areas against impacts of storms and soil erosion and provides rich habitats for nursery species.
Description	Besides a list of priority areas in the country, the Mangrove regulations set out stipulations required to alter or trim mangroves. These regulations considered, among others, potential adverse environmental impacts, carbon storage and sequestration potential of the mangroves. The Regulations also put measures in place for offsetting through restoration or planting new mangrove communities in adjacent degraded areas or other areas. Furthermore, no permit will be issued for alteration or selection trimming of mangroves within existing national parks, nature reserves, wildlife sanctuaries, natural monuments or other protected areas as defined or described in the National Protected Areas System Act.										
Assumptions	At the time of estimation, GHG Inventory estimated the conversion to Settlements land from Mangroves Forest Land in 603,18 hectares from 2001 to 2018 (33,51 ha(s)/year). In the same period, the disturbance area in mangroves is estimated at 5,59 ha(s)/year. Based on this, it is assumed that an average of 39,1 ha is deforested annually. Parameters and emission factor used are provided in the GHG emissions Inventory. The estimated above ground biomass (AGB) is 81 t.d.m, the ratio between below and above ground biomass (R) is estimated as 0,49; the carbon content in the biomass (tc/tdm) is equal to 0,45 and the growth rate for mangroves (Gw) is 9,90 tdm/ha/year. The Likely scenario assumes that deforestation and disturbance in mangroves will be avoided in a 100%. The carbon captures in the avoided deforestation areas are included in the emission reduction estimation.									

2. REDD+ strategy and the Forest bill act	2017-2020	Reduce carbon dioxide emissions and increase carbon sequestration from Belize's forest, strengthening legal instruments for improved forest management.	National	National Climate Change Office, REDD+ Unit	World Bank	Financial/ Technical/Capacity	CO2	4,080,000 USD	Ongoing	2055.7 t CO_2eq between 2020 and 2033	The effective rollout of REDD+ and enhanced forest management (Forest Bill) include alleviating poverty, enhancing biodiversity, improving forest governance, and protecting other environmental services.
Description	The NDC proposes that "all forest outside reserves are to be put under management plans to secure their sustainable use and protection." This target means the halt of deforestation and forest degradation in Belize is 100%, but the timeframe is not specified.										
Assumptions	At the time of estimation, GHG Inventory estimated average emissions from forest land converted to non-forest land (deforestation) reach to 2,660 Gg CO2eq per year. The deforested area is distributed by final land use and forest strata affected. A a specific value for biomass content and average growth rate is used for each forest stratum. A reference scenario has been estimated assuming that the deforestation rate will be maintained as reported in GHG Inventory. The likely scenario assumes that 100% of deforestation will be halted linearly from 2020 to 2033. The non-deforested areas removed carbon during this period.										
3. Mangrove restoration	2018-2030	Protect and restore mangrove forests through enforcement of the Forest Regulations (2018).	National	Forest Department	N/A	Policy	CO2	N/A	Ongoing	66.1 Gg CO2-eq per year between 2020 and 2033	Maintaining mangrove ecosystems enable the protection for low-lying coastal areas against impacts of storms and soil erosion and provides rich habitats
Description	Belize's NDC includes an activity to protect and restore mangrove forests. On June 18, 2018, the Forest (Protection of Mangroves) Regulations 2018, established the regulations to protect the mangroves. However, actions to promote restoration of mangroves is not explicitly incorporated in the Regulations. The restoration 4000 hectares of mangroves is considered possible by involved stakeholders, which would still offset the losses since 1980 in the long run but allows avoiding the vicinity of settlements.										

Assumptions	The estimated carbon removal by mangroves based on the GHG emissions Inventory is 9.9 t.d.m/ha/year. A reference scenario has been estimated to estimate the impact of the measure, assuming that the mitigation action is not implemented. A Likely scenario has been also estimated assuming that the 100% of the 4.000 hectares planned has been restored in a lineal progression between 2020 and 2030. The reference scenario is estimated as the average removals in mangroves during the period 2001-2018, excluding the emission due to natural hazards like hurricanes.	for nursery species.

Table 4.5 AFOLU sector mitigation actions with non-GHG impacts (extracted from the Biennial Update Report, 2020)

Mitigation Action	Timeframe	Specific Objectives	Coverage							Emissions Reduction Potential
			Scope	Implementing Entity	Support Entity	Support Type	Gas	Funding Provided	Status	
4. Belize Agriculture Information Management System (BAIMS)	2018-2019	The Belize Agriculture Management Information System (BAIMS) is a web-based application that serves as a central repository for all agriculture data. IT was populated from the Agriculture Census 2018. This information is critical for evidence-based decision making by the Ministry.	National	Department of Agriculture	IADB	Finance/ Policy	N/A	420,000 USD	Completed	N/E
Description	The BAIMS evolved from an in-depth Country Assessment on Agriculture Statistics, and a Strategic Plan for Agriculture and Rural Statistics (SPARS) following the standards set by the Food and Agriculture Organization (FAO). It is a web-based application that serves as a central repository for all agriculture data. Data are used by farmers and policy makers to analyse agriculture data for proper timely decision making on the agriculture sector's contribution to the socio-economic development including GDP, national accounts, and employment. Although this activity does not have intrinsic mitigation impacts, its development contributes to the MRV of key GHG emitting agricultural practices.									
5. Resilient Rural Belize (Be-Resilient)	2019-2024	Strengthen smallholder participation through the development of climate resilient value chains and climate resilient rural infrastructure and assets for main agricultural products	Sub-national	Ministry of Economic Development (MEDPITC), Ministry of Finance	GCF via International Fund for Agricultural Development (IFAD)	Finance/ Capacity /Technical	N/A	2,000,000 USD (3.2 M GoB, 8 M GCF, 8 M IFAD. Producer Organizations - 1.6 M))	Ongoing	N/E
Description	The programme aims to increase the economic, social, and environmental resilience of smallholder farmers, thus creating the conditions for farmers to have a sustainable market access for their produce. In the context of smallholder farmers in Belize, improved resilience is defined as the capacity to									

	minimise the impacts of climatic and economic shocks, enabling farmers to confront periodic variations better and strengthening their capacity to cope and recover in times of extreme stress. Although this is mainly an adaptation and vulnerability focused, mitigation co-benefits are presented through enabling sustainable production processes using fewer resources.

Table 4.6 Water sector mitigation actions with GHG impacts (extracted from the Biennial Update Report, 2020)

Mitigation Action	Timeframe	Specific Objectives	Coverage							Emissions Reduction Potential	Co-Benefits
			Scope	Implementing Entity	Support Entity	Support Type	Gas	Funding Provided	Status		
1. Improved Waste Management system via Solid Waste Management Project II	2016-2019	This mitigation action comes from the National Solid Waste Management Strategy and Implementation Plan as well as the Solid Waste Management Project II and Solid Waste Master plan for touristic areas.	National	Solid Waste Management and Authority	IADB	Financial/ Policy	CO2	10,200,000 USD	Ongoing	34.78 Gg CO2 eq by 2033	The improvement of the waste management practices in the country will significantly increase the overall health conditions of the country, avoiding the spread of diseases, preventing water and soil contamination.
Description	This action aims to improve waste management system based on the following targets of the National Solid Waste Management Strategy and Implementation Plan: waste generation at a maximum of 360 kg/capita/annum, 100% of collected MSW requiring final disposal is deposited in sanitary landfills; 100% of household and commercial premises receive regular collection service.										
Assumptions	The waste generation rate is already below 360 kg/capita/annum, so it has no impact. All wastes going to landfill are managed semi-aerobically Open burning of wastes is reduced to 0, and percentage of wastes going to landfill is 100%										

4.3 Additional Mitigation Options

The GHG emission scenarios were developed using options from the assessment of the implemented mitigation actions previously outlined (Biennial Update Report, 2020). Additional mitigation options were also created from the 2017 Technology Needs Assessment and are the basis for the suggested options. These mitigation options are divided and explained by each sector, where some are broken down into mitigation options that the subsectors can undertake.

4.3.1 Energy Sector

The first mitigation option that will be practical is the effective implementation of the Sustainable Energy Action Plan (SEAP) that was developed in 2015. This initiative, undertaken by the Belize Energy Unit, has major mitigation potential if implementation prioritized (Biennial Update Report, 2020). Some of the activities under the SEAP speaks to the usage of renewable energy options which is vital for Belize to:

1. Decrease capital utilized for the importation of electricity.
2. To prevent Belize from increasing its emissions due to reducing the importation of electricity.

Seeing that Belize imports 37% of its electricity as previously mentioned, developing renewable energy options will be crucial when it decides to supply its own energy needs. If renewable energy is not considered, then fossil fuel options will need to be utilized if Belize reduces its electricity importation, which will increase emissions from the energy sector. Therefore, this mitigation measure must be prioritized when the country makes this shift in energy consumption. Based on the 2017 Technology Needs Assessments (TNA), six technological advancements can be made when this consumption shift occurs (Biennial Update Report, 2020). They are:

a. Solar PV Off-Grid – From the TNA, this is described as technology that will produce cost effective electricity generation in homes and small businesses.
b. Solar PV On-Grid – The TNA explains this to be a solar panel grid system housed at the University of Belize as a pilot project developed in 2010. This initiative was funded by the Japan International Cooperation Agency (JICA) to provide information on producing and selling clean energy to the Belize Electricity Limited (Biennial Update Report, 2020).
c. Gasification – The Technology Needs Assessment details the process of electricity production by small modular gasifiers (Biennial Update Report, 2020). This process is aimed at agro-processing facilities for coconut oil and water, where the system will utilize biomass waste to run the system.
d. Micro Hydropower Run-of-the-River Facility for Douglas D' Silva Forest Station - This is an initiative that will replace the diesel generator being used by the Douglas D' Silva Forest Station in the Mountain Pine Ridge area by using hydro-electrical options. Extracted from the Mountain Pine Ridge Forest Station Master Plan, the forest station is set to become an eco-tourism, research and education centre running on clean energy.
e. Biomass Potential (Waste to Energy) – According to the TNA, this initiative is shared by the Belize Sugar Industries, American Sugar Refineries and Santander Sugar to harness sugar

cane by-products for power generation. This biomass initiative also focuses on harnessing rice husk and biogas for electricity generation, and other organic waste from banana farms, shrimp farms, municipal solid waste, and animal manure.

f. Wood Consumption Reduction – This initiative pinpoints measures to reduce wood consumption by 66% for residents (Biennial Update Report, 2020). This will ensure an improvement in energy efficiency by using clean cooking methods, which would reduce emissions from this activity substantially.

The country can utilize these options to ensure that importation of electricity can be reduced without depending on fossil fuels as the replacement. Table 4.7 below shows the long-term reduction of emissions that can occur if some of these Mitigation Measures are implemented in the Energy Sector (Mitigation Potential). It also shows the "Impact of Imports" emission if fossil fuels are used instead of the other options outlined.

Table 4.7 Mitigation options for the energy sector

Year	New RES Capacity (Gg CO_2-eq)	Impact of Imports (Gg CO_2-eq)	Improved Cook Stoves (Gg CO_2-eq)	Energy Efficiency Commercial and Residential (Gg CO_2-eq)	Energy Efficiency Industry (Gg CO_2-eq)
2020	14.27	281.61	1.18	19.89	0.51
2030	157.01	393.41	12.99	27.78	0.71
2033	199.83	434.92	16.53	30.71	0.79

Extracted from the Biennial Update Report, Box 4.2 presents some assumptions that can be made for estimating the potential impacts of the options in Table 4.7 (2020).

Box 4.2 Assumptions for estimating energy sector mitigation options

- The **17% of electricity produced** with fossil fuels is *replaced by Renewable energy sources by 2033.*
- A **66% reduction by 2033** in the consumption of fuel and associated emissions *from the use of wood in the residential sector*.
- **The impact of energy efficiency standards and labels** for appliances in commercial and domestic sectors, *is assumed as a 16% of reduction of electricity consumption*. Assumption extracted from: https://pdfs.semanticscholar.org/9734/0a359a213eb4986dabcc8bb1c1e302ffdf8a.pdf
- The **impact of energy efficiency standards and labels** for appliances in the Industrial sector *is assumed as a 10% reduction in fuel consumption* (extracted from GAMCO and industry chapter in IPCC AR4)

4.3.2 The Transport Sector

The mitigation option that will be practical to reduce emissions in the transport sector is to improve the Transportation Master Plan that guides development within the transport sector. Although the

CNTMP does not explicitly address reducing emissions for the sector, low carbon alternatives must be considered, and the plan should be revisited. One option that can be utilized is low carbon fuel incentivization and the promotion of public transportation.

Some options that can be used to reduce emissions in the transport sector were outlined in the TNA that was completed in 2017.. They are:

a. Utilizing Fuel-Efficient Buses for Public Transportation: The public transportation system in heavily used by the public, particularly the Western route that stems from Belize City to Benque Viejo del Carmen Town. Therefore, this technology intervention is recommended to focus on creating a pilot project to purchase and use fuel-efficient buses. The long-term goal is to eventually phase out fossil fuel-run buses. However, until the country can develop mechanisms and equipment for electric vehicles, the short-term goal is to reduce as many emissions as possible with the current energy usage circumstances.
b. Vehicle Emissions Duty on Imported Vehicles: Seeing that Belize does not manufacture vehicles; all vehicles are imported for domestic use. This technology intervention is then recommended to add duty on vehicles based on the number of emissions they produce and the amount of fuel they consume for operation. This would aid in reducing emissions by making more fuel-efficient vehicles common and taxing those vehicles that are not fuel efficient.
c. Retrofitting Vehicles with LPG Fuel Systems: Although there is no data on vehicles that may already be utilizing liquefied petroleum gas (LPG) within the country, this technology intervention hopes to change 15-25% of vehicles to use LPGs. This initiative would lower emissions and enhance the job markets for individuals who would be able to retrofit the systems of existing vehicles.

These recommended options for transportation can further reduce emissions in the Energy sector. Table 4.8 below shows the impacts of options a and c in long term emissions reductions.

Table 4.8 Mitigation options in the transport sector

Year	Retrofitting Vehicles with LPG (Gg CO_2-eq)	Improved Public Transportation System (Gg CO_2-eq)
2020	18.01	6.64
2030	198.10	73.07
2033	252.13	93.00

Extracted from the Biennial Update Report, Box 4.3 presents some assumptions that can be made for estimating the potential impacts for the transportation options in table 4.8 above.

Box 4.3 Assumptions for estimating transport sector mitigation options

- Improved Public Transportation: **93 Gg CO2-eq per year by 2033** (assumption extracted from 2017 TNA).
- The average g/km **emission factor is reduced from 333 g CO2-eq/km to 180 g CO2-eq/km**, the average from the study *Cleaner and more efficient fuels and vehicles in Belize*. https://www.globalfueleconomy.org/media/597572/establishment-baseline-fe-belize.pdf This would be translated in a reduction by 50% of the current emissions of the road transport sector. The approximate impact of the option is 50% of the BaU emissions of category 1A3b Road transport, to be achieved in 2050.

4.3.3 Waste Sector

For the Waste sector, the first mitigation option that will be practical in reducing emissions is the effective implementation of the National Solid Waste Management Strategy and Implementation Plan. The Belize Solid Waste Management Authority developed this plan in 2015 which focused on better management of Municipal Solid Waste and Sludge from wastewater, two areas where emissions are known for this sector.

Furthermore, referring to the mitigation option "e" outlined for the energy sector on page 82, the waste to energy option is also reiterated as an option for this sector. Developing this synergy between the two sectors will ensure that this aspect of the Sustainable Energy Action Plan and the National Solid Waste Management Strategy and Implementation Plan will provide a multiprong approach to emissions reduction for the country. This will also focus on reducing waste products in landfills, even though not projected to be by much.

Looking at wastewater management practices, the development of effective water discharge systems and wastewater treatment, as a focus in the National Solid Waste Management Strategy and Implementation Plan, will ensure major reductions in emissions for the waste sector.

Based on the recommended options above, Table 4.9 shows approximations of the emission reductions that can be expected for the long term if those measures are taken for the Waste Sector.

Table 4.9 Mitigation options in the waste sector

Year	General GHG Impact from Waste Sector (Gg CO_2-eq)
2020	3.82
2030	42.02
2033	53.48

4.3.4 Industrial Processes and Product Use Sector

For the IPPU sector, only one potential option that can be taken to reduce emissions. Looking at HFC emissions, it is noted that from the country's GHG Emission Profile, the tourism sector is increasing the rise of this gas. Therefore, the option is to incentivize the utilization of low carbon HFCs alternatives and to tax their consumption impacts the reduction of emissions for this sector (Biennial Update Report, 2020).

Based on the recommendation mentioned, Table 4.10 shows the approximations of long-term emissions reduction if the mitigation measure is taken for the IPPU sector.

Table 4.10 Mitigation impacts of the IPPU sector (HFCs)

Year	HFC Impact (Gg CO_2-eq)
2020	5.83
2030	64.10
2033	81.58

4.3.5 Agriculture, Forestry and Other Land Use (AFOLU) Sector

Many mitigation options can be taken to reduce emissions in the AFOLU. The first practical option will be the complete and effective implementation of the Forestry Act revised in 2011 and amended in 2017. This act guides how forested lands are managed and utilized and affects emissions from land-use changes in forested lands. Furthermore, the National Climate Change Office is planning the implementation of the REDD+ Strategy which will make extensive strides in reducing emissions from the FOLU sector. The implementation of these two options will ensure that all other measures under this sector can be executed much easier.

This section will be tackled into two parts: the agriculture sector and the Forestry and Other Land Use (AFOLU) Sector. Seeing that these sectors influence emissions separately, they will be outlined in two groupings.

Agriculture

Two mitigation options can be taken to reduce emissions for the Agriculture sector. These options are:

a. Improvement of Livestock Feeding Practices to reduce Enteric Fermentation – This initiative will aim to change nutrient ratio in feed to affect livestock digestibility. This option is estimated to cause a reduction in methane emissions from enteric fermentation by 20% (Biennial Update Report, 2020).
b. Improvement of Manure Management – This initiative is expected to reduce emissions in the livestock subsector. However, estimations cannot be currently made due to lack of information on the amount of manure managed and new management practices. Emissions

from livestock are increasing by 32% annually, despite manure management only representing 10% of the livestock subsector (Biennial Update Report, 2020).

Forestry and Other Land Use

There are three mitigation options that can be taken to reduce emissions for the FOLU sector. Although this sector is a net sink, it has the potential to ensure further emissions reduction for the country through the following measures:

a. Improved Forest Fire Prevention and Control – This initiative will focus on reducing anthropogenic causes of forest fires such as burning for land clearing/crops and burning of waste by communities within and surrounding forests. Good practice measures such as awareness campaigns will be used to reduce the occurrence of fires. It is estimated that 119.59 Gg of emissions are released from forest fires annually, therefore this measure will ensure a reduction in that quantity (Biennial Update Report, 2020).
b. Improved Sustainable Forest Management Practices – This initiative will focus on further improving sustainable forest management practices that already exist. Since most of Belize's forest is classified under managed lands, improving management practices will further reduce emissions. This will also ensure the continued growth of healthy forested ecosystems, thus increasing the country's removal potential.
c. Increase Reforestation, Afforestation and Degraded Land Restoration – This initiative will aim to create programs where degraded areas that were highly deforested would be restored to the forested ecosystems that were once there. This will ensure that Belize's forested area remains constant in areas where sustainable forest management practices are executed and increased in areas with high degradation. This in turn will increase the country's emissions reduction ability. (Biennial Update Report, 2020).

Based on the recommendations mentioned for the agriculture sector and the FOLU sector, Table 4.11 show the mitigation options for the entire AFOLU sector.

Table 4.11 Mitigation options in the AFOLU sector

Year	Enteric Fermentation (Gg CO_2-eq)	Forest Fires (Gg CO_2-eq)*
2020	36.84	119.59
2030	47.64	119.59
2033	52.81	119.59

4.4 Belize's Low Emission Development Strategy

As previously mentioned, even though Belize GHG emissions are minimal when compared to global levels, significant strides are still being made to mitigate climate change. One of these great initiatives include the development of a Low Emission Development Strategy (LEDS). The LEDS is planned to be a strategy and action plan that will assist Belize developing a sustainable low-carbon economy,

while prioritizing positive socio-economic progression. This strategy is currently being undertaken by the National Climate Change Office of Belize and covers a time period of 2021 to 2050. Based on information from the Greenhouse Gas Inventory and the mitigation options previously outlined, the LEDS will prioritize certain objectives that will achieve socio-economic development, connect low-emission development actions to national and sectoral development plans, and link financial, technological, and capacity needs for the LEDS implementation.

Looking at the critical components that will be covered under the LEDS there are six activities that will be undertaken to create an effective long-term strategy. They are:

1. Modelled baseline scenarios for Business as usual (Conditional/Unconditional) emissions.
2. Identification/prioritization of mitigation options for each sector.
3. Construction of high/very high ambition scenarios for decarbonisation of each sector.
4. Assessment of gaps/barriers for sector decarbonisation and actions implementation.
5. Assessment of co-benefits and socioeconomic impact of actions, including gender.
6. An action plan that includes the estimation of high-level cost and financing needs of actions and designing an MRV structure for the monitoring and evaluation of the LEDS.

These actions will be complimentary to the mitigation options previously mentioned to strengthen Belize's long-term emission reduction targets. The development of this strategy will be finalized by the end of 2021, considering that some of the actions outlined in the LEDS will already be in progress.

4.5 Additional Barriers to Mitigation

Even though some of the barriers for effective mitigation were covered in the mitigation options section, there are still some barriers that Belize face for full emissions reduction to occur. These include institutional, technological, social, and cultural barriers. However, some of these barriers are slowly phasing out for Belize to eventually reach its goals in emissions reduction. Table 4.12 below shows some of the additional barriers not mentioned.

Sources of barriers for the AFOLU sector

Table 4.12 Additional sources of mitigation barriers by sector

Sector	Sources of Barriers	Examples of Market/Institutional Imperfections	Examples of Social and Cultural Barriers
AFOLU	Land Clearing/ Development/ Maintenance	Land Tax Act (Levy & Taxes and Speculation Taxes) National Lands Act (Lease Land application)	Misunderstanding of these laws by general public

As seen in Table 4.12, one of the major sources of barriers for mitigation in the AFOLU sector is land clearing, development, and maintenance for the country. Currently, a REDD+ Strategy is being drafted by the National Climate Change Office under the REDD+ Readiness Project. The development of Policies and Measures thus far for the REDD+ Strategy identifies the importance of strengthening institutional coordination, legal and policy framework, and enforcement (Draft REDD+ Strategy, 2021). Zoning in on the legal aspect, one barrier faced for reducing deforestation and forest degradation (effective climate change mitigation measures) are laws geared toward increasing land clearing, development, and maintenance for the country. These laws that are detrimental to effective mitigation measures are:

1. The Land Tax Act - Section 23 of part IV of this law says that anyone who owns unimproved land more than 300 acres, will get a 5% increase in taxes on the land. It further states, however, that if that same land is improved or developed, where 30% or more of the land is used for agricultural purposes or for some type of production, then the extra 5% tax will not be levied (Chapter 58 of the Laws of Belize, Land Tax Act, 2003).
2. The National Lands Act – Section 9.3 of part II of this law states that anyone whose application for a lease land is approved will have six months to occupy the land (clearing, development, maintenance) or else the lease will become void (Chapter 191 of the Laws of Belize, National Lands Act, 2011).

The first law it is evident that some private landowners will have challenges participating in REDD+ for reducing deforestation and forest degradation, thus assisting in emissions reduction. The Land Tax Act allows a taxation on landowners with more than 300 acres unless some type of improvement or development is done. This improvement is further described in the law as either agricultural land or giving the land some other type of production value. Although the law states that only 30% or more of the land should be “improved”, there is a cultural misunderstanding with tendencies to fully clear lands for agriculture purposes or simply having it fully cleared to signify a type of “improvement”. This is considered a perverse incentive in the draft REDD+ Strategy, which is detrimental to deforestation and forest degradation reduction initiatives.

The National Lands Act also presents challenges for participating in REDD+. Section 9.3 of the National Lands Act is clear as it states who leases land can potentially have the land taken away if it does not show some level of occupancy or development within six months of application approval. This law then leads to people leasing lands and immediately clearing it to prevent seizure of the land.

These laws combined creates a cultural and social misunderstanding for private landowners who own lands less than 300 acres. It creates a belief and fear that if land is not cleared then the following may occur:

1. Lands can be taken away (which stems from the National Lands Act that speaks to lease land)

2. Being taxed extra if land is unimproved, which stems from the Land Tax Act for those landowners with over 300 acres of land.

Noteworthy, the REDD+ strategy and greater processes is pushing for the amendment of these laws to overcome these barriers.

5 Constraints and Gaps, Related Financial, Technical and Capacity Needs

Belize continues to mobilize necessary resources from various regional and international sources to battle the effects of climate change and reduce national emissions. Various means of support, including financial aid, technical assistance, capacity building and technology transfer, have assisted the country in effectively addressing some of its challenges. Nevertheless, some existing gaps and constraints require additional support for the government to meet UNFCCC requirements. This chapter highlights some of the constraints, gaps, related financial, technical, and capacity needs.

5.1 Greenhouse Gas Inventory

Belize recently reported on its national GHG emissions and removals in the Energy; Industrial Processes and Product Use; Agriculture, Forest, and Other Land Use; and Waste Sectors. Though improvements have been made, existing limitations and gaps were identified and highlighted in Belize's Fourth Greenhouse Gas Inventory Report.

Table 5.1 highlights some of the gaps and limitations within the reported sectors.

Table 5.1 Gaps and constraints

Sector	Constraints and Gaps	
Energy	i.	Disaggregated data on fuel consumption, by fuel type, is not available.
	ii.	There is lack of data on heavy duty equipment used in the construction industry.
	iii.	Disaggregated data on marine transport is not available.
	iv.	There is a lack of data on fugitive emissions from oil and gas activities.
IPPU	i.	The lack of accurate and reliable data continues to be a constraint for this sector.
	ii.	Reluctance of producers to provide data
	iii.	Challenge in obtaining data from privately owned companies
AFOLU	i.	Through the REDD+ Readiness project, improvements have been made under the FOLU sector in improving data availability and accuracy, however, there is more to be done in the in terms of data collection in the Agriculture sector.
Waste	i.	This sector has benefited from recent solid waste studies done on waste characterization and composition. Nonetheless, there is lack of data in areas such as open burning of waste, and total volume of wastewater produced by industry.
	ii.	Incomplete data available on domestic and commercial wastewater.
	iii.	There is lack of data from the industrial sector, as there is no formal reporting on the generation of liquid waste from shrimp culture and other small industries.

	iv. Data is not readily available, and existing data is not user friendly.

5.2 Research and Systematic Observation

The UNFCCC calls on Parties to promote and cooperate in systematic observation of the climate systems. In this regard, the National Meteorological Service (NMS) is part of a wider global network responsible for collecting 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 NMS has already initiated the following processes in collaboration with other national and regional institutions to better advance the scientific understanding of the climate. However, as a priority, additional assistance is needed in (7.2.2) and (7.2.5), with the item (7.2.7) being the overarching priority.

Assembling the data

The NMS maintains a data archive of essential climate variables (ECVs) assembled as part of larger data collection. In addition, 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.

Adjusting Data to Account for Inhomogeneities

Good quality control procedures can remove errors and improve data quality. However, some observations suffer from artificial inhomogeneities that are brought about by changes in observer or observation practices. The NMS is developing operational means of detecting or assessing inhomogeneity through artificial intelligence and establishing automated quality control procedures. Additional financing is required to continue developing the NMS's Climate Database Management System (CDMS) to tackle inhomogeneity in the datasets.

Real Time Updates

The NMS automatic weather stations (AWS) sample ECV's every five to ten seconds. They run basic calculations on those samples every five minutes (stations using satellite communications do every fifteen minutes) and store the results of those calculations for transmission every 30 minutes. A few stations transmit every fifteen minutes, and the satellite stations transmit every hour. All this data is ingested by the current Climate Data Management System (CDMS). The data is aggregated into hourly, daily, monthly, and yearly data summaries and is available in real-time to the NMS and its stakeholders. Therefore, vast improvements have been made in collecting data in real-time that can then be used to better identify trends and monitor changes in the climate.

Postproduction 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. The NMS is developing its data quality management system and automating basic quality control procedures through its CDMS.

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. The NMS faces significant challenges with maintenance of its vast observation network due to financial and transportation constraints. In its strategic plan for 2020-2025, the department will work on ways to overcome these challenges. This includes seeking project funding as well as partnering with local governmental and non-governmental agencies.

Advancement in Data Assimilation Technology

The increased demand for high resolution real-time data has caused the NMS to make significant advancements in its technological stack over the last five to six years. The NMS operates a network of computers behind a firewall with a high-speed internet feed of approximately 260Mbps. Six physical servers are used to ingest, process, and distribute various data types. These are listed below.

1. FTP server - used to collect and store raw data from our automatic weather stations, lightning detection network, radar, and other raw datasets,
2. WRF server – used to run Weather Research and Forecasting (WRF) model locally
3. CDMS server – processes and distributes ECV's
4. Virtual Server Stack – used to runs approximately 5 Virtual machines
5. EWS – Early Warning system which ingests and visualize a wide range of data sets and is capable of issuing C.A.P. alerts
6. Domain Controller –General Office Network Domain Controller

Of important note are the plans being made as it relates to the advancement of the CDMS. These are listed below:

1. The name of the CDMS is S.U.R.F.A.C.E. (System for Unified Real-time Forecasting of Atmospheric and Climatic Events)
2. Developed in 2017 and upgraded in 2019 as part of the Japan Caribbean Climate Change Partnership Project (JCCCP)
3. Currently used by NMS and select stakeholders for real time monitoring
4. Deployed on a Linux server using Docker and is made up of six Docker containers working in tandem.
5. Uses Restful API to access data instantaneously from backend - this is currently being used by the NMSB website and the International Cooperation and Development Fund (ICDF) of Taiwan for an alerting system in San Ignacio
6. Recently received funding through WMO hydro hub to develop machine learning AI for Quality Control
7. Currently working with WMO OPEN CDMS to become part of that initiative.
8. Ongoing improvements such as: WIGOS metadata integration, Quality Control procedures, Instrumentation and maintenance tracking and logs

9. Currently in discussion with the Caribbean Community Climate Change Center to possibly use the system as a means of collecting data.

With all these technological advancements the need to maintain these servers have become of great importance and is a current need within the service. Unfortunately, there is also a shortage of skilled staff to maintain and manage these various components properly.

Manpower/Human Resource

The need for Climate Information and Services continues to expand across the climate- sensitive sectors of Belize to minimize climatic risk and increase resilience to climate change. The basic need for the greater involvement by the NMS in Climate Change research continues to be the availability of enough suitably qualified staff who can be devoted to that specific activity.

Procurement of Equipment

Much of the observation platforms, such as automated weather stations, are procured through grants or donations from local, 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 must settle for whatever package is donated. This can have a negative impact on data quality and continuity of the data collection process due to the acquisition of faulty sensors or sensors not acclimatized to tropical environments.

5.3 Financial, Technical and Capacity Needs

Belize's geographic location makes it exceptionally vulnerable to the impacts of natural disasters and their exacerbation by continued climate change. Having been faced with hurricanes, flooding, sea level rise, coastal erosion, and droughts in the past, the country continues to prioritize financial investment in climate change mitigation and adaptation. A recent study on Belize's climate finance landscape for the period 2015-2019 showed a total of BZD 454,740,347 was geared to climate investments in the country. This same study also stated that of the 6 sources of financing highlighted, multilateral development banks represented the highest figure with a total of were BZD 179,276,386, representing 39.42% of total climate investments for that period.

Notwithstanding Belize's continuous efforts, there is need for greater financing for the country to effectively address the impacts of climate change. In an effort to do this, a Technology Needs Assessment was carried out in 2017 to identify and prioritize technologies and tools that can contribute to adaptation and mitigation goals compatible with national sustainable development goals and priorities. This has been critical to quantify support in terms of actions and finance in key sectors. Nevertheless, a comprehensive and integrated needs assessment with respect to finance, technical assistance, capacity building, and technology has not been done and documented in any single report or data source. The absence of a comprehensive Needs Assessment adds to the difficulty in precisely determining the support needed by the country.

In recent years, multiple studies and assessments have been carried out that have helped to identify enabling conditions, prepare national plans that integrate climate change, and project the potential

impacts of climate change in Belize (TNA, TAP, and stakeholder analysis). However, few sector-specific analyses have also been done to assess the gaps and constraints in finance, technical capacity, and technology (first, second, third national communications, TNA – Barrier Analysis and Enabling Framework). Although these studies are not sufficient to determine effectively and comprehensively all of Belize's needs, they are a good baseline to build upon for future National Communications and assessments.

Table 5.2 Climate investments in Belize by the source of finance from 2015 - 2019

Source of Climate Investments	Amount BZD	%
Government of Belize	42,394,693	9.32
Multilateral Development Banks	179,276,386	39.42
Bilateral Donors	94,940,162	20.88
Climate Funds	49,750,606	10.94
Private Investments	14,034,800	3.09
Other	74,343,700	16.35
Total	454,740,347	100.00

Table 5.3 Financial, technical, and capacity needs

Need identified	Support needed	Specific type of support requested [technology transfer, capacity building, financial support]	Finance Required	
			National budget available (USD)	Financial support needed (USD)
Design an awareness and implementation plan for off-grid solar PV technology to electricity homes in rural communities	Technical assistance for preparation of a plan	Technical assistance		80,000
Design an awareness and implementation plan for distributed and centralized on-grid solar PV systems	Technical assistance for the preparation of a plan	Technical assistance		120,000
Funding for implementation of Solar Water Heating NAMA	Financial support to implement actions in SWH NAMA for commercial, industrial, and	Financial support		5,882,440

	residential sectors			
Capacity building to increase knowledge of gasification systems and proper operation	Capacity building for technicians for proper set up, operation and maintenance of gasification systems	Capacity building		
Capacit building to increase knowledge and services offered for solar PV systems	Capacity building for installation, use and maintenance (services offered) of solar PV systems (on-grid and off-grid)	Capacity building & Financial support		69,000
Develop plan for funding options and incentives for farmers to import, purchase, and operate improved PCS technology with cooling systems using RE	Technical assistance to develop a plan	Technical assistance		
Funding to strengthen a grain seed production system for four farmers' groups and the MoA Seed Production Unit through a CBA, project concept, policy formation and incentives for farmers	Procure finance and technical assistance to strengthen climate resilient, certified grain seed production and make marketable	Financial support & technical assistance		22,000
Funding for installation of small-scale solar PV off-grid systems in three villages in the Toledo District pilot project	Financial support for purchasing equipment and installation of 75 small-scale, off-grid, 100W solar PV systems for homes in rural Toledo	Financial support		80,300

Funding to install biomass gasification system at two agro-processing facilities where there is suitable biomass waste stream	Financial support for purchasing equipment and installation of two gasification systems	Financial support & Technology transfer	Cost dependent on feedstock and gasifier model chosen	Support needed dependent on feedstock and gasifier model chosen
Train technicians/locals to install, maintain and monitor micro-hydro power plants	Capacity building for technical experts and interested locals by developing training program for micro-hydro power plant installation, maintenance, and monitoring	Capacity building		30,000
Capacity building to enhance national technical expertise in NAMA & NAP preparation and implementation	Capacity building for government technical experts to prepare and implement NAMAs and NAPs	Capacity building		
Capacity building to incease knowledge about production of climate resilient grain seeds	Finance for the development and execution of a training programme for seed producers	Financial support & capacity building		47,000
Establish seven improved drip irrigation/ fertigation systems with rainwater catchments for 5 farming cooperatives and the MoA field training stations in Belmopan, Belize	Financial support to establish seven systems for improve drip irrigation/ fertigation with rainwater harvesting	Financial support		
Develop and execute training programme for farmers on improved drip irrigation/ fertigation	Financial support and capacity development by training individual farmers and	Financial support & capacity building	12,000	30,000

systems and rainwater harvesting	farming cooperatives and for training of trainers			
Limited knowledge of improved PCSs and limited services offered for locally manufactured PCSs	Financial support and capacity building for training on erection and operation of improved PCS and training to certify local technicians	Capacity building & financial support		
Upgrade of UB's plant micro-propagation laboratories and nurseries to produce certified potato seed tubers	Financial support to upgrade laboratory facility, including nurseries, at UB	Financial support		40,000
No protocol exists for production of certified Irish potato seed tubers through micro propagation	Funding for contracting of a bio-technology expert to develop Irish potato micropropagation protocol and best practices	Financial support		25,000
Training programme developed by bio-technology expert and training carried out for laboratory technicians and nursery field technicians	Funding for bio-technology expert and training to be carried out	Financial support & capacity building		35,000
Potato seed tubers imported for planting each year due to lack of local variety for planting	Secure funding for production of climate resilient Irish potato seed tubers through micropropagation at laboratory and nurseries	Financial support		

Refurbishment of 8 protective covered structures' cooling systems using renewable energy	Financial support for purchasing equipment and installation of cooling systems for 8 PCSs that are in disrepair using renewable energy for cooling	Financial support	8,000	40,000
Funding for the development, testing and production of climate resilient, certified grain seeds (heat & drought resistant open-pollinated corn & beans) by four farmers' cooperatives and the MoA Seed Production Unit	Financial support to establish a certified grain seed production system	Financial support & technology transfer		

5.4 Capacity Building Support Received

Expanding national capacity becomes increasingly important under the implementation of the Paris Agreement, whereby the focus on intensified emission reduction efforts will be needed while simultaneously increasing resilience to climate change impacts. Table 5.4 and Table 5.5 outline capacity-building initiatives undertaken in several areas during the period 2015-2019.

Table 5.4 Capacity building support received

Capacity Building Activity	Period	Source of support
Education and human resource development: capacity-building interventions for government institutions and NGOs in planning and monitoring	2015	Basic Needs Trust Fund VIII
Build capacity for Belize Water Service to conduct CRVA of their remaining systems. Prepare and conduct workshops for BWS's key	2015	Water Utility Climate Risk and Vulnerability Assessment Project

personnel and relevant staff of government ministries.		
Public awareness campaign aimed at educating residents on the importance of avoiding littering and the disposition of solid waste in drains and canals; Development of the DOE's capacity to supervise and ensure the Program's compliance with environmental regulations, training in program supervision and monitoring in Belize, support with a technical environment specialist; Conduct a natural disaster risk assessment study of Belize City	2016	Flood Mitigation Infrastructure Program for Belize City
Coastal Zone, Sea Level Rise, and Related Processes workshop: Capacity Building for national technical experts for integrating coastal zone, sea level rise and other related processes into climate actions, development plans and strategies by using analytical and modelling methods to gather data for informed assessments. The workshop focused on sea level variation and coastal dynamics and ecosystems, how to measure variations and analytical and modelling methods that can be used to collect data on such variations and processes. Participants learned how to assess variations found and how sea level rise can influence coastal ecosystems and its components, such as water quality, wetlands, coral reefs, etc.	2018	Fourth National Communication/First Biennial Update Report Project (GEF)

Training in the use of Collect Earth Software, Saiku data analysis tool, and GHG Inventory Tool for AFOLU Sector	2018	REDD+ Readiness Preparation Project CfRN FAO
Training national experts in IPCC 2006 GLs	2018 - 2019	CCMRV Hub for English Speaking Caribbean Countries and GHG Management Institute
Engagement with Data Management Working Crew to develop Regional GHG Management System	2018 - 2019	CCMRV Hub for English Speaking Caribbean Countries and GHG Management Institute
Vulnerability and Capacity Assessment Workshop: Training of 20 technical personnel from the public and private sector on how to conduct vulnerability assessments and increase adaptive capacity knowing what vulnerabilities exist. Attendees were also taught how to use vulnerability assessments in their decision making. Four technical officers from key sectors, namely, coastal zone, fisheries, water, and climate change, were then further trained in Cuba.	2018 - 2019	Fourth National Communication/First Biennial Update Report Project (GEF)
Belize Climate Change Negotiators' Training Workshop	2015	EU-GCCA Project: Enhancing Belize's Resilience to Adapt to the effects of climate change
Capacity Building for Low Carbon Development	2015	EU-GCCA Project: Enhancing Belize's Resilience to Adapt to the effects of climate change
Mainstreaming CC into Sector Plans Workshop	2015	EU-GCCA Project: Enhancing Belize's Resilience to Adapt to the effects of climate change
VCA Workshop	2018	FNC and BUR to the UNFCCC
Assess and implement Strategic Environmental Assessments in (SEA) Belize	2018-2019	Capacity Building for the strategic planning and management of natural resources in Belize and

		FNC and BUR to the UNFCCC
Coastal zone, Sea Level and Related Processes Training workshop	2019	FNC and BUR to the UNFCCC
Climate Change and Gender Workshop	2019	FNC and BUR to the UNFCCC
South-South Cooperation with Institute of Meteorology (INSMET) Cuba	2018	FNC and BUR to the UNFCCC
Training Programme on UNFCCC GHGI Reporting and IPCC 2006 Guidelines for Belize's GHGI Team	2018	FNC and BUR to the UNFCCC
Training on IPCC 2006 Guidelines	2018	UNFCCC
Training on Land Use Land Use Change monitoring using Open-Foris Collect Earth Software	2018	REDD+ Readiness Project
Training on the use of Saiku Data analysis software	2018	REDD+ Readiness Project

Table 5.5 Capacity building received by the National Climate Change Office

Capacity Building National Climate Change Office	
Chief Climate Change Officer (CCCO)	
2017	2018
Regional Forum for CTCN National Designated Entities (NDE's) in parallel with the Structured Dialogue of the Green Climate Fund for the Caribbean	Contribution of Nuclear Science and Technology to Building Climate Resilience in the Caribbean Region
COP 23 UNFCCC Climate Change Negotiations	Meeting Session United Nations Climate Conference
CARICOM Pre COP Meeting and Transparency Workshop	Second IMPACT Project Workshop, IPCC Special Report on Global Warming at 1.5 and Regional Preparatory Meeting

International Conference on Climate Change	Workshop on the Project on Advancing Climate Transparency (PACT) – and – CARICOM Regional Workshop on the IPCC Special Report on 1.5 and the Talanoa Dialogue
Least Developed Countries Expert Group Regional Training Workshop on National Adaptation Plans for Latin America and the Caribbean – in San Jose, Costa Rica September	
Deputy Chief Climate Change Officer	
2015	
Capacity Building Training for the TNA Phase II Project	
Regional Training on Carbon Finance for Latin America and the Caribbean	
Climate Change Officer - Mitigation	
2018	
Workshop Intro to REDD+ Readiness Project in Belize	
Workshop: Presentation of the baseline results of carbon dioxide emissions and fuel efficiency for vehicles registered in Belize in the year 2013, 2014, 2015 and 2016	
Workshop with CfRN on Defining Belize's Forest Definition, Classifications, and Land Use Matrix for GHG Inventories and FREL	
APC Colombia Workshop Exchange of Colombian Experiences in Climate Change Mitigation and Adaptation	
UNFCCC Voluntary Peer Review of Belize's GHG Inventory (TNC) and sharing of recommendations	
Workshop on the Building of Sustainable National Greenhouse Gas Inventory Management Systems, and the Use of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories for the Latin America and Caribbean Region	
CGE webinar: Good practices and lessons learned towards building sustainable GHG inventory management systems.	
Greenhouse Gas Management Institute, Online Courses on IPCC 2006 Guidelines, Crosscutting, and 5 IPCCC Reporting Rectors	
Greenhouse Gas Management Institute, In country training on essential components of GHG Inventory Preparation (components of Online Training), and development of QA/QC procedure with Belize's GHG Team	
Regional hands-on training workshop on the preparation and reporting of mitigation actions for Latin America and the Caribbean region	
SIB workshop - on SPSS, Data Dissemination, engaging the media and stakeholders, quality indicators	
Collect Earth Land Use Change Mapping Application (GIS Application)	
Climate Change Officer - Adaptation	
2017	2018

International Conference on Climate Change – in Port-of-Spain, Trinidad from	Vulnerability and Capacity Assessment Training Part II
	Workshop on the exchange of Colombian Experiences in Mitigation and Adaptation to Climate Change

5.5 Public Education and Awareness

Public Education and awareness continue to be key in driving national support for climate action, encouraging support for government policies and measures, and influencing positive change in habits. Belize continues to make strides in educating the populace on climate related issues through both public and private sector initiatives, with significant progress achieved through the Marine Conservation and Climate Adaptation Project (MCCAP). The project facilitated the training of several teachers in delivering climate change instruction to students and fellow teachers; guided the development and distribution of training manuals for teachers; and, through close collaboration with the Ministry of Education, supported the development of a climate change unit into Belize's secondary curriculum. Building on this, the Ministry intends to implement a similar approach at the primary school level. Proposed Projects:

Project	Funding/ Executing Agency	Project Cost (BZD)	Support Area	Sector
Regional Hurricane Shelters	NEMO	25,000,000	Adaptation	Infrastructure
Proposed multi-use structure near Ml. 25, George Price Highway, with capacity to house residents of vulnerable communities in the event of hurricanes or floods. The proposed concept is similar to the Georgetown High School/Shelter/Auditorium. This project is categorised as development which reduces the effects of disasters.				
George Price Highway Project II (Section IV)	IADB	34,000,000	Adaptation	Transport
Expansion of the rehabilitation of the highway to the Western Border				
Lamanai Road	MOW	TBD	Adaptation	Transport
Upgrade to all weather road				

Table 5.6 Proposed projects

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Annex 1

Climate Adaptation Survey

The purpose of this survey is to determine the level of knowledge of respondents in terms of climate change adaptation, respondents' level of adaptation planning and to gather information on current adaptation initiatives. The results of this survey will be used to inform the Adaptation Analysis that forms part of Belize's Fourth National Communication and will be compared to a previous stakeholder survey that was conducted by the National Climate Change Office (NCCO) in 2018.

Adaptation is defined as adjusting to actual or expected future climatic changes. The goal is to reduce vulnerability to the harmful effects of climate change (sea-level rise, more intense extreme weather events or food insecurity). It also encompasses making the most of any potential beneficial opportunities that may arise (for example, longer growing seasons or increased yields in some regions). The adaptation planning process helps to adjust to the impacts of climate change, including actions taken to reduce the negative impacts of climate change, or to take advantage of emerging opportunities. Adaptation planning allows us to analyse, select and prioritize measures in response to a changing climate.

Kindly respond to the questions to the best of your ability. The NCCO greatly appreciates your assistance in this endeavour.

1. Name and Job Title
2. Name of organization
3. How well informed are you about the effects of a changing climate?
    a. Not informed
    b. Slightly informed
    c. Moderately informed
    d. Very well informed
4. How convinced are you that climate change poses a serious problem for Belize?
    a. Not convinced
    b. Somewhat convinced
    c. Neutral
    d. Very convinced
    e. Completely convinced
5. Can you name at least 4 impacts of climate change that we have experienced or are currently experiencing in Belize or the region?

6. Please describe your organization's/ department's priority areas (if any) in responding to climate change?
7. Has your organization assessed its potential impacts, risks, or vulnerabilities to future climate changes?
    a. Yes
    b. No
8. If no, could you elaborate on why your organization has not done such an assessment?
9. If yes, could you please name the report developed from the assessment and share if possible?
10. Does your organization have any existing policy, plan or practices related to climate change adaptation, that is, planning for the future impacts of CC? If yes, please state name and share if possible.
11. If no to question above, can you elaborate on why your organization does not have any policy or plan relating to climate change adaptation?
12. Does your organization work in collaboration with other government departments, NGOs, private sector agencies etc. to plan for climate adaptation? If yes, please list collaborators
13. If yes, how did these collaborations come about; if no, are any planned for the near future?
14. Please rate how important it is in your work to address climate change through adaptation efforts to plan, prepare for or manage the projected impacts of climate change.
    a. Top priority
    b. Medium priority
    c. Low priority
    d. Not on the agenda
15. In your own words how has or how will climate change affect activities required to reach the goal of your organization?
16. Nationally, what are the main drivers to adapt to the effects of climate change in Belize?
17. Nationally, what are the main barriers to integrate adaptation into the decision-making process in Belize?
18. If you are professionally involved in 'adaptation planning', what prompted your involvement? (you may choose more than one)
    a. Not currently involved
    b. Organizational/department level strategy
    c. Legislative mandate
    d. Supervisor's directive
    e. Development or update of a local climate action plan
    f. Provide community support
    g. Funding became available
19. Which of the following best describes your current phase of climate change adaptation planning and implementation?
    a. Not currently involved in planning to adapt to the effects of climate change

   b. Knowledge building: We're in an early stage, trying to gather knowledge to understand the potential impacts of climate change and vulnerabilities
   c. Planning: we are moving forward, trying to assess what our options are to prepare for and decrease vulnerabilities and risks to climate change, in order to increase resilience
   d. Implementing: advanced stage, we have planned for climate change and are currently implementing identified adaptation solutions and monitoring their effects

20. Please list and describe in as much detail as possible all the adaptation measures/ techniques that your organization is currently planning or implementing. (For example: adapting building codes to future extreme events, moving towards drought tolerant crops, implementing measures to use water resources more efficiently – improved irrigation, etc)
21. As you have become involved in or aware of adaptation planning, what are some obstacles that you have personally faced or are currently facing? Please select all that apply.
    a. Lack of urgency
    b. Insufficient staff or human resources
    c. Lack of public support
    d. Insufficient funding
    e. No legal mandate
    f. Lack of data
    g. Insufficient technical expertise to analyse and utilise relevant information
    h. Unsure
22. What sort of services are required by your organization to increase capacity for planning for climate change adaptation?

Annex 2

Stakeholder List

Organization
Association of Professional Architects
Association of Protected Areas Management Organizations
Belize Chamber of Commerce and Industry
Belize Association of Planners
Belize Brewing Company Ltd.
Belize Bureau of Standards
Belize Fisheries Department
Belize Social Investment Fund
Belize Enterprise for Sustainable Technology
Belize Tourism Industry and Association
Caribbean Agricultural Research and Development Institute
Caribbean Community Climate Change Centre
Coastal Zone Management Authority and Institute
Development Finance Institution
Energy Unit
Friends for Conservation and Development
Galen University
Greensun Ltd.
Inter-American Institute for Cooperation on Agriculture
Ministry of Tourism and Civil Aviation (Sustainable Tourism Program II)
National Biodiversity Office
National Association of Village Councils
Protected Areas Conservation Trust
Statistical Institute of Belize
Sugar Industry Research & Development Institute
Solid Waste Management Authority
Toledo Institute for Development and Environment
Turneffe Atoll Sustainability Association
UB Environmental Research Institute

United National Development Programme
University of Belize - Central Farm
Ya'axche Conservation Trust

Annex 3

Adaptation Activities

Organization	**Please list and describe in as much detail as possible all the adaptation measures/ techniques that your organization is currently planning or implementing. (For example: adapting building codes to future extreme events, moving towards drought tolerant crops, implementing measures to use water resources more efficiently – improved irrigation, etc)**
Association of Professional Architects	We are not planning any other than looking forward to a national Building Code being developed in near future
Association of Protected Areas Management Organizations	Climate smart, conservation and management programmes and plans implemented for marine and terrestrial habitats, which increases the resiliency within the network of vulnerable Protected Areas and use of solar technologies. Improve adaptation capacity to climate change and climate resilience of the ecosystems in buffer communities. Improved awareness of climate change impacts and mitigation and adaptation measures towards climate resilient ecosystems development in the buffer communities.
Belize Chamber of Commerce & Industry	ProAdapt Belize project – Increasing Climate Change Resilience and Related Business Opportunities Project; trainings
Belize Association of Planners	Our projects and programs are both knowledge based and planning related -serve in an advisory capacity on Climate Change Subcommittee, involved in documenting coastal land tenure and vegetation, work with visiting university students doing planning related research in Belize, working with Belize City Southside community to build urban resilience, working with Association of NGOs to build administrative capacity and collaboration among NGOs, working with municipalities/communities on various planning related programs, etc.
Belize Brewing company ltd.	implementing measures to use water resources more efficiently by recycling, conservation and Zero Discharged of wastewater
Belize Bureau of Standards	RE and EE standards for lights bulbs, refrigerators, and air conditioners, currently conducted through regional project training on the regional EE Building Codes. Looking toward the adoption of the Regional EE Building Codes

Belize Fisheries Department	Implementing: effective management of fisheries resources and marine reserves; coral restoration; Planning: Monitoring of fisheries using climate information; early warning system, etc.
Belize Social Investment Fund	Many of our sub-projects have civil output to improve the lives of the beneficiaries. Classroom Buildings, Rudimentary Water System, Water distribution network, health centres, polyclinics, and resource centres would all require - adaptation of building codes, individual site's vulnerability to flooding, fire, etc. Other social intervention that are implemented alongside or separately includes; training teachers, parents, students, community works, and other identifiable stakeholders in water conservation, W.A.S.H., to operate and maintain the facility, equipment and knowledge improvement.
Belize Tourism Industry Association	Minimal. BTIA's roll mainly focuses on providing recommendations from tourism sector and to share relevant information with our members.
BEST - Belize Enterprise for Sustainable Technology	BEST has been promoting adaptation measures such as covered structures for agricultural production, use of insurance to cover storm damage to structures and having farmers use the technical resources of the Ministry of Agriculture in selecting seeds and planting material .
Caribbean Agricultural Research and Development Institute	water harvesting drought tolerant variety trials biofortified crops cover crops and agro-forestry systems Cover structure Early warning pest and disease app for farmers
Caribbean Community Climate Change Centre	Several initiatives within Belize and Caribbean, project management, provide support
Coastal Zone Management Authority & Institute	Part of WWF's Smart Coasts Project, Development of a project proposal for Adaptation Fund, use of ecosystem-based adaptation approaches for coastal protection
Development Finance Corporation	Climate smart financing (e.g., drainage and irrigation, covered structures). Renewable energy financing, ensuring project adherence to approved building codes, ensuring project adherence to environmental laws.

Energy Unit, Ministry of Public Service, Energy and Public Utilities	Adaptation Measures: •Development of National Energy Information System: improved access to reliable and time-sensitive information to support energy policy and decision-making processes linked to climate adaptation and mitigation. •Capacity Development: Energy Planning and Forecasting: to carry out long-term energy and climate adaptation planning to identify policies, investments, and capabilities that are necessary to achieve Government of Belize's objectives in addressing the vulnerabilities in the energy sector. •Energy Diversification: Energy policies that support energy diversification. For example, proposals were being invited (RFP, 2013 PUC) for the addition of some fifteen (15) MWe of rated capacity generation or supply facilities utilizing wind or solar technology or other non-firm renewable generation sources. By diversifying the energy sector, energy supply is less vulnerable to climate variability and change, in particular to fluctuations in water availability. •Energy Efficiency Projects: Energy Conservation Measures (ECM) Implementation in Buildings and the development and implementation of Energy Efficiency Labels and Standards (On-going). Higher temperatures can lower generation efficiency and increase energy demand during warmer periods of the year. These climate change effects can be compensated for via energy efficiency by designing more efficient energy infrastructure. These projects and demand-side management can alleviate supply constraints.
Friends for Conservation and Development	With farmers, we have been promoting the efficient use of water; likewise, at our other facilities, we have promoted the harvesting of rainwater. FCD developed an internal plan to reduce our carbon foot-printing at the office. It's a working progress.
Galen University	Increasing knowledge, We are in the process of designing a new campus --- this campus is envisioned to be a GREEN/Eco-friendly campus, complete with an Energy Farm producing fossil-free energy (wind and solar), and the collection of water from the rain, and the treatment of grey water for use in bathrooms and to water the garden and university farm. It is also expected that we will offer programs related to Energy Farm and sustainable agriculture (small kitchen organic gardening).
Greensun ltd	Providing solar energy technology, Home Biogas

Inter-American Institute for Cooperation on Agriculture	Supporting adaptation planning in the agricultural sector, identifying, and implementing climate responsive practices, knowledge management, e.g., support rural communities to improve resilience to climate change with activities such as regenerative agriculture, improved water management. Support coordination within public and private sectors.
Ministry of Tourism and Civil Aviation (Sustainable Tourism Program II)	1)Capacity building/strengthening to improve, knowledge, understanding and awareness of risk and risk reduction/adaptation options; and improve disaster risk reduction and climate change adaptation coordination 2) implementing the tourism policy and legislation to address risk reduction and adaptation, 3) promoting climate resilient and/or green designs for new tourism/tourism support infrastructure as well as retrofitting of existing tourism/ tourism support infrastructure to consider climate change, 4) strengthen disaster preparedness through business continuity planning, 5) evacuation planning and community-based adaptation by developing disaster risk management plan and destination specific local crisis management plans, 6)Conduct coastal baseline studies and develop shoreline management plans to increase coastal resilience (this is where most tourism activities and infrastructure are located) for Caye Caulker, Toledo and Corozal 7) installation of water retaining system in archaeological sites to ensure availability of water supply to sites
National Association of Village Councils	Building awareness on conserving and using water appropriately, implement irrigation systems in crop fields
National Biodiversity Office	promoting sustainable forest and biodiversity management and use through regulations
Protected Areas Conservation Trust	PACT does not implement activities, but they provide support on several initiatives and projects that are currently ongoing.
Statistical Institute of Belize	Moving-to/Piloting Remote Data Collection.
Solid Waste Management Authority	Closure of open burning of municipal waste, several dump sites have been closed down, transfer facilities have been established and a sanitary landfill is in use.
Sugar Industry Research & Development Institute (SIRDI)	Recommending Minimum tillage in land preparation, incorporating fertilizer application, promoting the elimination of the second burning of harvest residues, use of biological agents for pest control, evaluating sugarcane variety to

	withstand the changes in the climatic conditions, Irrigation trials experiment, fertilizer dosage trail.
Toledo Institute for Development and Environment	reforestation along riverbanks, livelihood diversification opportunities, ongoing outreach to create awareness of and impacts of CC, building away from the coast, advise on re-location of communities highly impacted by coastal erosion etc. We also use solar energy at our 3 field stations and practice energy saving measures at the main office.
Turneffe Atoll Sustainability Association	Exploring supplementary livelihoods options (seaweed mariculture)
UB Environmental Research Institute	Our work is research oriented as we are an academic institution
United Nations Development Programme	Providing support, managing programmes/projects – several in country
University of Belize - Central Farm	Moving towards drought tolerant crops, implementing measures to use water resources more efficiently – improved irrigation, water harvesting, energy/protein banks, biopesticides and biofertilizers, IPM and cover crops, CSA training programs
Ya'axche Conservation Trust	Moving towards drought tolerant crops, adopting smart agriculture practices such as agroforestry and inga alley cropping and moving away from slash and burn practices, better water resource efficiency, developing early warning fire detection, capacity building