BARBADOS' SECOND NATIONAL COMMUNICATION

Under the United Nations Framework Convention on Climate Change

PRIDE AND INDUSTRY

April 2018

Barbados' Second National Communication

Under the United Nations Framework Convention on Climate Change (UNFCCC)

April 2018

Barbados' Second National Communication (SNC) under the UNFCCC was developed according to Articles 4.1 and 12.1 of the UNFCCC and in line with the requirements of the Non-Annex I Convention Parties. The SNC targets Convention Parties, stakeholders and a wider audience.

Published by Government of Barbados

Draft Prepared by Environmental Gain Ltd in association with Aether Ltd. and The Caribsave Partnership on behalf of the Government of Barbados, and

Edited by Policy, Research, Planning and Information Unit, Ministry of Environment and Drainage, Government of Barbados, Warrens Tower II, Warrens, St Michael, Barbados, W.I.

GOVERNMENT OF BARBADOS

Second National Communication

Under the United Nations Framework Convention on Climate Change

April 2018

CONTENTS

TABLES

FIGURES

FOREWORD

The Government of Barbados presently submits this long overdue report which commenced preparation in 2010. As requested in the Terms of Reference for the project, readers will note that the Greenhouse Gas (GHG) inventory provided only covers assessments over the 2001-2010 period. This was with the intention that the entire report would have been finalzed and submitted by 2011. However, this was not to be and, in the intervening period thereafter the Ministry of Environment exercised significant effort to update and include information on the range of actions undertaken or planned that would realize a reduction in the national GHG emissions footprint as well as enhance climate resilience across a variety of sectors.

Like many other Small Island Developing States (SIDS) Barbados considers climate change to be a significant threat to its growth and prosperity. This was most recently communicated in our Nationally Detrmined Contribution (NDC) submitted to the United Nations Framework Convention on Climate Chante (UNFCCC) and by our ratification of the Paris Agreement on April 22, 2016 along with many other Parties to the Convention. Barbados' NDC cites adaptation (i.e building national resilience to climate change) as our main priority, identifies emissions reductions targets that are largely to be met by actions in the energy sector, and preconditions these against the availability of technical and financial support from the international community. The recent approval by the Green Climate Fund (GCF) of US$ 27.61 millon in grant resources of a US$45.21 million water resources management project is highly significant as it attaches to one of the most critical sectors of the economy and, we hope, will be catalytic in stimulating enhanced domestic consultation, planning and engagement with the international community.

The process of preparing this SNC document has revealed that many of the constraints and challenges communicated in the First National Communication still remain. Despite this, we are pleased that staisfactory progress has been made in several key sectors; particularly with regards to the conduct of sectoral assessments and the recognition of inherent climate vulnerabilities. Implementation of required actions remains the hurdle that we must now surmount and that we are focussed on.

Ministry of Envionment and Drainage

EXECUTIVE SUMMARY

This is Barbados' Second National Communication produced under the United Nations Framework Convention on Climate Change. It provides a comprehensive overview of the current and future development of Barbados and assesses how these aspects may be affected by climate change. The Communication specifically identifies:

- Key environmental and socio-economic vulnerabilities to climate change within Barbados
- Practices and measures that facilitate adaptation to climate change
- Practices and measures that facilitate mitigation of greenhouse gas emission
- Uncertainties and limitations within the assessment methodology, notably in terms of data accuracy and accessibility.

Barbados is a small island and one of the most southerly in the Lesser Antilles Caribbean island chain located on the southern edge of the North Atlantic Hurricane Belt. The island possesses many of the defining characteristics of Small Island Developing States, including low-lying topography, relative remoteness, limited resources and vulnerability to global changes. The island has a population of approximately 0.28 million, with a density in the region of 660 persons per km^2. The majority of the population and infrastructure is located along or near to the coast. Barbados is also affected by a number of social challenges, including poverty, unemployment, and chronic disease. The combination of these factors are likely to result in the country being one a handful of countries most intensely affected by the future impacts from climate change. The identification of key vulnerable areas, sensitive receptors, potential hazards and early uptake of adaptation and mitigation measures, are therefore imperative.

Barbados' primary greenhouse gas emitted is carbon dioxide, which, in 2010, provided over 99% of the total country contribution, with the remainder from methane and nitrous oxide gases. Emissions are from four key sectors: energy, including domestic transport (73.7%), industrial processes (8.5%), agriculture (3.0%) and waste (14.9%). Land use, land use change and forestry provide a sink of greenhouse gas emissions of 51 Gg CO_2e in 2010, which is equivalent to a reduction of 2.6% of total emissions for that year.

Although Barbados' greenhouse gas emissions equate to less than 0.01% of the global total, the Government has committed to sustainable measures for effective emissions reduction, energy conservation and renewable energy supply.

The compilation of the National Greenhouse Gas Inventory was hindered by data availability limitations and the majority of emission estimates for this report were based on activity data from United Nations Statistics, extrapolations or interpolations, surrogate or secondary datasets and expert opinion. Following international guidance, a calculated 12% uncertainty has been

identified for the 2010 greenhouse gas emissions results. Improving dataset accuracy and availability is important for future communications, where emissions estimates will be calculated from joint Government enterprises.

Climate change is a challenge that will likely affect both the natural environment as well as the social and economic stability of the country. The priority sectors assessed for climate change vulnerability and adaptation are agriculture, water resources, human health, coastal resources and human settlement, tourism, fisheries, and insurance. The tourism and insurance sectors are the most significant contributors to Barbados' economic growth.

Assessments of current and future climate change effects utilises a tandem of regional and global climate models. The environmental risk profile of Barbados is dominated by coastal and weather effects, especially sea level rise, storm surge and increased tropical storm and hurricane intensity and frequency. These effects have significant impacts on food production, drought, rainfall patterns, disease outbreaks and storm damage, as well as exacerbating existing vulnerabilities to health and water availability. The environmental effects are expected to pose a significant threat to coastal resources, residents and infrastructure. This will significantly affect Barbados' tourism sector, because of the reliance on low-lying coastal resources, and their inherent vulnerability to climate impacts.

Alongside the direct, environmental effects of climate change, the social and economic impacts are equally important; they include impacts on:

- **Health**: including increased water stresses and greater prevalence of water and vector-borne diseases;
- **Tourism**: including damage to coastal tourism infrastructure;
- **Water resources**: including groundwater contamination from flooding, soil or pollutant infiltration and saline intrusion, leading to reduced water availability;
- **Fishery and agricultural industries:** drought, flooding and storm damage, saline intrusion, pest and invasive species outbreaks and spread and ecosystem destruction all of which can result in a loss of domestic and international competitiveness; and
- **Financial risk and insurance**: where there is a direct correlation between climate change adaptation/projections and insurance cost/availability.

Barbados' activities and measures to tackle climate change are split between mitigation and adaptation options.

Mitigation measures involve reducing national emissions, primarily through the uptake of renewable energy and energy efficiency practices. The mitigation strategies are based on the National Greenhouse Gas Inventory and primarily focussed on emissions within the energy sector (including domestic transport), as this is the largest contributor of greenhouse gases emissions. Barbados is dedicated to the implementation of sustainable energy technologies,

including wind, solar, cogeneration and waste-to-energy strategies. These practices also reduce the cost of electricity and the dependence on imported fossil fuels.

Adaptation measures require the identification of potential climate change impacts and climate sensitive sectors and the implementation of practices, incentives and infrastructures to reduce the susceptibility to predicted impacts. Adaptation strategies are categorised according to the urgency of implementation, the cost-benefit, type, specifications and lifetimes. Financial risk-sharing mechanisms are also a necessity to ensure against potential climate change-related weather events.

Priority adaptation strategies are:

- Efficient data collection, focussed research and development, and the establishment of robust and comprehensive datasets
- Education and awareness, particularly in the water, health and tourism sectors
- Mainstreaming of adaptation strategies into decision making, governmental policy and development plans
- Integrating management and stakeholder participation to assist climate change adaptation implementation
- Consistent, long-term and dynamic tourism brand development.

Although research and understanding are still developing, it is evident that the impacts to all sectors of Barbados are likely to be substantial and beyond the direct damage of climate change alone, affecting economic growth, development, sustainability and security. The effects of climate change over future decades cannot be prevented; however, it is possible to protect Barbados' environment, society and economy from many of the impacts. The implementation of mitigation and adaptation measures is a necessity to build resilience and minimise the cost and risks of climate change whilst taking advantage of new opportunities that may be presented. Barbados recognises the current economic inflexibility and social challenges that can limit the capacity for mitigation and/or adaptation to climate change effects and is implementing measures to improve both of these considerations to improve its adaptive capacity. Enhancing the country's adaptive capacity will yield immediate and long-term benefits and provide a strategy for national development.

It is not a requirement of the United Nations Framework Convention on Climate Change for Non-Annex I countries to set emission reduction commitments. However, Barbados is endeavouring to become a low carbon economy, which will also provide ancillary benefits for sustainable energy usage and developments, as well as reducing the cost of adaptation. Mitigation strategies also result in regional and global benefits, whose evidence will be witnessed in future decades.

ABBREVIATIONS

AIMS	Atlantic, Indian Ocean, Mediterranean and South China Sea Region
ACCC	Adaptation to Climate Change in the Caribbean
AR5	Fifth Assessment Report
AusAID	Australian Agency for International Development
AWMS	Animal Waste Management System
AWS	Automatic Weather Stations
BCIC	Barbados Cane Industry Corporation
BL&P	Barbados Light & Power Company Limited
CariCOF	Caribbean Regional Climate Outlook Forum
CARICOM	Caribbean Community
CBD	Convention on Biological Diversity
CCCCC	Caribbean Community Climate Change Centre
CCORAL	Caribbean Climate Online Risk and Adaptation Tool
CDKN	Climate Development Knowledge Network
CDM	Clean Development Mechanism
CDPMN	Caribbean Drought and Precipitation Monitoring Network
CFC	Chlorofluorocarbon
CHENACT	Caribbean Hotel Energy Efficiency and Renewable Energy Action Programme
CIMH	Caribbean Institute of Meteorology and Hydrology
CMO	Caribbean Meteorological Organisation
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CPACC	Caribbean Planning for Adaptation to Climate Change
CREDP	Caribbean Renewable Energy Development Programme
CYEN	Caribbean Youth Environment Network
DFID	UK Department for International Development
DIREKT	Developing Island Renewable Energy Knowledge and Technology Transfer Network
DMA	Disaster Management Agencies
ECLAC	Economic Commission for Latin America and the Caribbean
EU	European Union
FAO	Food and Agriculture Organization
FNC	First National Communication
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GTZ	German Organisation for Technical Cooperation (GTZ)
GWP	Global Warming Potential

HCFC	Hydro-chlorofluorocarbon
HIV/AIDS	Human Immunodeficiency Virus Infection and Acquired Immune Deficiency Syndrome
HPMP	HCFC Phase-out Management Plan
IDB	Inter-American Development Bank
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
LEAP	Long-range Energy Alternative Planning
LED	Light Emitting Diode
LULUCF	Land Use, Land Use Change and Forestry
MACC	Mainstreaming Adaptation to Climate Change
MAFFW	Ministry of Agriculture, Food, Fisheries and Water Resources Management
MHEWS	Multi-hazard Early Warning Systems
MSW	Municipal Solid Waste
NAMA	Nationally Appropriate Mitigation Actions
NAP	National Action Programme
NBSAP	National Biodiversity Strategy and Action Plan
NMHS	National Meteorological and Hydrological services
NOAA	National Oceanic and Atmospheric Administration
ODS	Ozone Depleting Substances
OTEC	Ocean Thermal Energy Conversion
PAHO	Pan-American Health Organization
PDD	Programme Design Document
PDP	Physical Development Plan
POA	Programme of Activities
PSSEP	Public Sector Smart Energy Program
PV	Photovoltaic
SGP	Small Grants Programme
SIDS	Small Island Developing State
SNC	Second National Communication
STAR	System for the Transparent Allocation of Resources
SWAC	Seawater Air-conditioning
TCDPO	Town and Country Development Planning Office
UK	United Kingdom
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification and Drought
UNEP	United National Environment Programme / UN Environment
UNFCCC	United Nations Framework Convention on Climate Change
US/USA	United States of America
USAID	US Agency for International Development

Units

BBD$	Barbados Dollar
cm	Centimetre
Gg	Gigagram
ha	Hectare
kg	Kilogram
km	Kilometre
km^2	Square Kilometre
km/h	Kilometres per Hour
m	Metre
m^3	Cubic Metre
mm	Millimetre
MWh	Megawatt Hour
t	Tonne
°C	Degrees Celsius
US$	Unites States Dollar

Greenhouse Gas Inventory

	Chlorofluorocarbons
CH_4	Methane
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide equivalent
HFCs	Hydrofluorocarbons
NMVOC	Non-Methane Volatile Organic Compounds
N	Nitrogen
NO_x	Nitrogen Oxides
N_2O	Nitrous Oxide
PFCs	Perfluorinated Compounds or Chemicals
SF_6	Sulphur Hexafluoride
SO_2	Sulphur Dioxide

1 NATIONAL CIRCUMSTANCES

1.1 Geographical Location and Governance Structure

Geographically, Barbados is located at latitude 13°4' north and longitude 59°37' west and is the furthest east and one of the most southerly of the Caribbean Islands (Figure 1.1). Its nearest neighbours are St. Lucia, at approximately 160 kilometres (km) to the northwest, St. Vincent and the Grenadines, at approximately 170 km to the west, and Trinidad and Tobago, at approximately 245 km to the southwest.

Figure 1.1 Map of the Caribbean Region

Source: Map data copyright 2015 Google

The island is 34 km along the north-south axis and 24 km wide, with a total land area of 431 km^2 that includes 97 km of coastline. Its north and east coasts are exposed to very high waves and strong currents from the Atlantic Ocean which are characteristically different to the calmer west

coast that faces the Caribbean Sea. Coral reefs surround most of the island, extending up to 3 km seawards in some areas, and resulting in fine, white beach sand.

Political Structure and Legislature

Barbados became an independent parliamentary democracy after declaring its independence from the United Kingdom of Great Britain on the 30th of November 1966. It is closely linked to the United Kingdom in political and legal matters where the British Monarch is Head of State and represented locally by the Governor General. Barbados' Prime Minister and Government exercise executive power. The Senate has 21 members, all appointed by the Governor-General; and the House of Assembly has 30 elected members, reflecting the 30 constituencies of the island.

The Constitution of Barbados is the supreme law of the nation and the Chief Justice heads the independent judiciary. Barbadian law was initially based entirely on English common law and there have been a few local adaptations and, along with the Barbados Constitution, these form the basis of the country's legal system. More recently, international organisations have influenced the legislation, including the United Nations (UN), the Organization of American States, and other international bodies. Barbados is a full and participating member of the Caribbean Community (CARICOM).

As a consequence of the established governance structure, the realized post-independence social and economic stability and level of development, Barbados is considered to have low political risk and has attained one of the highest living standards in the developing world.

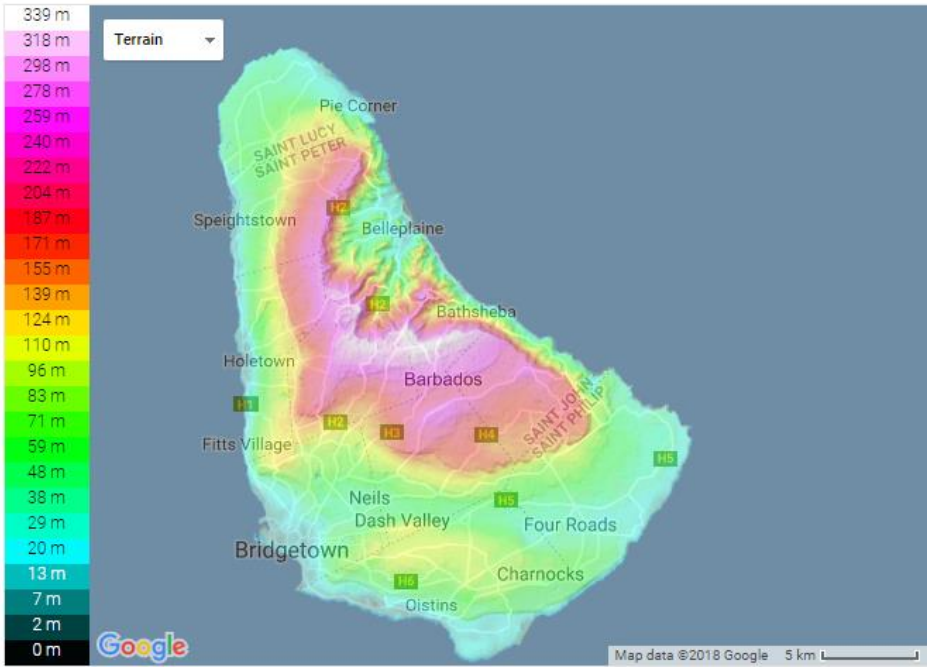
1.2 Physical Characteristics

Barbados has a rather unique geography, being formed of two landmasses that have merged, making it one of a few non-volcanic low-lying islands in the Caribbean. As a result, 86% of the surface area is made up of limestone coral ranging in age from 400,000 to 800,000 years old. Distinctively different is the Scotland District in the northeast, an area of approximately 40 km^2 of older sedimentary rock with rugged ridges and valleys. The highest point on the island, Mount Hillaby, is located at 336 m above sea level.

Barbados' general topography is represented in Figure 1.2. The coral cap is highly fractured with many gullies radiating from the central uplands to the coastline. Due to extensive deforestation over the course of its history, no significant rivers remain. Rainfall percolates through the coral cap to underground aquifers that serve as the primary sources for drinking water. The small size and high population density of the island has led to its identification as one of the top ten most

water scarce countries in the world. Barbados' remaining forested area occupies approximately 84 km^2 (19.5%) of total land area and arable land 160 km^2 (37.1%).

Figure 1.2 General Relief Map of Barbados

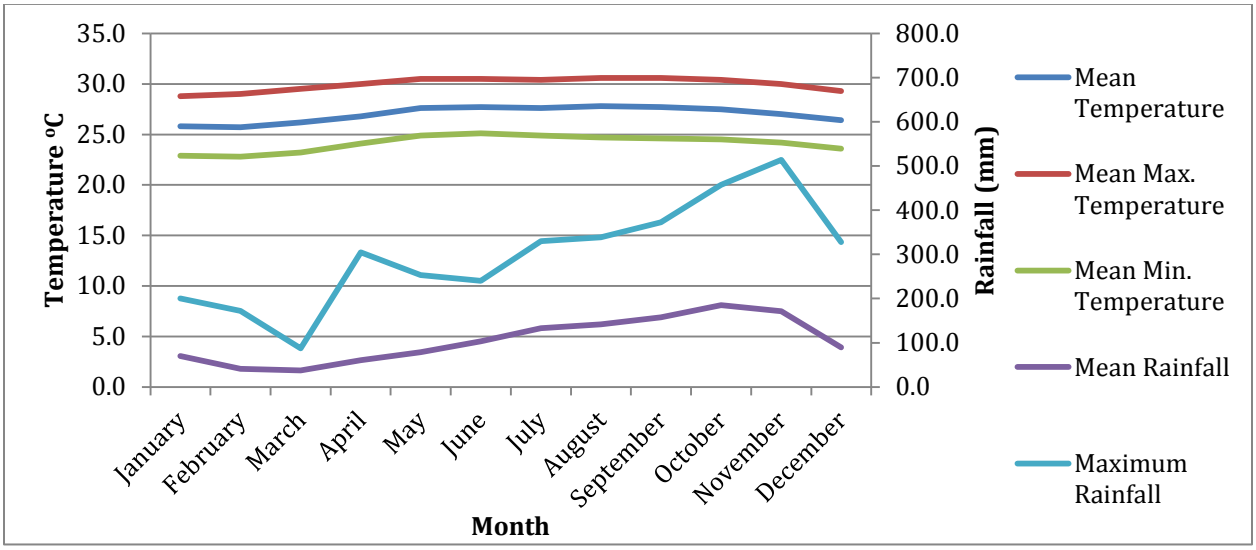


Source: Map Data copyright 2018 Google

1.3 Weather and Climate

Barbados' tropical climate is characterized by two distinct wet (June to November) and dry (December to May) seasons. Weather during the dry season generally includes warm days, cool nights and relatively low rainfall. The wet season is characterised by high humidity, low wind speeds and high rainfall. Maximum air temperatures are experienced during the wet season, peaking in September–October, with cooler temperatures occurring during the dry season. Figure 1.3 represents the changes in temperature and rainfall between the dry and wet seasons based on the 30-year annual rainfall averages for the period 1981 to 2010 (Barbados Meteorological Services, 2012).

Figure 1.3 Barbados Wet and Dry Season Air Temperature and Rainfall Variations (Data Averaged between 1981 and 2010)



Between 1981 and 2010:

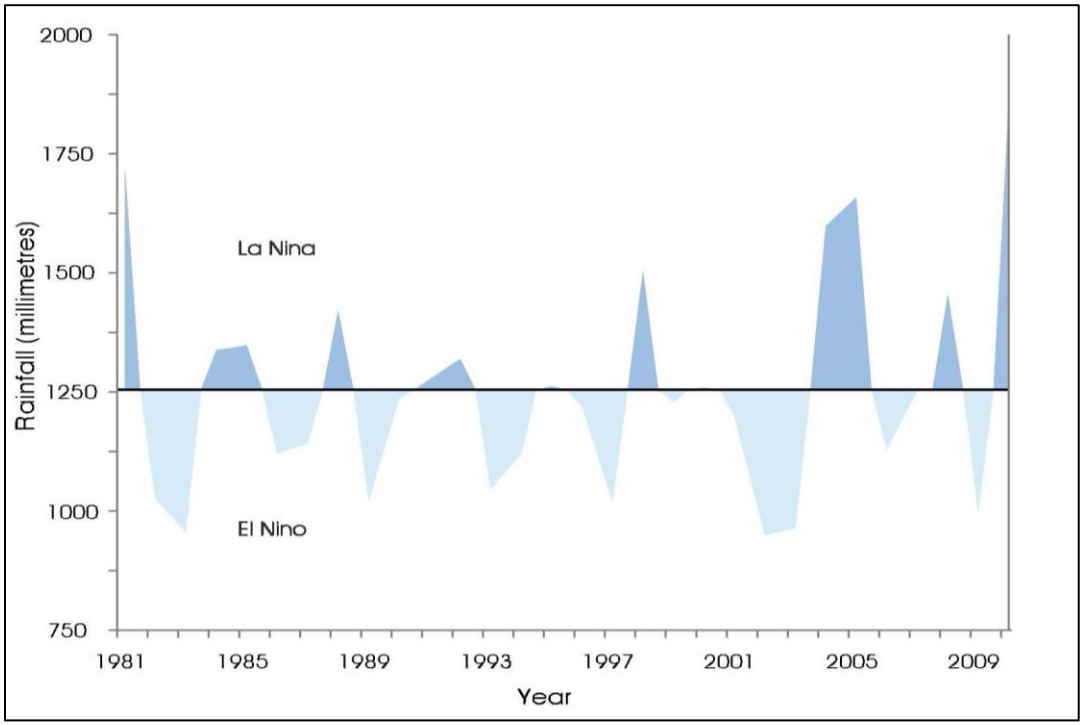
- average daily air temperatures varied from 22 degrees Celsius (°C) to 31 °C with an annual mean of 27 °C;
- annual average coastal water temperatures varied from 26 °C to 29 °C;
- average monthly relative humidity varied between 75% in March to 83% in November;
- average monthly rainfall varied between 37.4 millimetres (mm) in February and 185 mm in November; and
- annual rainfall increased, with peak values of over 1600 mm occurring in 2004, 2005 and 2010;
- the maximum recorded monthly and daily rainfall readings were 513.9 mm (November 1991) and 235.4 mm (30 October 2010); and
- the minimum recorded monthly rainfall was in February 2010 at 3.6 mm. The lowest daily humidity recorded was in February 2008 at 39%.

Rainfall variations in the Caribbean are largely influenced by the prevalence of El Niño or La Niña Southern Oscillation phases[1]. La Nina periods tend to produce above average rainfall and create wet conditions, whereas the inverse is true for El Nino events which create dry conditions. The

[1] El Niño events are associated with a warming of the central and eastern tropical Pacific, while La Niña events are the reverse, with a sustained cooling of these same areas. These changes in the Pacific Ocean and its overlying atmosphere occur in a cycle known as the El Niño–Southern Oscillation.

influence of these phenomena on annual rainfall patterns in Barbados over 1981-2010 is illustrated in Figure 1.4.

Figure 1.4 Barbados La Niña and El Niño Rainfall Variations, 1980–2010



The prevailing wind direction is north easterly to easterly, due to the yearlong trade winds that affect the region and which are strongest during the dry season. Due to its location on the southern edge of the North Atlantic Hurricane Belt Barbados is rarely directly hit by hurricanes. The last major strike was Hurricane Janet (Category 3) in 1955. Barbados does however frequently experience the impacts from tropical depressions and storms, the most recent of which were tropical storms Tomas in 2010 and Matthew in 2016. These events resulted in damages to buildings, vehicles, roads, electricity and communication lines; fallen trees; and water supply infrastructure (CDEMA, 2012; CCRIF, 2016) all of which accounted for a fair amount of social and economic disruption.

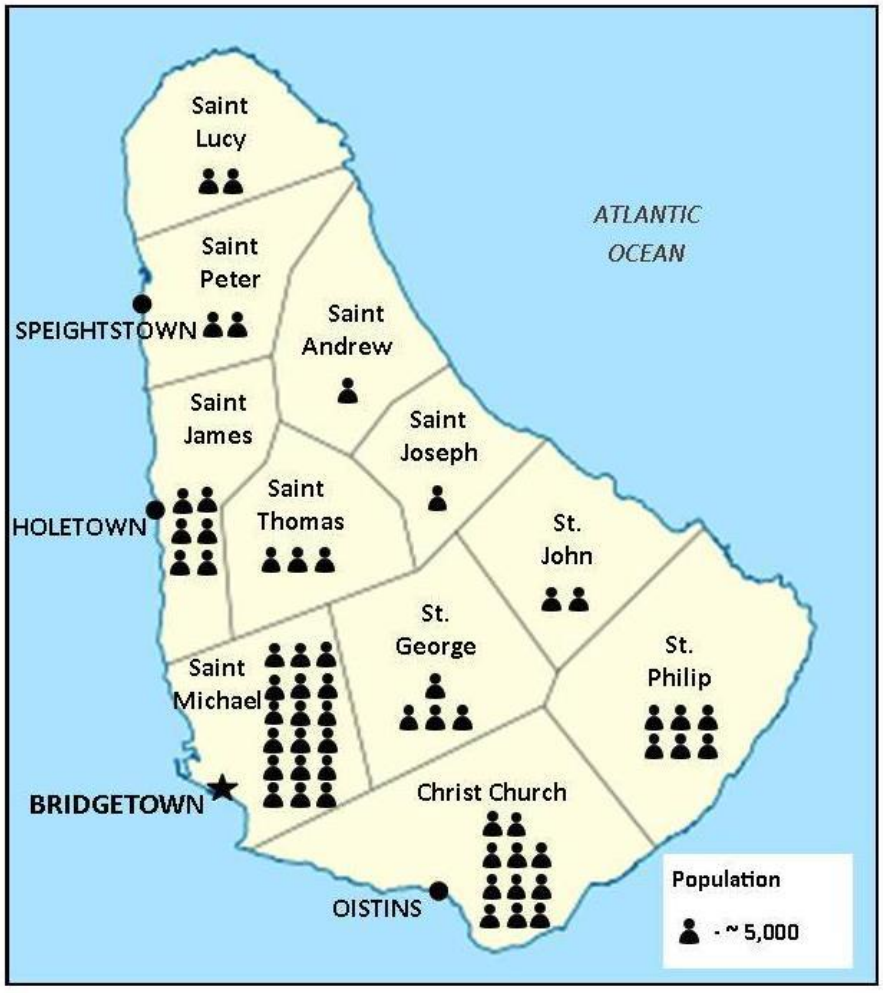
1.4 Population and Demographics

Barbados has a population of approximately 280,000. With an approximate density of around 660 persons per km^2 it is one of the most densely populated islands in the Caribbean and is within the top twenty most densely populated countries in the world. The population growth rate is estimated at -0.3%.

The population has a male to female ratio of 48 to 52. Ninety two percent (92%) of the population is predominantly of African descent, with the remainder being of European (3%), Asian, Mixed or Other (5%) ancestry. Residents over the age of 65 were estimated at 12.9% of the population (Barbados Statistical Service, 2013). The life expectancy of males and females is 72 and 79 years respectively (Springer, 2012).

The country is divided into 11 parishes and has four towns, with Bridgetown as its capital. Over 60% of the island's population resides in the three coastal parishes of St. James, St. Michael and Christ Church (Figure 1.5) which also support the four main urban centres – Bridgetown, Speightstown, Holetown and Oistins. Much of the island's infrastructure and many communities are situated within 2 km of the coast, exacerbating the risk from climate change impacts, particularly sea level rise, coastal flooding and storm surge.

Figure 1.5 Barbados Population Distribution by Parish



Adapted from Nam, 2009; updated based on Barbados Statistical Service, 2013

Culture

Barbadian culture emerged out of the plantation slavery economy as a distinctive synthesis of British and West African traditions. The governmental and educational systems, traffic laws, national sports and religion are based on British systems, as is much of the architecture in Bridgetown. The creative arts (music, dance and the fine arts) are influenced by West African culture and the island's major cultural expressions are exhibited during the Crop Over Festival in July to early August and the National Independence Festival of Creative Arts (NIFCA) in November.

Literacy Rates and Education

Barbados has an adult literacy rate of 99.7%. Education constitutes an important element of human development with the Government contributing a significant portion of its expenditure to all levels of education. This investment allows for the provision of free education at the primary and secondary levels and also heavily subsidised tertiary education. Enrolment of children in a formal education system up to the age of sixteen is mandatory (UWI, 2012). The education of women marginally exceeds that of men, where 93.0% versus 90.6% reach a secondary or higher level of education (UNDP, 2016). Despite this, Barbados has shortages of skilled labour, particularly in the environmental, agro-industry, agriculture, fisheries, housing and building industries.

Housing

Barbados' low-income houses were typically timber constructed until the 1970s and consisted of approximately 30,000 dwellings (Watson et al, 2001). More recently the construction of concrete homes has increased to more than 50% in some urban areas. Many wooden low-income and rental homes are still prevalent and remain classified as vulnerable to hurricanes and other extreme weather events.

The 2010 Population and Housing Census reported 94,173 dwellings as compared to 91,406 in 2000 and 82,204 in 1990. These represent a 1% and 0.3% annual increase over the respective 10 year periods.

Health

The Government, through the Ministry of Health, is responsible for the provision of primary, acute, secondary and tertiary care to citizens and residents of Barbados. Service is free at the point of delivery at public healthcare facilities, regardless of socio-economic status. Primary care is delivered through eight (8) polyclinics around the island and secondary care is available at the Queen Elizabeth Hospital, the Geriatric Hospital and the Psychiatric Hospital. A wide variety of

private sector health facilities for general and specialized services are available for access by residents and visitors. Private health insurance schemes are available that provide coverage to approximately 25% of the population (PAHO, 2008). General and specialized health care support services are also delivered by a number of non-governmental institutions such as the Barbados Red Cross Society, the Chronic Disease Research Centre, the Heart and Stroke Foundation of Barbados, and the Barbados Cancer Society.

Chronic non-communicable diseases are becoming more prevalent. Of the 190,000 Barbadians aged 20 years or over, it is estimated that 90,000 are overweight, 38,000 suffer from hypertension, 19,000 are diabetic and one person suffers from a stroke per day. The related annual costs of the health care services delivered at the Queen Elizabeth Hospital amounts to 65% of its allocated budget. Prescription drugs and indirect costs have been estimated at around US$ 138 million annually. Generally, the national health of Barbados has shown a decrease in the incidence of most communicable diseases.

1.5 Infrastructure

Transport

The island has had substantial Government investment in its road network and the majority of the 1,578 km highway network is largely maintained. The ABC Highway is the main urban highway, connecting the International Airport located in Christ Church with the capital city Bridgetown in St. Michael. The ABC Highway was widened in 2007 to accommodate the increasing traffic on the island. A diverse network of other highways and connecting streets allow for access to almost all parts of the island. Highway 1 and highway 7 are two coastal highways that run along the breath of the north and southeast urban corridor extending from Bridgetown. Both lie in the low coastal elevation zone and, in several areas, are highly vulnerable to coastal erosion, flooding and sea level rise, among other impsacts.

Bridgetown has a deep-water harbour, which accommodates large cruise liners and other commercial vessels. There are also two marina developments at Port St Charles and Port Ferdinand in the north of the island. The Grantley Adams International Airport is a major hub for international travel, receiving flights from Europe, North and South America and the Caribbean.

Communications

Barbados has a sophisticated information technology infrastructure which is due to skilled small-medium sized enterprises providing internationally accredited information technology services. In 2007, telephone and internet connectivity was reported at 55 users for every 100 persons,

making it the 14th most connected country in the world and the highest in the Caribbean and South America.

Non-Renewable Energy

As many island nations are, Barbados is largely reliant on the consumption of fossil-fuels for the provision of its energy services. The Barbados Light & Power Company Limited (BL&P) provides a reliable electricity service throughout the island, most of which is generated from fuel oil. The BL&P started operation in 1911 and works from three power generation stations at Spring Garden, the Garrison and the Grantley Adams International Airport.

Approximately 10% of the energy needs of the country are supplied by natural gas that is delivered by an extensive distribution network predominantly in the urban corridor. There has been a considerable reduction in oil production in Barbados in the last decade, declining from 1,271 barrels in 2001 to 739 barrels in 2010. In 2008, the Government of Barbados started marketing, and granting, offshore oil and gas drilling licences. The programme is intended to stabilise oil imports and secure long-term national growth and prosperity.

Renewable Energy

Barbados has been successful in encouraging the widespread uptake of solar water heating technology with over 50,000 solar water heaters having been installed on commercial and residential properties, saving consumers on average US$ 13 million in energy costs annually (CDKN, 2012).

Other renewable energy technologies including wind (at utility scale), biomass cogeneration, hybrid PV/thermal systems, and municipal solid waste to energy and seawater air conditioning (commercial scale) have been deemed to be economically viable for Barbados. Investigations into several of these options are ongoing while solar photovoltaic installations are becoming quite prevalent across the Barbadian landscape.

The integration of renewable energy sources as well as energy efficiency technologies and practices are forecasted to reduce the wholesale reliance on fossil fuels, save revenue for other important socio-economic pursuits, as well as reduce the domestic greenhouse gas (GHG) emissions footprint (Government of Barbados, 2010b). These developments have been bolstered by the passing of the 2013 Barbados Electric Light and Power Act which established the legal parameters for the integrating renewable energy into the electrical grid.

Solid Waste and Sewage Infrastructure

The Environmental Protection Department of the Ministry of Environment and Drainage, and the Environmental Health Officers of the Ministry of Health are the regulators overseeing the

operation and enforcement of all environmental issues pertaining to solid waste and sanitation. The Sanitation Services Authority is responsible for the collection and disposal of municipal solid waste and operates the island's Sanitary Landfill at Mangrove in the parish of St. Thomas.

Since 2009, the Sustainable Barbados Recycling Centre, a privately owned waste transfer station, has been in operation with its primary objective being to maximise the landfill's lifespan by diverting recyclable materials. At present, 65–70% of recyclable materials including glass, plastics, vegetation, rock and soil, electronic, construction and demolition waste, wood and metals are diverted from landfill. There are also a number of small, private recycling facilities on the island.

Sewage disposal in Barbados varies depending on location, type of structure and in which water protection zone the premises are situated. Since 1963 a zoning system has been in place to protect groundwater against bacteriological contamination. This system identifies five water protection zones offering allowance for varying degrees of physical development. Zone 1 is the most restrictive due to proximity to drinking water production wells, whereas in Zone 5 the provisions for development are most relaxed. As it is called, the Barbados' Groundwater Protection Zoning Policy is implemented through the Town and Country Development Planning Office (TCDPO) working primarily in collaboration with the Barbados Water Authority (BWA) and the Environmental Protection Department (EPD). Incorporated into the Zoning Policy is the revised policy on private sewage and wastewater disposal systems, which provides control over any liquid waste disposal systems that could potentially damage the ground water resources abstracted for domestic use.

There are two government operated sewage treatment plants in Barbados, located in Bridgetown and Graeme Hall on the south coast. A number of hotels and other developments have either privately owned sewage treatment plants or septic tanks that are emptied by tanker. These tankers carry their loads to the South Coast Sewage Treatment Plant. Domestic and commercial properties not serviced by the two plants generally discharge their waste to suck wells or septic tanks, depending on their location relative to the Zoning Policy.

1.6 Economic Profile

Barbados has one of the highest per capita incomes in Latin America and the Caribbean, having transformed itself from a low-income economy dependent on sugar production, into an upper-middle-income economy driven by the tourism and financial services industries.

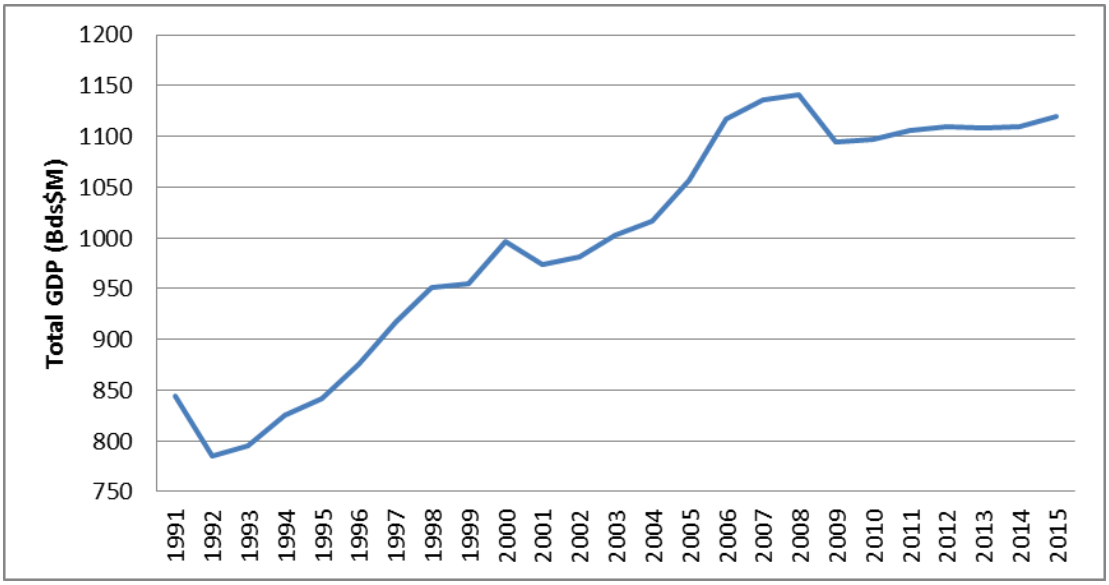
The island has the defining characteristics of Small Island Developing States (SIDS), including low economic diversity, limited natural resources, high import-export dependency and susceptibility to natural disasters and climate events. It is sensitive to global economic events

and market fluctuations, which limits the national capacity for economic growth and international competition. Increasing domestic production and labour is important to supporting Barbados' long-term sustainable development interests.

Over the past 20 years, the Barbados' GDP has shown annual growth of 1.3%, but with notable decreases in 1992, 2001 and 2009 (Figure 1.6). Barbados' economy was affected by the global economic crisis in 2008 and the economy contracted by 4.7% in 2009. The majority of GDP is provided by four main sectors—business and general services, Government services, tourism, and wholesale and retail (Figure 1.7). The value of the Barbados dollar has been relatively stable at an exchange rate of BBD$ 2.00 to USD$ 1.00.

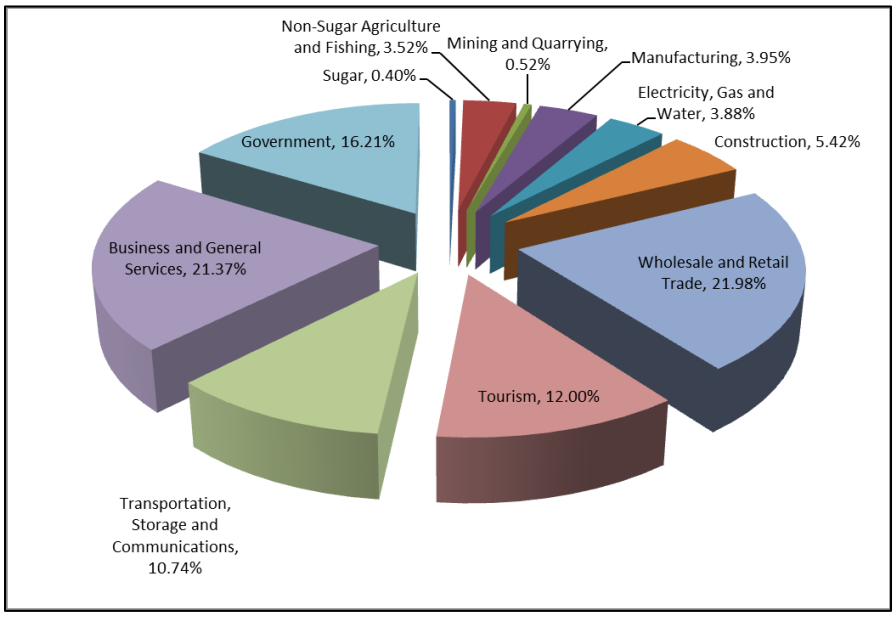
At the end of 2016, the Central Bank of Barbados reported that the outlook for economic growth is encouraging, and the forecast growth rate for the next five years continues to be about two percent. Economic growth is expected to be anchored by the tourism sector with significant contributions from the construction sector. Efforts are being put in place to restore growth in the financial services sector. Since 2012 there has been an exponential rate of growth of the renewable energy sector which is expected to be maintained, this is expected to realize a significant contribution to growth (Central Bank of Barbados, 2017).

Figure 1.6 Barbados Real GDP (BDS$M), 1991–2015



Source: Central Bank of Barbados. Real GDP is GDP adjusted for inflation.

Figure 1.7 Barbados GDP Contributions by Sector, 2015



Source: Central Bank of Barbados

Exports

Exports were valued by the Barbados Statistical Service at approximately US$ 506.0 million in 2015, including manufactured goods, sugar and molasses, rum, chemicals, electrical components and other foods. The largest export market is the Caribbean Community (CARICOM) (51.0%), with other significant markets in the US (18.0%), UK (5.0%) and Canada (3.0%). China is also an increasingly important market for the island.

Imports

Barbados is dependent on a number of imported basic commodities: food, energy and most consumer goods. Other imports include manufactured goods, labour and technology. In 2015, these are mainly sourced from US (35.5%), UK (4.2%), Canada (2.4%), Japan (2.1%) and CARICOM, primarily Jamaica and Trinidad and Tobago (21.0%). Other countries account for 33.0%.

Employment and Unemployment

The total labour force in 2015 was approximately 144,600, which equates to over 50% of the total population. The Barbados Statistical Service estimates that, of the economically active population, 50.2% are women. The majority of employment is in services, with 15% in industry and 10% in agriculture. The unemployment rate estimated in 2015 was 12.3% for males and 10.3% for females.

Poverty

Poverty rates in Barbados are the lowest in the Caribbean, resulting from a GDP of US$ 4.4 billion, a population of 280,000 and a per capita income of approximately US$ 16,000. However, there remain small and concentrated pockets of poverty.

Financial Services

The financial services sector employs approximately 5,500 people and is the leading contributor to Barbados' foreign exchange earnings after tourism. Investment opportunities in Barbados include offshore banking, credit card companies, insurance, consumer finance, stock brokerages, investment funds, holding companies and trust companies.

1.7 Tourism

Tourism has significantly increased in the last 50 years, driving the growth of real GDP since the late 1970s. Major tourism in Barbados is focussed in the coastal zones, along the west and south coasts, with over 1 million person visit days annually. Barbados, like most Caribbean destinations, has been challenged to preserve and gain global tourism market share since 2005. While market share, both in terms of international tourist arrivals and receipts, has been lost particularly to Dutch and Spanish-speaking Caribbean countries, the World Economic Forum's Travel & Tourism Competitiveness Index 2015 Ranking placed Barbados at 46 out of 141 countries, with only Mexico (30), Panama (34) and Costa Rica (42) within the wider Caribbean region ranking higher. This translated to a regional rank of 7 for Barbados within the Americas (World Economic Forum, 2015).

The Government of Barbados has prepared a Tourism Master Plan for Barbados (2014-2023) which outlines a path for the future growth of the tourism sector that suggests new ways of doing business internally and with the world. The Tourism Master Plan addresses:

- The Environment: Tourism sustainability, resilience and adaptability
- People and Organisations
- Our Visitors and the Barbados Visitor Economy: Economy and Linkages
- Services, Infrastructure and Products: Transportation and Accommodation; Niche Markets
- Cultural Heritage and Attractions: Infrastructure and Experiences

Barbados' climate and its coastal features, including the coral reefs, are some of the key attractions for tourists. However, these resources are sensitive to climate variability and are slow to recover from change. This increases the vulnerability of the tourism sector as Barbados becomes less attractive to tourists due to factors such as higher temperatures, water scarcity and

increased diseases. There have been initiatives to develop niche markets within tourism, notably the Crop-Over Festival as well as sport, agro-, eco-, health and wellness tourisms and conferences. The Ministry of Tourism has also developed management programmes for the potential loss and damage resulting from natural disasters.

Other key institutions involved in the management of the tourism industry include the Barbados Tourism Marketing Inc. (BTMI), Barbados Tourism Product Authority (BTPA), Barbados Tourism Investment Inc. (BTII), the Tourism Development Cooperation (TDC) and Barbados Hotel and Tourism Association (BHTA).

1.8 Agriculture

Barbados' main agricultural products are sugar, rum, cotton, a range of fruits and vegetables, as well as poultry, pigs, mutton and milk. Historically, the sugarcane industry was the major contributor to the island's economy; however, since 1980 its production has declined significantly. The recent introduction of sugarcane biomass energy and agricultural produce for domestic markets aims to support agricultural diversity and sustainability. A steady, though small, growth in population has led to increased demand for land for residential and commercial use. Consequentially, the percentage of agricultural land use has decreased from 44.2% in the 1980s to 32.6% in 2010.

Agricultural activities are also limited by the availability and price of water for irrigation. This is prohibitively expensive for small farmers, who are then extremely reliant on rainfall to meet their needs. Agricultural productivity is particularly at risk from prolonged drought conditions which cause increased difficulty in managing crop planting cycles, pests and diseases. Increased air temperatures and high humidity have been known to cause disease and death in livestock. In addition, tropical storms severely damage crops and sea level rise of 1–2 m will affect at least 1% of agricultural land.

The National Strategic Plan (2006–25) states that the main objectives of the agricultural sector are to: (1) facilitate access to the domestic and export markets for agricultural output; (2) enhance competitiveness of the sector; (3) promote sustainable agricultural development; (4) contribute significantly to food and nutrition security; and (5) develop strong rural communities. Key strategies include, *inter alia*:

- Increase yields and add value through food processing and marketing
- Develop the livestock sector and ensure quality production, inexpensive feed and fair prices
- Revitalise the sugar industry
- Adopt land use policy to ensure adequate availability of arable land

- Adopt adequate soil conservation measure and sustainable framing practices
- Create beneficial infrastructure, such as market facilities
- Expand youth programmes to develop a cadre of young farmers.

The Ministry of Agriculture, Food, Fisheries and Water Resource Management is responsible for the management and development of the Barbados' agricultural sector. Non-governmental organisations, including the Barbados Agricultural Society and farmer and community based groups work together with the Ministry to deliver the strategy.

Fisheries

The fishing industry plays a major role in the national economy, culture, food structure and, more recently, the tourism product. It is considered by the Government as "non-sugar agriculture" and falls under the purview of the Ministry of Agriculture, Food, Fisheries and Water Resource Management through its Fisheries Division and Markets Division. They are responsible for fisheries management, including the conservation of resources and the development of fisheries and the management of landing sites. The 2004-2006 Fisheries Management Plan (2004-2006) was defined to provide longer-term and coordinated management of the following nine main fisheries:

1. Shallow-shelf reef fishes: hinds, parrotfishes, grunts, surgeonfishes and triggerfishes.
2. Deep-slope and Bank reef fishes: snappers, groupers and small tunas.
3. Coastal pelagics: jacks, herrings, silversides, anchovies, ballyhoo, robins/scads, barracuda, garfish, small tunas and the young of large tuna such as yellowfin.
4. Large pelagics: tunas, wahoo, kingfish (billfishes), dolphinfish, swordfish, mackerels
5. Flying fish: four-winged flying fish.
6. Sea urchins: white sea urchin.
7. Lobsters: Caribbean spiny lobster.
8. Conch: Queen Conch.
9. Turtles (closed since 1998): hawksbill turtle, green turtle, leatherback turtle and loggerhead turtle.

The Barbados fisheries sector employs approximately 6,000 people directly and indirectly in areas of fish processing; retailing and wholesaling; boat building; and fish exports. In 2015, the main species caught were flying fish (26.7% total landings) and dolphin fish (26.3%). Demersal species (deep-slope and Bank reef fishes) are important during the hurricane season, when pelagic species are less abundant and offshore fishing is limited by weather conditions. Nearshore coastal fishing generally provides lower weight catches, but provides an additional income for the pelagic fishers.

Coastal habitats, particularly coral reefs, mangroves and seagrass beds are under threat of destruction due to natural and anthropogenic activities. These resources play crucial ecological, physical and economic roles for Barbados by providing critically important fish nursery grounds and spawning sites, wave protection and tourism and fishery locations. Additional pressures from invasive species are a serious threat to the local marine resources, such as the Indo-Pacific lionfish which is a voracious and fecund carnivore, with no natural predator and has been identified preying on over fifty-six different marine species.

The warming climate and changes in ocean circulation are changing the distribution patterns of many Caribbean marine species, including the distribution of fish spawning sites, reducing larval duration, increasing fish mortality rates as well as shifting seasonal migration patterns. The fisheries sector also suffers from a lack of modern facilities and maintenance at landing sites, such as berthing and hauling equipment and facilities for cold storage.

1.9 Water Resources

Barbados is ranked amongst the world's most water scarce countries as it has an average availability of less than 1,000 cubic metres (m^3) per person per year. Currently, Barbados' available water resources are approximately 305-310m^3 per person per year. The country has little surface water due to its small size, flat terrain and karst hydrogeology. Instead, water filters into underground streams through sinkholes that periodically flow into and refill Barbados' underlying aquifer (Government of Barbados, 2008a). Several deep gullies channel rainwater to the coast meaning Barbados lacks permanent rivers or lakes.

Water availability in Barbados is directly affected by the periods and intensities of the wet and dry seasons and by extreme weather systems. During the dry season, precipitation levels are constant, but low. There is an increase in water availability during the wet season; however rainfall through this season is primarily influenced by storm events.

The Barbados Water Authority is the statutory authority with overall responsibility for the island's management of water resources, which are all protected by Parliamentary Acts. Groundwater abstractions from the aquifer supply 98.6% of the island's potable water. Almost 90% of the islands' potable water is pumped from 22 groundwater abstraction wells, and small quantities are obtained from two springs in Scotland District. Since 2000, a reverse osmosis desalination plant, located in Brighton St. Michael, has been used to supplement Barbados' water supply, and to provide a 10% reserve for a 1:20 year drought event. Small amounts of rainwater harvesting are used for non-potable purposes at the domestic level.

Sustainable water management is a global concern and one that is profoundly important in Barbados. In 2016, 40 million cubic metres of water was consumed based on records from water

metres. Given an estimated rate of 40% for 'unaccounted for water', a total of 66 million cubic metres of water is estimated to have been produced by the Barbados Water Authority. Efforts to reduce the demand for potable water have been implemented, including public education campaigns, water saving devices and low water fixtures. Water losses from Barbados' potable water supplies are mainly from leaks. Actions have been taken to minimise overall losses by 30% of total potable supplies, but there are still significant losses that may be exacerbated by climate change. There have also been efforts to reduce water consumption in the hotel industry and a requirement for all buildings to incorporate water collection systems.

1.10 Coastal Resources & Settlements

Coastal ecosystems

The coastal ecosystems of Barbados are recognised to be under severe threat from over-exploitation of their resources and from pollution discharges associated with intensive urbanisation of the west and south coast corridors. These coastal ecosystems are known to be additionally affected by the climate and weather events that give rise to increases in sea surface temperature, ocean acidification, sea level rise and erosion.

Key coastal ecosystems of Barbados include:

- *Coastal swamps* - found in Chancery Lane, Inch Marlow and Graeme Hall in the south and south west of the island, and the Long Pond on the east coast. These are major wetlands providing an important link in the food chain of offshore fish and birds;
- *Coastal mangrove forests* – many mangroves have been cleared for development along the south and west coasts. The only significant remaining mangrove is the Graeme Hall Swamp, which stands on approximately 20 hectares. It contains the largest remaining area of red mangrove and white mangrove, and includes the largest body of fresh/brackish water on the island. It is the only wetland in Barbados recognised internationally under the Convention on Wetlands of International Importance. It acts as a significant Caribbean stopover for migratory birds between North and South America;
- *Tidal flats* - tidal flats and wave ridges occur mostly off the east coast within eroded limestone plateaus and other low lying rock formations;
- *Tide pools* – tide pools are located on the south and south west coast, an important ecological resource, acting as nurseries for juvenile fish, ghost crab and sea roaches as well as marine plants like sea moss;
- *Low lying rock formations* - particularly prevalent along the north-east and south eastern points, and supporting a diversity of species such as periwinkles, sea anemones, crabs and snails;

- *Coastal cliffs* - cliffs of coral and sandstone are located in the north, (parish of St Lucy) and around the south east coast (parish of St Philip); and
- *Coral reefs* – Barbados' coastline is surrounded by a narrow insular coral shelf, which functions as a natural breakwater along the coast and represents one of the most important natural sea defences available to Barbados. It supports a variety of living reef systems and marine species; Barbados has over 50 hard coral species and 600 species of fish. Coral reefs generally support more than 25% of all marine species, making them the most biologically diverse of marine ecosystems and an equivalent, in terms of biomass productivity, to rainforests on land.

Coastal Settlements

The coast supports a diverse range of settlements and economic activity. Population growth has led to high urbanisation and sprawl along the coast extending from Checker Hall in St. Lucy to Ragged Point in St. Philip and spans the four major towns of Oistins, Bridgetown, Holetown and Speightstown. Approximately 25% of the island's population lives within 2 km of the coast (Udika, 2009)

1.11 Insurance

The role of risk-sharing mechanisms for climate change adaptation and mitigation was highlighted in the Hyogo Framework for Action 2005–2015. In the aftermath of natural disasters, the Government and local communities face the challenge of obtaining immediate access to cash to implement urgent recovery efforts and maintain essential Government services. This challenge is particularly acute for small islands, where economic resilience is limited by mounting vulnerability and high levels of indebtedness as well as by the scale of natural disasters that can cause damage that is equivalent to or exceed the GDP of a country. The effects of climate change will compound this issue as the scale and frequency of extreme events increases, and the associated increasing insurance premiums. Risk transfer mechanisms can be an effective way of managing specific risks, particularly for communities and countries that build resilience to climate risks. Insurance should, however, only be used after more cost-beneficial risk reduction measures have been exhausted. Insurance mechanisms are more effective when combined with reward-risk measures such as retrofitting homes with hurricane straps to reduce the potential for wind damage.

1.12 Policies and Institutional Arrangements

National Climate Change Policy

The Government of Barbados has drafted a National Climate Change Policy Framework that provides the country's overarching approach to climate change adaptation and mitigation. The primary goal of this policy framework is to "establish a national process for adapting to climate change effects and minimising greenhouse gas emissions over the short, medium and long term, and to do this in a manner that is coordinated and consistent with the broader sustainable development aspiration." Its objectives are to:

- Establish and appropriate mechanism for responding to challenges to climate change;
- Engage in regional and international climate change negotiation, planning and response mechanisms;
- Effect full stakeholder engagement in the development and execution of domestic climate change mitigation and adaptation actions; and
- Conduct climate change research.

The Draft Policy is monitored by the National Climate Change Committee (NCCC), which is chaired by the Ministry of Environment and Drainage and comprises of the representatives of government ministries, non-governmental organisations and private sector agencies listed below. The MED may co-opt other members as appropriate.

- **Ministry of Environment and Drainage :** Policy, Planning and Research Unit (Chair); Coastal Zone Management Unit; Environmental Protection Department; Natural Heritage Department; Drainage Division
- **Ministry of Agriculture, Food, Fisheries and Water Resource Management:** Agricultural Planning Unit; Barbados Meteorological Services Department; Barbados Water Authority
- **Ministry of Finance and Economic Affairs:** Division of Economic Affairs; Public Investment Unit
- **Ministry of Health:** Environmental Health Department
- **Ministry of Home Affairs:** Department of Emergency Management
- **Ministry of Social Care, Constituency Empowerment and Community Development:** Social Care Division; Bureau of Gender Affairs
- **Ministry of Transport and Works**
- **Ministry of Tourism and International Transport**
- **Office of the Prime Minister:** Division of Energy and Telecommunications (Energy Division)

- **Representative from a Youth Group:** Caribbean Youth Environment Network -Barbados Chapter
- Representative from a Community Based / Non-Governmental Organisation: Global Environment Facility Small Grants Programme - Barbados
- **University West Indies (UWI Cave Hill):** Centre for Resource Management and Environmental Studies
- **Representatives from Business Sector:** Insurance Corporation of Barbados; Barbados Light and Power

By signature of the Paris Agreement in April 2016 the Government of Barbados has communicated its focus on building resilience to climate change across diverse sectors as well as reducing its level of contributions to global GHG emissions. Through the NCCC consultations on medium to long range planning against current and future contributions to the Paris Agreement have commenced including the identification of supporting Implementation strategies.

Other Policies relevant to Climate Change and Sustainable Development

Various environmental protection policies, laws and management programmes contribute to the pursuit of Barbados' sustainable development aspiration. Several of these that are particularly relevant and influential in shaping the national climate change response are as follows:

- Natural Resources Department of the Energy Division. 1951: Petroleum Winnings Operations Act (obliges licensee to prevent pollution of territorial waters);
- Barbados Water Authority. 1953: Underground Water Control Act (control of use of underground sources);
- Ministry of Agriculture, Food and Fisheries. 1959: Soil Conservation Act (utilisation of lands in the Scotland District);
- Government of Barbados. 1963: Groundwater Protection Zoning Policy (ensures that, by law, any development plan that is deemed to fall within a Zone 1 area is circulated to the BWA and the Environmental Protection Department for their review and comments before the TCDPO can make a final decision on the matter);
- Ministry of Health. 1969: Health Service Act and Regulation 18 (removal and disposal of refuse);
- Government of Barbados. 1973: Pesticides Control Act 83 (provides for the control of the importation, sale, storage and use of pesticides);
- Government of Barbados. 1974: Pesticides Control Regulations;
- Barbados Water Authority. 1980: Barbados Water Authority Act (management of water resources);

- Fisheries Division, Ministry of Agriculture and Rural Development. 1993: The Fisheries Act (preparation of fisheries management plan, protection of marine life including coral reefs);
- Ministry of International Business and International Transport. 1994: Shipping (Oil Pollution) Act86 (prevention of pollution by oil);
- Coastal Zone Management Unit. 1998: Coastal Zone Management Act (preservation of marine areas and discharge standards);
- Coastal Zone Management Unit. 1998: Marine Pollution Act (control of marine pollution);
- Town and Country Planning Department. 1998: Town and Country Planning Act (control of built development);
- Government of Barbados. 2002: Draft Policy Framework for Water Resources Development and Management (national strategies and policies are contained in this document);
- Government of Barbados. 2004: National Sustainable Development (NSD) Policy for Barbados (the overarching goal of this policy is to ensure the optimisation of the quality of life for every person by ensuring that economic growth and development does not occur to the detriment of ecological capital);
- Ministry of Agriculture and Rural Development. 2004: Barbados Fisheries Management Plan 2004-2006 (provides longer-term and coordinated management of the key fish species associated with various coastal ecosystems);
- Government of Barbados. 2007: The National Strategic Plan of Barbados 2006-2025 (provides the blueprint for the realisation of Barbados' vision of becoming a fully developed society that is prosperous, socially just and globally competitive by the end of the first quarter of this century);
- Government of Barbados. 2008: Integrated Water Resources Management (IWRM) Roadmap for Barbados (establishes the need for management of water resources and sets foundations for development and preparation of an Integrated Water Resources Management Plan);
- Government of Barbados. 2012: Draft National Climate Change Policy Framework for Barbados (establishes a national process for adapting to climate change effects and minimising greenhouse gas emissions over the short, medium and long term);
- Government of Barbados 2013. The Electric Light and Power Act (relates to the supply and use of electricity and the promotion of electricity generation from renewable energy sources.)
- Moore W. et al. 2014. Barbados' Green Economy Scoping Study (articulates objectives and strategies in the areas of natural resources management, land use planning, water resources, energy, transport, and disaster management).

2 NATIONAL GREENHOUSE GAS INVENTORY

2.1 Introduction

This chapter quantifies greenhouse gas emissions and sinks for Barbados. To inform this, an inventory has been compiled in accordance with *IPCC Guidelines* (IPCC, 1996) and *Good Practice Guidance* (IPCC, 2004). Emission estimates have been made at yearly intervals for the period 2000 to 2010, for the following sectors: Energy; Industrial Processes; Waste; Agriculture; and Land Use, Land Use Change and Forestry (LULUCF). Further detail for each of the sectors' emissions and sinks is provided in the Annex.

The Barbados Greenhouse Gas Inventory has considered:

a) Gases with **direct** greenhouse warming effects:

Carbon Dioxide	CO_2
Methane	CH_4
Nitrous Oxide	N_2O
F- Gases	
Hydrofluorocarbons	HFCs
Perfluorocarbons	PFCs
Sulphur Hexafluoride	SF_6

b) Gases with **indirect** greenhouse warming effects:

Non-methane Volatile Organic Compounds	NMVOC
Nitrogen Oxides	NO_x
Sulphur Dioxide	SO_x
Carbon Monoxide	CO

2.2 Sources of Greenhouse Gas Emissions and Sinks

For each sector, sources of greenhouse gases were identified and values estimated. Emissions of CO_2 accounted for the majority of greenhouse gas measured, but CH_4 and N_2O emissions have also been estimated for all source sectors.

Emissions in the '**Energy**' sector were primarily controlled by combustion related activities (both stationary and transport/mobile), but also included emissions from manufacturing and construction industries, commercial and residential combustion and mobile agricultural machinery.

'**Industrial Processes**' in Barbados included processes that directly or indirectly gave rise to greenhouse gas emissions. Important processes included cement production (producing CO_2 from the use of primarily limestone feedstock) and food and drink manufacturing (chiefly sugar which produces non-methane volatile organic compounds (NMVOC) from fermentation and food production processes). There was no significant production of primary ferrous or non-ferrous metals or of chemicals. Emissions from the use of fluorinated gases (HFC and SF_6) used in refrigeration, air conditioning, fire equipment, aerosols and some foams were included in the industrial processes sub-sector. Globally, emissions of these gases have increased dramatically since 1995 as a result of them being used to substitute chlorofluorocarbons (CFCs) banned by the Montreal Protocol and with the impending phase-out of HCFC gases.

Emissions of greenhouse gases from the '**Waste**' sector in Barbados arose predominantly from solid waste disposal on land and wastewater handling. The majority of solid wastes, both Municipal Solid Waste (MSW) and industrial waste, were historically disposed of at the Mangrove Pond Landfill. Recently, recycling improvements have led to the diversion of large quantities of solid waste away from landfilling.

The '**Agriculture**' sector included all anthropogenic emissions associated with agricultural activities except for fuel combustion and sewage emissions, which were included in the energy and waste sectors respectively. The agricultural greenhouse gas emission sources were enteric fermentation, manure management and agricultural soils. For several decades the agriculture sector in Barbados has been in decline and currently provides for approximately 3% of the national GDP and 2.5% of the labour workforce (Food and Agriculture Organization of the United Nations (FAOSTAT), 2013). Arable farming is dominated by sugarcane, but a wide range of vegetables are also produced. Pastoral farming in Barbados is a small industry, when compared with other Caribbean countries.

The '**Land Use, Land Use Change and Forestry**' **(LULUCF)** sector estimated greenhouse gas emissions and sinks from four categories including changes in forest and other woody biomass stocks, forest and grassland conversion, abandonment of managed lands, and CO_2 emissions and removals from soils. After the settlement of Barbados by the British in 1627, the majority of the forest cover in Barbados was removed to facilitate the establishment of sugarcane plantations. In 2010, wooded areas in Barbados covered 8,320 ha, which is approximately 19% of the total area of Barbados. Of this area, approximately 20 ha are virgin forest found in an area of the island called Turner's Hall Woods. Several areas of land that traditionally formed sugar plantations have now been invaded by secondary forest growth. The land was abandoned due to the decline of the sugar industry, thus making abandonment of managed lands the primary LULUCF category for the island's inventory. Woodland has expanded by approximately 3,250 ha between the 1970s and 2010, due to the abandonment of sugarcane areas.

2.3 Barbados' Contribution to Global Warming

Barbados' contribution to global warming as a whole is almost imperceptible in comparison with developed countries (for example USA, Japan and countries of the EU) and emerging economies (for example China, Iran or Brazil). In 2010, Barbados' emissions contributed an estimated 1,930 gigagrams (Gg) of CO_2 equivalent (CO_2e), which represents significantly less than 0.01% of global emissions of greenhouse gases. In addition to this, international shipping and international aviation emissions were estimated to be 103 and 410 Gg CO_2e respectively; however, these are not included in national inventory totals, in accordance with the IPCC guidelines. The overall trend between 2000 and 2010 was an increase of 456 Gg CO_2e, which was mainly driven by increases in the energy sector.

2.4 Emissions by Types of Gases

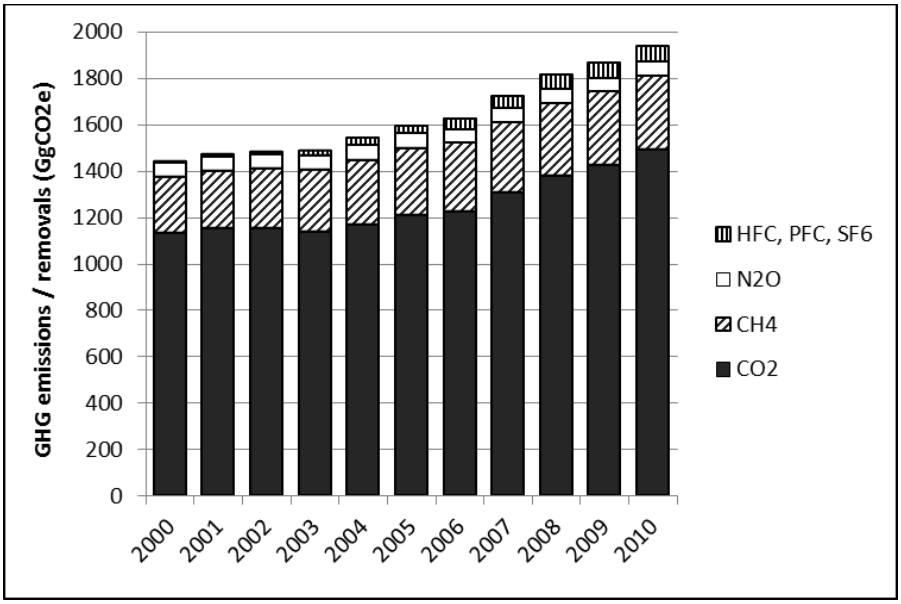
Barbados' greenhouse gas emissions between 2000 and 2010 are presented in Table 2-1 below. CO_2 makes up the majority of total emissions followed by emissions of CH_4. Figure 2.1 shows that emissions of the F-Gases HFC, PFC and SF6 have increased across the assessment years and have surpassed total N_2O emissions in 2009 and 2010.

Table 2-1 Barbados' Greenhouse Gas Emissions ($GgCO_2e$), 2010

Year	CO_2	CH_4	N_2O	HFC, PFC, SF_6
2000	1134	284	52	4
2001	1152	284	49	8
2002	1152	287	48	15
2003	1138	294	47	21
2004	1166	300	54	31
2005	1208	306	50	34
2006	1225	309	47	45
2007	1305	321	48	54
2008	1380	330	49	60
2009	1427	336	46	64
2010	1491	325	47	67

[A] The sum of the component parts is 100.1% due to rounding.

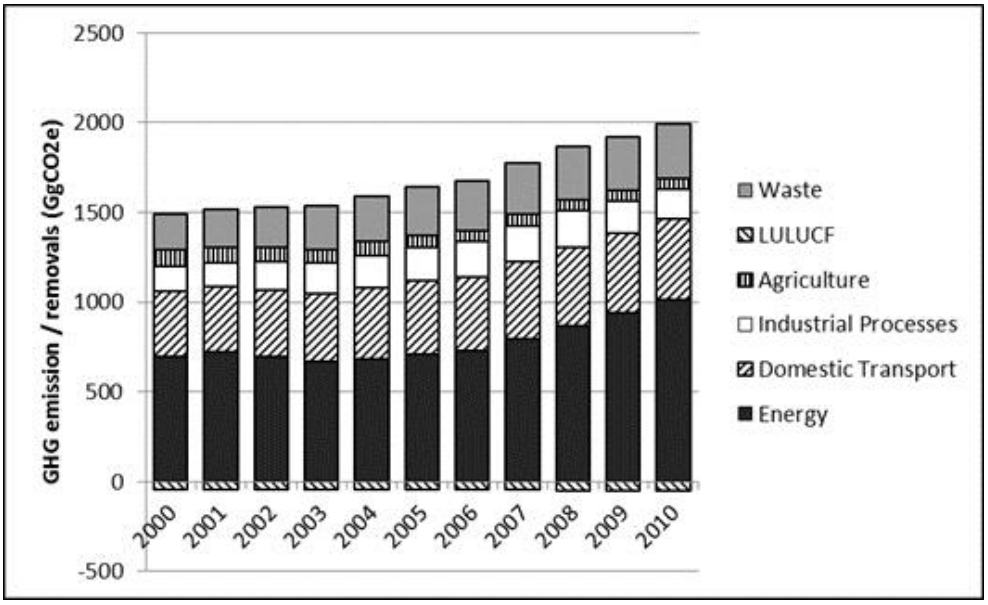
Figure 2.1 Barbados' Greenhouse Gas Emissions by Gas 2000–2010 (Gg CO_2e)



2.5 Emissions from all Sectors

Estimated greenhouse gas emissions arising in Barbados annually between 2000 and 2010 are presented in Figure 2.2 below, for each of the sectors.

Figure 2.2 Barbados' Greenhouse Gas Emissions/Removals by Sector 2000–2010 (Gg CO2e)



The energy sector (energy generation plus domestic transport) has produced the majority of greenhouse gas emissions in the years investigated. It was responsible for approximately 74% of Barbados' total greenhouse gas emissions in 2010. Industrial processes, agriculture and waste were responsible for approximately 8%, 3% and 15% respectively of greenhouse gas emissions in 2010. LULUCF removed approximately 51 Gg CO2 in 2010, which is equivalent to a 3% removal of 2010 total emissions. Figure 2.3 and Figure 2.4 show the emissions contribution by sector in 2010, and the CO_2 sinks in the same year.

Figure 2.3 Barbados' Greenhouse Gas Emissions per Sector (2010)

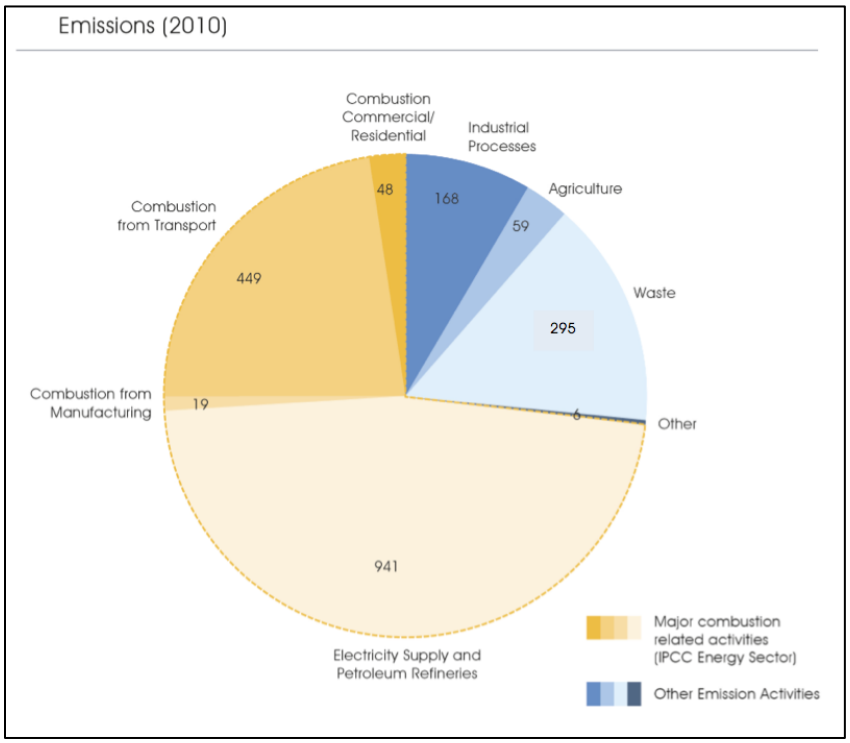
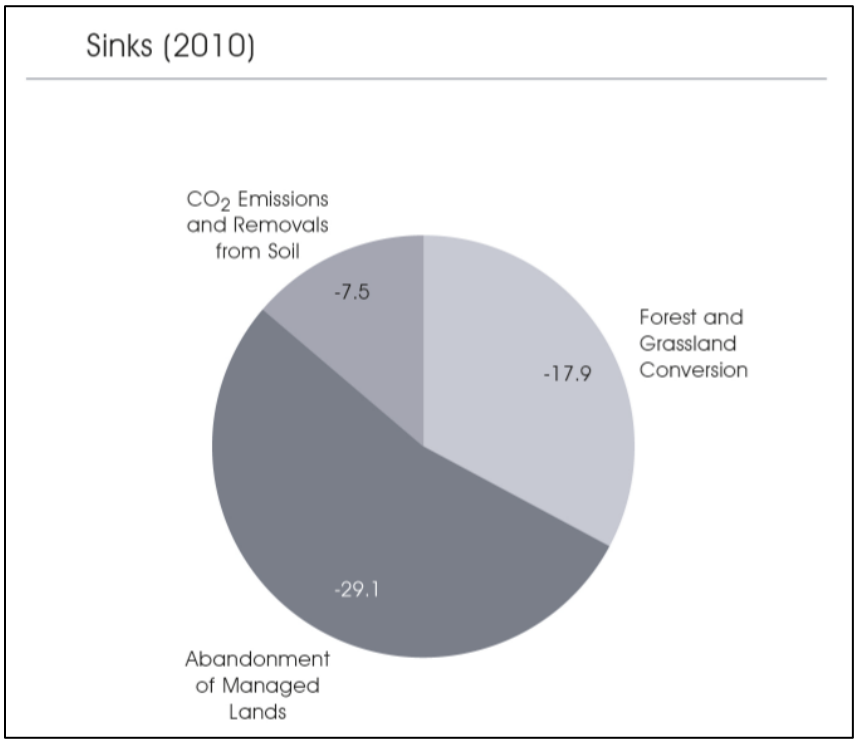


Figure 2.4 Barbados' Greenhouse Gas Sinks of LULUCF (2010)



2.6 GHG emissions estimates by sector

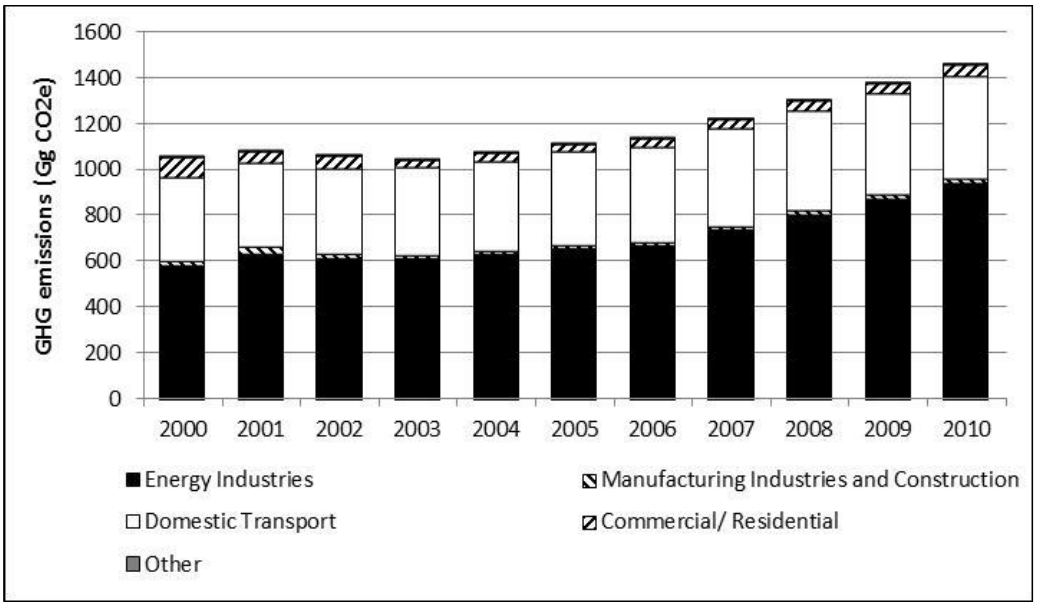
Energy Emission Estimates

United Nations (UN) Statistics were used up to and including 2009, and extrapolated to 2010. Although data was made available from the Energy Division of the Prime Minister's Office of Barbados for 2010, it could not be used due of differences in the methods of calculation with the UN Statistics.

In 2010, Barbados' energy sector greenhouse gas contribution was 1,441 Gg CO_2e, the majority of which comprised of CO_2. 'Energy industries' made up approximately two thirds (i.e. 941 Gg CO_2e in 2010) of the total energy emissions, and 'Domestic Transport' emissions were approximately one third (i.e. 449 Gg CO_2e), with small contributions from the other sectors (approximately 70 Gg CO_2e). Figure 2.5 below shows a trend of increasing emissions from 2005, driven mainly by the increasing emissions from the energy production industries.

Greenhouse gas emissions from international shipping and aviation were estimated to be 103 and 410 Gg CO_2e in 2010 respectively. These are not included in national inventory totals, under the IPCC Guidelines.

Figure 2.5 Barbados' Energy Greenhouse Gas Emissions by Source Category, 2000-2010 (Gg CO_2e)

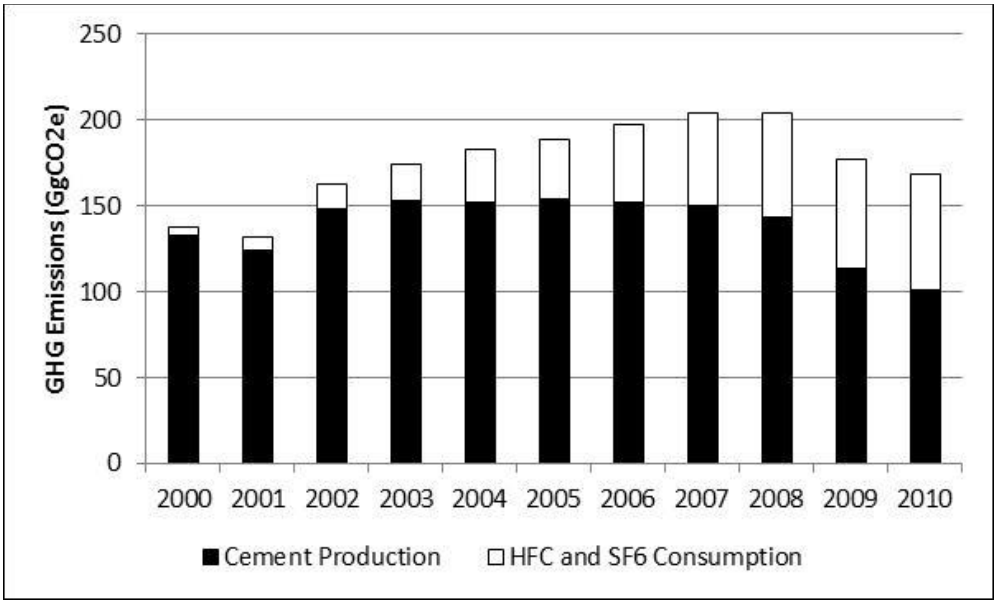


Industrial Processes Emission Estimates

As country specific factors were unavailable, the emission factors used to calculate emissions of greenhouse gas were taken from the IPCC 2006 Guidelines. This represents a Tier 1 approach to calculating emissions, in accordance with the guidelines. CO_2 rates from cement production were provided for 2002, 2004, 2006, 2008 and 2010 from the Arawak Cement Company Limited. Food and drink NMVOC emissions were estimated from Barbados Statistical Service beverage and food production datasets. HFC estimates were taken from annual reports from Malta (as a representative source of HFC emissions data). Figure 2.6 summarises the greenhouse gas (CO_2e) emissions for the industrial processes sector.

Since the late 1990s there has been a dramatic increase in HFC emissions, resulting from the substitution of CFCs with HFCs in refrigeration and air conditioning equipment. Emissions from the production of cement have declined dramatically as a result of a 24% reduction in the production of clinker between 2000 and 2010 with the steepest decline occurring after 2007 (33% reduction).

Figure 2.6 Barbados' Industrial Processes Greenhouse Gas Emissions by Source Category, 2000–2010 (Gg CO2e)



Agriculture Emission Estimates

Agricultural livestock data was supplied by Barbados' Ministry of Agriculture, Food, Fisheries and Water Resources Management (MAFFW), with the remainder of the inventory compiled from international sources and emission factors provided by IPCC 2006 Guidelines. Some country-specific farming practices were incorporated to best represent the entire agricultural sector and Barbadian farming practices. Figure 2.8 shows that the largest contribution to N_2O emissions

from agriculture is from manure management. Over the period recorded, there has been a decline in N_2O emissions, largely attributed to the decrease of livestock numbers in Barbados.

Figure 2.7 provides a time series of CH_4 emissions. These strongly reflect livestock numbers. Figure 2.8 shows that the largest contribution to N_2O emissions from agriculture is from manure management. Over the period recorded, there has been a decline in N_2O emissions, largely attributed to the decrease of livestock numbers in Barbados.

Figure 2.7 Barbados' Agriculture CH_4 Emissions, 2000-2010 (tonnes)

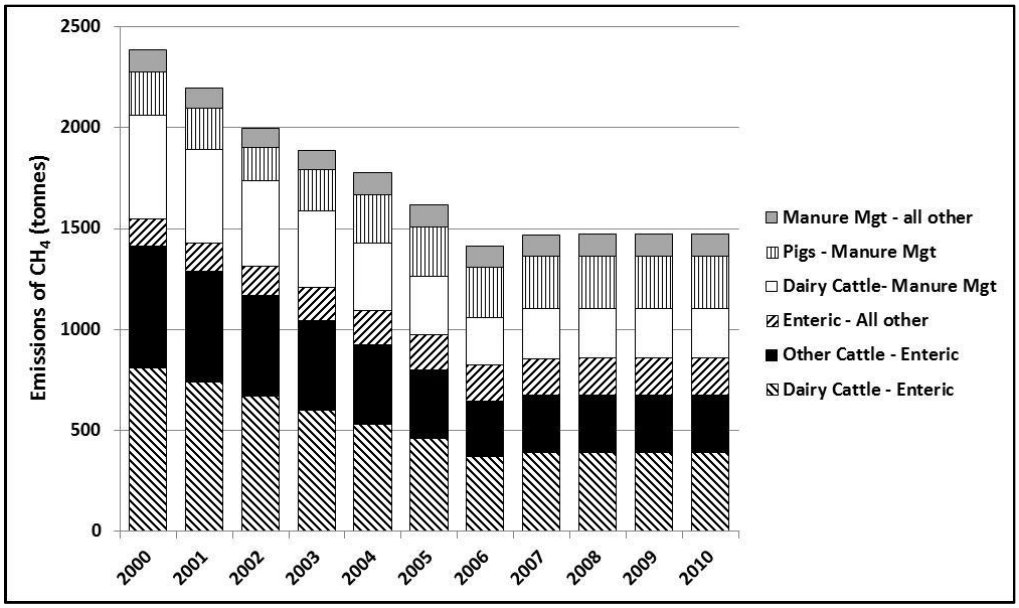
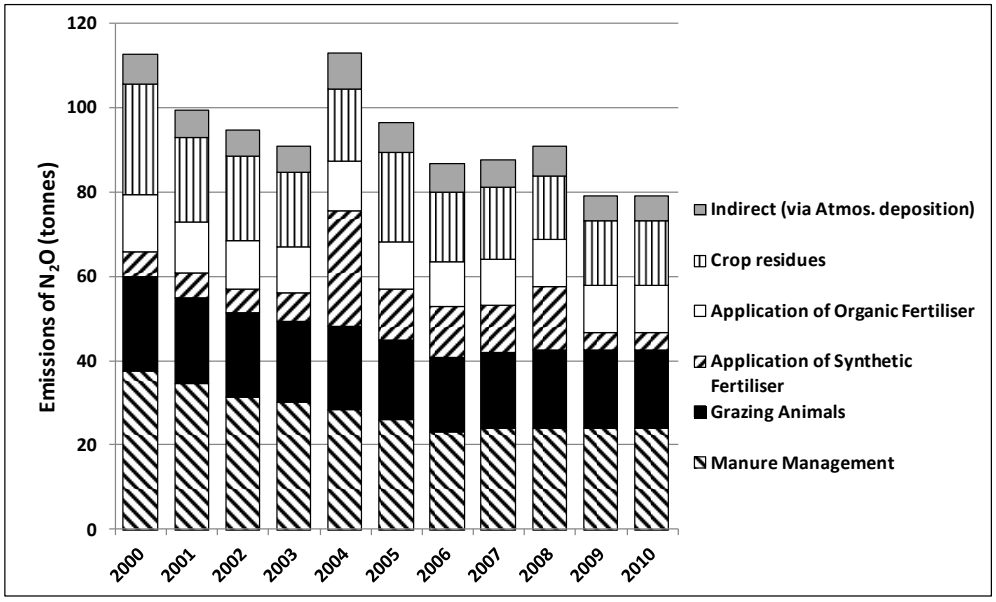


Figure 2.8 Barbados' Agriculture N_2O Emissions, 2000-2010 (tonnes)



Waste Emission Estimates

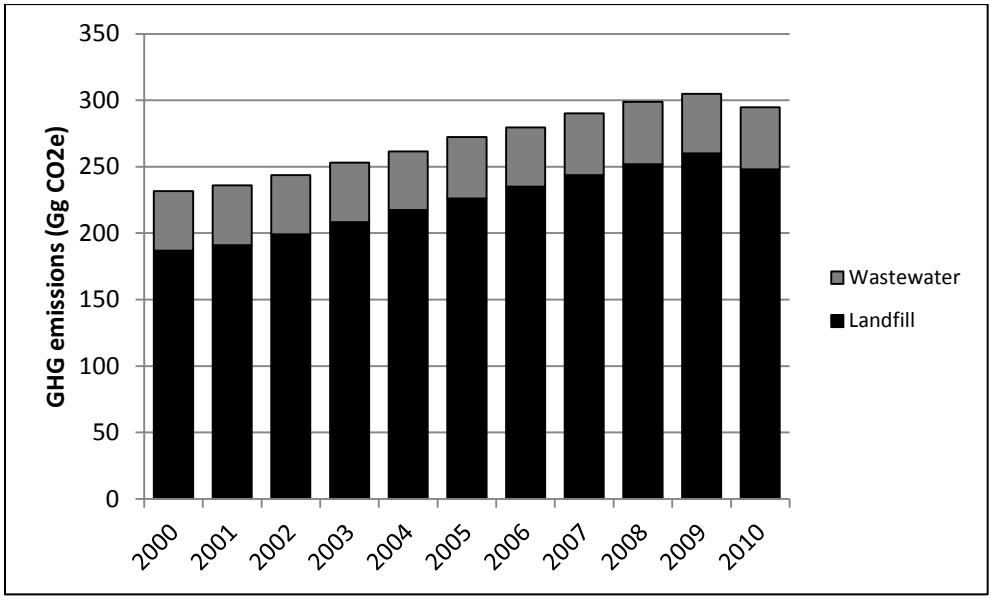
Limited data was available for historic solid waste characterisation up to the year 2005, which has meant that the data, and related uncertainties, have been extrapolated over several years. Where Barbados-specific information was unavailable, Tier 1 methods have been used as provided in the IPCC 2006 Guidelines. The emission estimates given in this sub-section should therefore be viewed as a baseline for more detailed estimates to be developed upon in future years.

Landfill emissions of CH_4 are the most important contributor to greenhouse gas emissions in this sector. Emissions of CH_4 and N_2O from wastewater handling, which comprises of effluents from domestic and industrial activities, are also accounted for in the Inventory.

The majority of CH_4 emissions in 2010 are a result of solid waste disposed to landfill (10.8 Gg CH_4 of 12.5 Gg CH_4). Wastewater is the only source of N_2O emissions (0.023 Gg N_2O). There are no estimated CO_2 emissions, as there is no recorded burning of MSW.

Emissions from the waste sector increased by 27% from 232 Gg CO_2e in 2000 to 295 Gg CO_2e in 2010. This is primarily from an increase in the volume of waste going to landfill between 2000 and 2008. Figure 2.9 below shows the contributions from landfill and wastewater between 2000 and 2010.

Figure 2.9 Barbados' Waste Greenhouse Gas Emissions by Source Category 2000-2010 (Gg CO_2e)



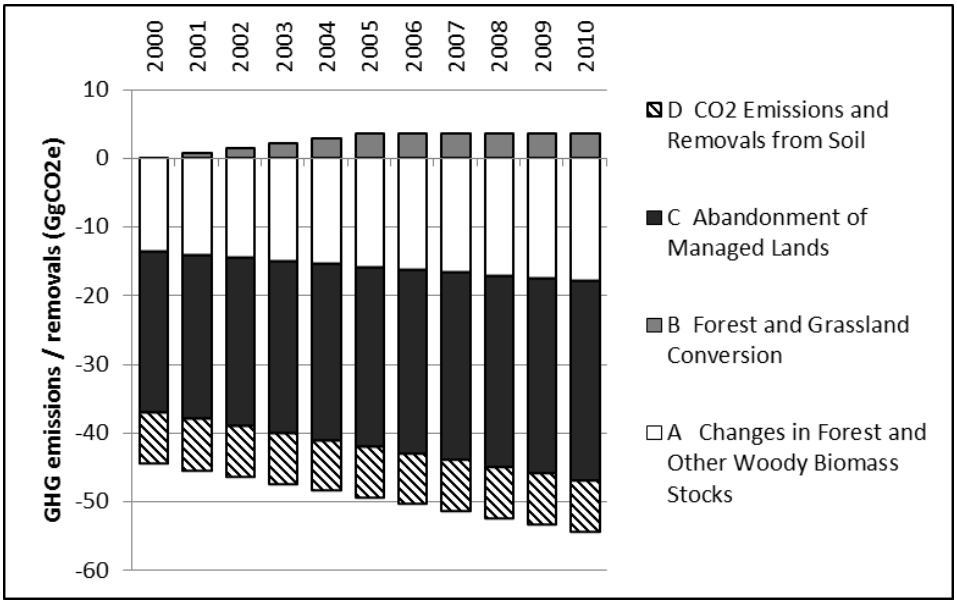
Land Use, Land Use Change and Forestry (LULUCF) Emission Estimates

The IPCC 2006 Guidelines provide a default approach for preparing a greenhouse gas inventory for the LULUCF sector. The data for this approach has been taken from UN Statistics. The approach involves estimating emissions and sinks from four categories. These are: (1) changes in forest and other woody biomass stocks, (2) forest and grassland conversion, (3) abandonment of managed lands and (4) CO_2 emissions and removals from soils.

For categories (1), (2) and (3), only changes of above ground biomass have been estimated as estimating stock changes from other carbon pools would contain large uncertainties. For CO_2 emissions and removals from soils, carbon accumulation has been assumed as a consequence of land use conversion from cropland to forest. The change in carbon accumulation between the land uses has been calculated using IPCC statistics. For this inventory, only forests that are managed for wood products are considered anthropogenic sources/sinks of greenhouse gasses. Therefore, greenhouse gas emissions and removals in Barbados' virgin forests have not been estimated.

Changes in Forest and Other Woody Biomass Stock include fuel wood consumption as well as natural mortality. The data has been interpolated to provide estimates of the emissions and sinks for other years. The Figure 2.10 presents the time series of the emissions and sinks by sector and by gas. Uncertainties associated with these emission estimates are large as activity data (e.g. the land area covered by the different land types) have been taken from international sources, as no data was available from Barbados directly.

Figure 2.10 Barbados' LULUCF Emissions/Removals by Source Category 2000-2010 (Gg CO_2e)



2.7 Data Uncertainty

Uncertainties in the emission Inventory estimates arise from both the activity data and the emission factors. The level of uncertainty for each source of data is quantified in the Annex. Default emission and uncertainty factors have been used throughout the compilation process based on the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories Manual. There are uncertainties in the activity data due to (a) lack of regular data collection; (b) lack of available data in some cases; or (c) data having been approximated from international sources.

2.8 Summary and Recommendations

Limited data availability has meant that a Tier 1 assessment methodology has been used. This is the minimum, or default, level required by the IPCC Guidelines. It provides the most basic level of emission estimates and relies upon default emission estimates (drawn from UN Statistics), surrogate datasets and expert opinion. Local data was used for calculations where available. Opportunities to improve greenhouse gas emission estimates relate to increasing the availability of longer, more accurate and more regularly collected time-series local level data.

Improvements to future communications primarily rely on increasing the availability and accuracy of local data and reducing dependency on non-Barbadian, UN, and North and South American data sets, emission factors and statistics.

Increasingly local data availability relies on the use of nation specific emission factors (utilising local knowledge and experts); increasing data collection (conducting censuses more regularly on, for example, energy fuel type and usage, populations (persons, farm animals and housing types); and increasing access to past studies.

Barbados has the installed infrastructure and knowledge to enable these improvements but relies on developing a consensus on the methods for data collection, analysis and reporting to ensure that data is accurate, standardised and accessible.

The Ministry of Environment and Drainage has designed a Greenhouse Gas Inventory Framework, as part of this SNC study that provides a mechanism through which Barbados can prepare future inventories. This allows Barbados to contribute to international reporting whilst prioritising actions and policies, informing industry and the public to support climate adaptation, and tracking measures aimed at reducing greenhouse gas contributions. The Framework establishes structure for greenhouse gas inventory governance, including data management requirements, and agreed work plan for delivery of objectives.

The factors that lead to uncertainties in the activity data as well as the key recommendations for each sub-sector are presented in Table 2-2.

Table 2-2 Summary of Recommendations for future GHG Inventories by Sector

No.	Sector	Improvement Issue	Priority Rating
1	Energy	Fuel consumption data across the time series (in this case 2000 to 2010) is required to make accurate emission estimates across the energy sector. This would be preferential compared to using data from UN statistics. The following is required: • An annual official energy balance (this would allow estimates to be compiled using the Tier 1 reference approach). • Fuel consumption by sector and type of fuel for the years being assessed.	Very High
2	Energy	Fuel Consumption Data Information on fuel consumption by plant (for each electricity plant and each industry) for the years being assessed Fuel analysis information showing average energy and carbon content of fuels.	High
3	Energy	Fuel Consumption Data Annual amount of fuel consumed by the light airplane club in Barbados. This would enable an estimate to be made of emissions arising from domestic aviation in Barbados.	Medium
4	Energy	Tier 1 emission factors have been used throughout. Detailed information on the characteristics of the energy industries – for example the technologies used, and information on the age of the transport fleet and the introduction of catalytic converters would enable more accurate estimates to be made.	Medium
5	Industrial Processes	To improve the estimates of emissions for HFCs and SF_6, using data on imports and exports of gases in appliances, the amount used for recharging appliances and any quantities lost in disposal or destruction of gases would be beneficial and improve the estimates provided here.	Medium
6	Industrial Processes	There is a relatively small chemical manufacturing industry on the island and the data on the types and quantities of chemicals produced could not be readily obtained from the production companies. A more detailed survey of the feedstocks (including the use of fossil fuels, limestone and/or dolomite) and products from chemical processing in Barbados is recommended.	High
7	Industrial processes	There may be emissions from the use of F-Gases in the electronics industry in cleaning and purging equipment. It is recommended that Barbados investigate possible sources and imports of PFCs for the electrical equipment industry.	Medium
8	Agriculture	Livestock Data Currently the livestock census in Barbados is not undertaken on a regular basis. It is recommended that a livestock census is	Very High

No.	Sector	Improvement Issue	Priority Rating
		undertaken at least every 5 years, and annual data are estimated from this. The census should resolve: • Cattle into dairy cattle and other cattle; • Chickens into layers and broilers; and • Pigs into market swine and breeding swine. This is a particularly important improvement as it affects a large number of sources.	
9	Agriculture	Cattle CH_4 Emission Factors, and N Excretion Rates Currently it is assumed that CH_4 emission factors for cattle and N excretion rates for all livestock in Barbados (and some livestock N_2O Emission Factors) can be represented by the average of North American and Latin American Emission Factors. This should be reviewed by local agriculture experts and amended as necessary. If possible, country specific N excretion rates should be used for cattle, to allow a Tier 2 method to be used.	High
10	Agriculture	Use of Waste Management Systems in Barbados This is a similar issue to above. The AWMS use that is assumed in Barbados is an average of North America and Latin America, with some other assumptions. This should be reviewed by local agriculture experts and amended as necessary.	High
11	Agriculture	N_2O Emissions from Grazing Animals Improvements outlined in point 9 above should bring improvements to the estimate of N being deposited to soils by grazing animals. This is a particularly important improvement as it is the largest single source of agricultural N_2O emissions.	Very High
12	Agriculture	N_2O Emissions from Synthetic Fertiliser Currently the annual amount of N being applied to land in synthetic fertiliser is relatively high in uncertainty. A regular survey/census would help improve estimates from this source.	High
13	Agriculture	N_2O Emissions from Organic Fertiliser This is not a particularly large source, and improvements to this will be brought about by improvements elsewhere (e.g. increased certainty of the use of different AWMS).	Medium
14	Agriculture	Crop Residues This is not a particularly large source, but it should be relatively easy to improve on some of the assumptions that have been included in the methodology (simply by drawing on local expertise).	Medium
15	Agriculture	Indirect Emissions of N_2O This is not a particularly large source, and improvements will be brought about by actions taken to improve the estimates of other emission sources. N.B. There are other indirect sources of N_2O, which it may be	Medium

No.	Sector	Improvement Issue	Priority Rating
		relevant to estimate, depending on the improvements that can be made elsewhere in the emissions inventory.	
16	Waste	Waste Characterisation Since compiling the first version of the inventory, a 2015 waste characterisation study has been commissioned and this has been incorporated into the inventory. It is recommended that this document be updated at least every 5 years. This would allow for more reliable data on the composition and level of waste generation to go into the inventory calculations.	High
17	Waste	Wastewater Treatment No data was made available on the wastewater treatment type used in Barbados for domestic and industrial/commercial wastewater. This information should be made readily available for future compilations.	Very High
19	Waste	Tier 1 Emission Factors The Tier 1 emission factors have been used based on Caribbean regional values for emissions from landfill in the IPCC Waste Model. Also, a number of Tier 1 emission factors based on international data sets have been used in estimating emissions from wastewater, an example being the degradable organic component of residential wastewater, where the default guidebook value for the Latin America region has been applied due to a lack of local/regional data. Studies to determine local/regional values would improve the accuracy of estimates. The following is a list of Tier 1 emission factors used in the wastewater estimates, which could benefit from location specific data being used instead: • Caribbean default values for landfill emissions; • Wastewater generation from industrial processes; and • Degradable organic component of residential and industrial/commercial wastewater.	Medium
20	LULUCF	Land Cover Data It is recommended that land cover data be collected on a routine basis so that this data can feed into the greenhouse gas inventory. This should consist of: Estimates of initial and final land use areas (million hectares) as well as the total area of land that is unchanged by category for each year of the inventory: • Forest land (unmanaged); • Forest land (managed) including the type of tree by age if possible; • Grassland (rough grazing); • Grassland (improved); • Cropland; • Wetlands; • Settlements; and	High

No.	Sector	Improvement Issue	Priority Rating
		• Other land.	
21	LULUCF	Biomass Carbon Stock Data It is recommended to collect data on forest species, their increment rate and harvesting; or to collect on a routine basis data on above ground biomass in order to evaluate stock changes by difference of consecutive surveys.	High
22	LULUCF	Soil Characterisation Areas under re-colonisation from forest vegetation should be apportioned among different soil types according with classification provided in chapter 3, Volume 4, of the 2006 IPCC Guidelines.	Medium

3 CLIMATE CHANGE IMPACTS, VULNERABILITY AND ADAPTATION MEASURES

3.1 Observed and Forecast Climate Changes

The Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) presented evidence that global temperatures are projected to rise by 0.3–4.8°C and mean sea level 0.26–0.82m by the end of the century (IPCC, 2013). Related predictions for the Caribbean region over the same period included a 1–4°C increase in atmospheric temperature with a tendency towards drier conditions in the traditional wet season (from June to November), a 12% decrease in total annual precipitation and 0.5-0.6 m of mean sea level rise.

As a low-lying Small Island Developing State situated on the southern edge of the North Atlantic Hurricane Belt, Barbados is highly vulnerable to all of these predicted consequences of global climate change.

3.2 Data Collection and Climate Modelling

Since Barbados produced its First National Communication Report, there has been considerable progress in climate science, thus allowing for greater confidence in the 50–100 year climate projections. Future predictions for Barbados have been based upon research carried out by Oxford University and the University of West Indies using a combination of regional (PRECIS)[2] and global (ECHAM4 and HadCH3) climate models, which together have provided good spatial resolution. The model scenarios, as defined by the IPCC, were developed for future climate changes using the A2 'worst case' and A1B 'medium-high' scenarios where emissions plateau during the 21st century, and a B1 'low' emissions scenario. The projections are for the years 2039, 2050, and 2080. The Climate Change Risk Atlas for Barbados and recent observational information were used to assist with the assessment of vulnerability.

3.3 Predicted Climate Changes

The climate variables that are most likely to be influenced by predicted climate change and result in significant effects for Barbados are increases in air and sea surface temperature, greater frequency and intensity of tropical storms, sea level rise and increased rainfall variability.

Air Temperature

The observed rising air temperature has increased by approximately 0.14°C per decade since the 1960s and since 1973 there has also been an increase in the annual number of 'hot' days over 30°C (Economic Commission for Latin America and the Caribbean (ECLAC) 2011a). Whereas the global climate models predict an increase of 0.5–1.8°C by 2050 and 0.9–3.1°C by 2080 (relative to the 1970–99 mean), the regional climate models predict a more rapid temperature increase of 2.4–3.2°C by the 2080s (Simpson et al, 2012). The projected mean temperature for Barbados is likely to increase from 28°C to 31°C by the end of the 21st Century.

[2] PRECIS is a regional climate model developed by the Hadley Centre of the Meteorological Office of the UK, and is for use by Non-Annex 1 Parties to the UNFCCC.

Sea Surface Temperature

Barbados has experienced a rise in sea surface temperatures of approximately 0.1°C per decade since the 1960s. The global climate model projections are that sea surface temperatures will rise between 0.8°C and 3.0°C by the 2080s (Simpson et al, 2012) and are likely to contribute to increased tropical storm activity affecting Barbados and the Caribbean region (ECLAC, 2011a).

Tropical Storms

Since the 1980s there has been an observed increase in the frequency and intensity of tropical storms globally, and hurricanes have been observed developing at lower latitudes. As an example, hurricane Ivan in 2004 was observed to form at 8° North (Nurse S., 2011). By 2100 there is a predicted increase in storm intensity and frequency of the category 4 and 5 storms and hurricanes. This activity is of particular concern to Barbados given the vulnerability of its housing stock and the increased probability of hurricanes making landfall on the island.

Storm Surge and Sea Level Rise

Sea level rise has been observed at approximately 1.8 mm per year since the 1950s (Church et al, 2004). The global climate model projection is that sea levels will rise by between 0.5 m (Nurse et al, 2014) and 1.4 m by 2100 (Rahmstorf, 2007). The projections of higher sea levels and increased tropical storm activity are expected to increase storm surge frequency and intensity. The main impact of storm surge is flooding and, because of Barbados' generally low-lying topography, it has been estimated that storm surge flooding events could extend over 150–300 m inland (Nurse L., 2011b).

Rainfall

Rainfall is controlled by the transition between El Niño and La Niña events, global and regional climate model projections suggest that mean rainfall will decrease in Barbados, creating a tendency for drier conditions through the wet season.

The climatic changes are summarised in the table below.

Table 3-1 Predicted Climatic Changes

Climate Change Projections	Historic Observations Extrapolated	Barbados' SNC Climate Change Findings	IPCC AR5 Prediction by 2100
Air Temperature (°C)	1.54 by 2080	0.9—3.1 (Global *); 2.4—3.2 (Regional**) by 2080	0.3—4.8 (All scenarios, Global)
Sea Level Rise (m)	0.28 by 2100	0.5—1.4 by 2100	0.26—0.82 (All scenarios, Global)

* ECHAM4 and HadCH3 ** PRECIS

3.4 Priority Sectors Vulnerable to Climate Change

Barbados and the island nations of the Caribbean are amongst the most vulnerable to a diverse range of weather hazards and climate change projections suggest more intense and more frequent extreme events are likely. These may lead to socio-economic challenges such as:

- Damage to coastal infrastructure and settlements;
- Deterioration of coastal conditions and resources;
- Increased water stresses from periods of drought and seawater contamination of aquifers;
- Increased evidence of vector-borne diseases;
- Pressure on and damage to marine ecosystems; and
- Knock on effects to sectors of the economy such as tourism, agriculture and fisheries.

Through its Nationally Determined Contribution Barbados has communicated that adaptation to climate change is an area of primary concern for its future development. Accordingly, the country has recognised the need to identify its key assets and sensitive receptors that are vulnerable to the potential impacts of climate change as well as for the early identification and implementation of appropriate adaptation strategies and actions. The following priority sectors and related key vulnerabilities have been identified and are further elaborated in this chapter:

- Agriculture—stocktaking of current and projected water usage and the effect of climate change on specific crop cultivation.
- Water Resources—vulnerability of public and private water supply wells and the compounding effects from a growing population and increasing water demands.
- Human Health—the spread of disease, for example, dengue fever, due to changing climatic factors such as increased temperatures.
- Coastal Resources and Human Settlement—potential effects of sea level rise, particularly storm surge and coastal erosion and impacts on human settlements and infrastructure, especially in coastal areas.
- Tourism—the impacts of climate change on tourist arrivals and the subsequent impacts on socio-economics.

There have also been various studies undertaken that have identified the links between climate change and adaptation strategies specific to Barbados. The Economic Commission for Latin America and the Caribbean (ECLAC) has recommended that adaptation to climate change should be mainstreamed into sustainable development plans and initiatives, particularly in relation to low elevation coastal zone areas that have high social and economic development

potential. Specifically in the case of Barbados, ECLAC has found that the country has developed the necessary adaptation policies to respond to the economic impacts of severe weather events.

The United Nations Development Programme 'Needs Assessment' for capacity building in the Caribbean has identified several data gaps in the assessment of adaptation and disaster risk reduction practices. These have been considered by this study and in the preparation of this SNC document.

3.5 Vulnerabilities and Adaptive Measures

Agriculture

Slow but steady population growth and development demands are transforming much of the Barbadian landscape. Consequently, land available for agricultural development is a resource that is becoming increasingly limited. Sugarcane production has significantly decreased from 20,200 ha in 1995 to around 5,800 ha in 2009 (Simpson et al, 2012). The effects of soil erosion in the Scotland District and some other areas of the country's more exposed topography further affects the quality of land available for food production. Approximately 32% of land is currently used for agriculture, compared to 44% in the 1980s (World Bank, 2013).

This land scarcity contributes to the high cost of food production in Barbados and further limits the competitiveness of domestic agricultural products in local and export markets. It has become increasingly difficult to recruit young farmers into the industry and the costs of new technology to improve operations puts added strain on current farming practices. Barbados imports more than 70% of its food requirements and most of its agricultural resources (Rawlins, 2003) and is exposed to international market fluctuations. Barbados' agricultural economy also has to contend with competition from temperate regions that produce tropical crops at greater scales and cost efficiency.

Rising air temperatures, varying rainfall patterns and tropical storms have already directly affected Barbados' food production. These have significantly affected crops production, and livestock and poultry rearing.

The critical changes forecasted for Barbados under the IPCC AR5 climate change scenarios (A2 and B1) are:

- A 1–2 m sea level rise is predicted to impact at least 1% of the available agricultural land. If sea level rise is at the more extreme extent of the range, inundation could result in coastal infrastructural losses, especially for agriculture, tourism and fisheries. A high-range SLR scenario indicated that annual and capital costs for agriculture could be US$ 1 million by 2050 and US$ 2 million by 2080 (Simpson, Scott *et al.,* 2009).
- Rising air temperatures will increase soil temperatures and further affect the growth and development of food crops and the health and productivity of livestock.
- Rainfall fluctuations and longer droughts will reduce the quality of crops, and flooding could damage property and infrastructure. There is also a greater risk of saline intrusion into available ground water abstraction and irrigation wells due to sea level rise.
- Increased frequency of extreme weather conditions and tropical storms will accelerate soil erosion.

The Government has identified the agricultural sector as a national development focus area and, in recent decades, the Ministry of Agriculture, Food, Fisheries and Water Resource Management (MAFFW) has created a substantial enabling environment to enhance growth within the sector. Adopted strategies include measures to enhance crop and quality livestock production, policies to safeguard arable land and conserve soils, creating new market facilities and expanding youth development programmes in farming practices. The Ministry has also provided education and incentive packages to promote sustainable farming practices including post-harvest technology, organic farming, permaculture and new crop technology.

New policies are being developed that will provide a framework for sustainable natural resource use and diversify the sector from its traditional dependency on sugarcane production for export, to a focus on food security, nutrition and health. The framework includes the establishment of food zones with the objectives of:

- Supporting modern sustainable technology and farmers committed to food and agricultural productivity;
- Improving food security by specifically reserving lands for long-term food production; and
- Stimulating production in surrounding Districts to provide buffering capacity.

The new approach specifically recognizes the observed and potential longer-term climate change impacts on the sector and promotes inter-sectoral linkages with tourism, manufacturing and energy where there have been long-standing land-use conflicts and/or missed enterprise opportunities. The use of sugar-cane bagasse for energy production is one such opportunity being explored

Barbados has expanded its agricultural community. There are now various informed groups including the Barbados Agricultural Development and Marketing Corporation (which has promoted research in food processing and commercialising local agricultural products), the Barbados Agricultural Society (which has introduced initiatives for local farmers such as the use of cassava as a fuel), and other farmer cooperatives and community-based organisations. These organisations are vital for the transfer of skills, knowledge and understanding in more sustainable farming practices not only to lead to improved long-term economic returns but to a collaborative approach for adaptation and resilience to the challenges Barbados will experience as the climate changes.

Water Resources

Barbados is classified as a water-stressed and water-scarce country as there is less than 1,000 m^3 of the total renewable water resource available per person per year (Cashman et al, 2010). Water demand now exceeds the total renewable freshwater resource supply, and desalination and rainwater harvesting are necessary to account for the deficit. In 2009, 98% of rechargeable freshwater resources were used (Emmanuel and Spence, 2009). The greatest demand comes from the agricultural and tourism sectors.

The water resource is further threatened by saline intrusion, frequent bouts of drought, and vulnerability to pollution. Water is distributed via ageing and decaying infrastructure, while new metering and leak detection systems have not been fully deployed across the country. Distributional losses have been estimated at between 26% and 60%. Supplementing the supply with desalinated water is an expensive option that costs Barbados around US$ 0.75 million per month in energy use.

On average, over 80% of potable water is extracted from Barbados' groundwater aquifers. Water availability is directly affected by the periods and intensity of wet and dry seasons. The water balance is not easily maintained due to its dependence on groundwater recharge, which normally requires 20–25% of retained rainfall. Urbanisation has also served to limit rainwater infiltration and aquifer recharge. Climate-related extreme events can reduce the availability of freshwater. After tropical storms or heavy precipitation ground water may be contaminated due to the infiltration of pollutants which may be flushed into aquifers through suck wells and sinkholes.

Observations already show that climate change may be causing long-term shifts in seasonal weather patterns that directly affect the ability of systems to recharge groundwater resources. Climate change is predicted to lead to reduced rainfall during the wet months when aquifers are ordinarily recharged. A reduction in precipitation will therefore affect the available water reserves to meet development needs as well as increase the risk of saltwater intrusion into coastal aquifers. The lengthening of the dry season, married with reductions in rainfall, higher

temperatures and higher evapotranspiration rates, will significantly compound these concerns and also serve to intensify the frequency and severity of drought stresses.

Increased climate variability also increases the cost of the infrastructure, information and systems needed to manage national water resources. Climate change will therefore not only further expose existing regulatory, infrastructural and technical weaknesses of the country's water management, but will also exacerbate the situation by increasing the costs of water services and of reliable service delivery to the population and key economic sectors: agriculture, power production and services.

The Barbados Water Authority (BWA) provides oversight for potable and wastewater management and monitors and tests these against international standards. Between 2007 and 2010, the Authority spent between US$ 7.5 million and US$ 9 million annually on replacing and installing new mains. The Government also invested US$ 1.2 million in research to inform future decisions on water supply network rehabilitation and upgrading. The US$ 50 million Water and Sanitation Systems Upgrade Project, funded by the Inter-American Development Bank is addressing some fundamental needs in water resources management under the following three components: (i) institutional strengthening through reorganising and modernising the Authority, (ii) rehabilitation of the potable water supply, and (iii) development of a wastewater treatment action plan.

The BWA has formulated a National Drought Management Plan and routinely implements its provisions as required. Stage 1 provides for voluntary water conservation measures, and launching of a drought management task force. There is an island-wide programme to replace at least 104,000 domestic and commercial water meters within a three-year period. The more efficient meters to be installed would better reflect water consumption patterns and the impact of adopted policy measures.

The Authority and Ministry of Education have launched a combination of public education campaigns for water conservation, new water monitoring, and water management objectives targeted at tourism and hotels, and the free provision of low flow sanitary fixtures for schools.

At the World Summit on Sustainable Development (2002) all countries were commissioned to develop integrated water resources management and water efficiency plans. In 2008, Barbados began the development of an integrated water resource management plan with contributions from the Caribbean Environmental Health Institute, the Global Environment Facility, the United Nations Collaborating Centre for Water and Environment, and the Global Water Partnership-Caribbean.

Human Health

Barbados, like many small islands within the tropical and subtropical zones, is particularly vulnerable to weather-related morbidity and mortality diseases affected by changes in temperature, and a number of emerging and re-emerging communicable diseases such as dengue fever, leptospirosis and food, insect, rodent and water borne diseases, respiratory diseases, and malnutrition (Simpson et al, 2012). The latter is a particularly important consideration since it draws the connection between climate change, agriculture and health. A 2004 University of the West Indies study revealed the following positive associations between diseases and climate parameters (Amarakoon, 2004a and 2004b):

- Dengue with temperature and rainfall
- Sahara dust and diarrheal illnesses with temperature and rainfall
- Asthma, bronchitis and respiratory-tract infections with temperature and relative humidity.

The relationship between climate change and human health is very complex as non-climatic factors, such as the quality and accessibility of health care services, the availability of financial and technical resources and the general health of the population are contributing concerns. Climate change will also adversely affect prerequisites for good health, such as clean air and water, adequate food and appropriate shelter. The Commonwealth Secretariat's assessment of the impacts of climate change on the health sector determined that the greatest risks are from vector-borne diseases promoted by changes in climate – such as leptospirosis by high rainfall levels, dengue fever by high rainfall and high temperatures, as well as the transmission of diarrhoeal diseases in water-scarce conditions (Simpson et al, 2012).

Malaria is significant in the context of climate change in the Caribbean because of its recent resurgence in several countries after near-total eradication between 1958 and 1965. Malaria is not endemic in Barbados, but two cases were diagnosed in 2010 (PAHO, 2012).

Gastroenteritis is one of the main diseases affecting children between 0–9 years old in Barbados. Since many of the causative agents of gastroenteritis are sensitive to environmental change, researchers anticipate that the impact of climate change on gastroenteritis will be highly significant with a greater number of incidents occurring (ECLAC, 2011b).

Another potential health impact of climate variability and climate change for SIDS is the increasing prevalence of marine bio-toxins. Climate-sensitive marine illnesses, such as scombroid fish poisoning, paralytic shellfish poisoning, diarrhoeic shellfish poisoning and ciguatera, can pose a serious threat, affecting fish, other marine life and human health (ECLAC, 2011b).

Extreme weather events associated with climate change such as thermal stress, floods and droughts, high wind events and storm surge, may lead to increased deaths, injuries and psychological disorders placing additional stress on health care services.

Between 2011 and 2015, The Global Environment Facility (GEF) Climate Change Adaptation to Protect Health project played a leading role in identifying and planning for the human health risks posed by changing climatic trends. Based on the most critical health and environmental protection issues identified for Barbados, a number of interventions were formulated and eventually served as the main performance indicators of the project. The outputs therefore focussed on developing adaption strategies to increase the capacity to cope with the proliferation of infectious or communicable diseases issues associated with water availability and water quality; and vector borne diseases. The main health risks focussed on were relevant to:

- Rainfall and vector borne diseases (Dengue fever and chikungunya)
- Drought mitigation via wastewater reuse (waterborne diseases)
- Water quality (waterborne diseases)

The primary outputs included:

i. The development of an Early Warning and Communication System (EWCS) for vector borne diseases and water quality
ii. Adaption of international guidelines for safe reuse of wastewater in Barbados
iii. Development of guidelines for safe storage of rain water
iv. Integrating climate change into the routine work plan of the Environmental Health Department (effective water quality surveillance systems and wastewater reuse licensing and monitoring)
v. Construction of a fish rearing facility to assist in the biological control of mosquitoes
vi. Enhanced public awareness to climate change and health (public and institution lectures, poster competition and school's workbook)

These recommended six long-term interventions fulfilled the objectives for Barbados component of the overall global project. However, it is recognized that implementation and sustainability will require further Ministry of Health support particularly in the areas of enhancing its institutional capacity, as well as securing long term support from other government and non-government agents whose contributions will be vital.

Coastal Resources and Human Settlements

High and often conflicting demands are putting considerable pressure on the country's coastal areas and resources. These low-lying areas are exposed to marine and meteorological forces and are particularly affected by anthropogenic activities. Given the extensive build-up of diverse infrastructures in the immediate coastal areas and the island's terraced and gullied topography, both point and non-point sources of pollution directly affect coastal ecosystems. Many of these systems have also shown signs of decline associated with climatic changes.

The last remaining local mangrove forest, the Graeme Hall Swamp, is under threat from reduced salinity and contaminated storm water run-off. The seagrass cover in the St. Lawrence lagoon has nearly disappeared due to periodic scouring, siltation, eutrophication and threats from invasive species. The decline of coral reef cover in Barbados has been attributed to deteriorating coastal water quality, overfishing, and has been compounded by the recent Lionfish (*Pterois volitans*) invasion. The accelerated decline of coral reef has removed natural coastal protection and has reduced the replenishment of sand, leading to significant beach erosion, particularly along the west coast. As a consequence, many beaches are narrower than in years past.

Since Hurricane Janet in 1955, Barbados has experienced several sizeable storm systems. On 24 September 2002, over 2,000 Barbadians were affected by Tropical Storm Lili, which caused US$ 200,000 in damages. On 8 September 2004, Hurricane Ivan affected 880 people and resulted in US$ 5 million in damages. In 2010, Tropical Storm Tomas caused US$ 8.5 million in damages and affected 2,500 people and 1,500 houses (Simpson et al, 2012). The intense winds, high seas and heavy rainfall associated with Tropical Storm Tomas caused damage to coastal residences and infrastructure, with many houses losing their roofs and thousands of residents without short-term electricity or water supply. On 11 April 2011, a low-pressure system passed over Barbados and caused flooding along much of the western coast. The country experienced repeated flooding due to heavy rains during April and May 2011.

These tropical systems also produce intense wave energy and have resulted in the displacement of thousands of cubic metres of sand from beaches to offshore deep water. This is especially evident on the west coast which has a narrow continental shelf. The erosive force of the waves has gradually narrowed these beaches, deposited coral rubble in the nearshore area and has caused considerable damage to coastal properties.

Rising sea surface temperatures and accumulated heat stress are significant threats to the future of Caribbean reefs. In 2005 and 2010 Barbados' coral reefs experienced two of the most devastating mass bleaching events ever recorded with high levels of coral mortality. In the 2005 bleaching event, corals remained bleached for over a year, resulting in the loss of approximately 25% of live coral cover (Oxenford, 2010).

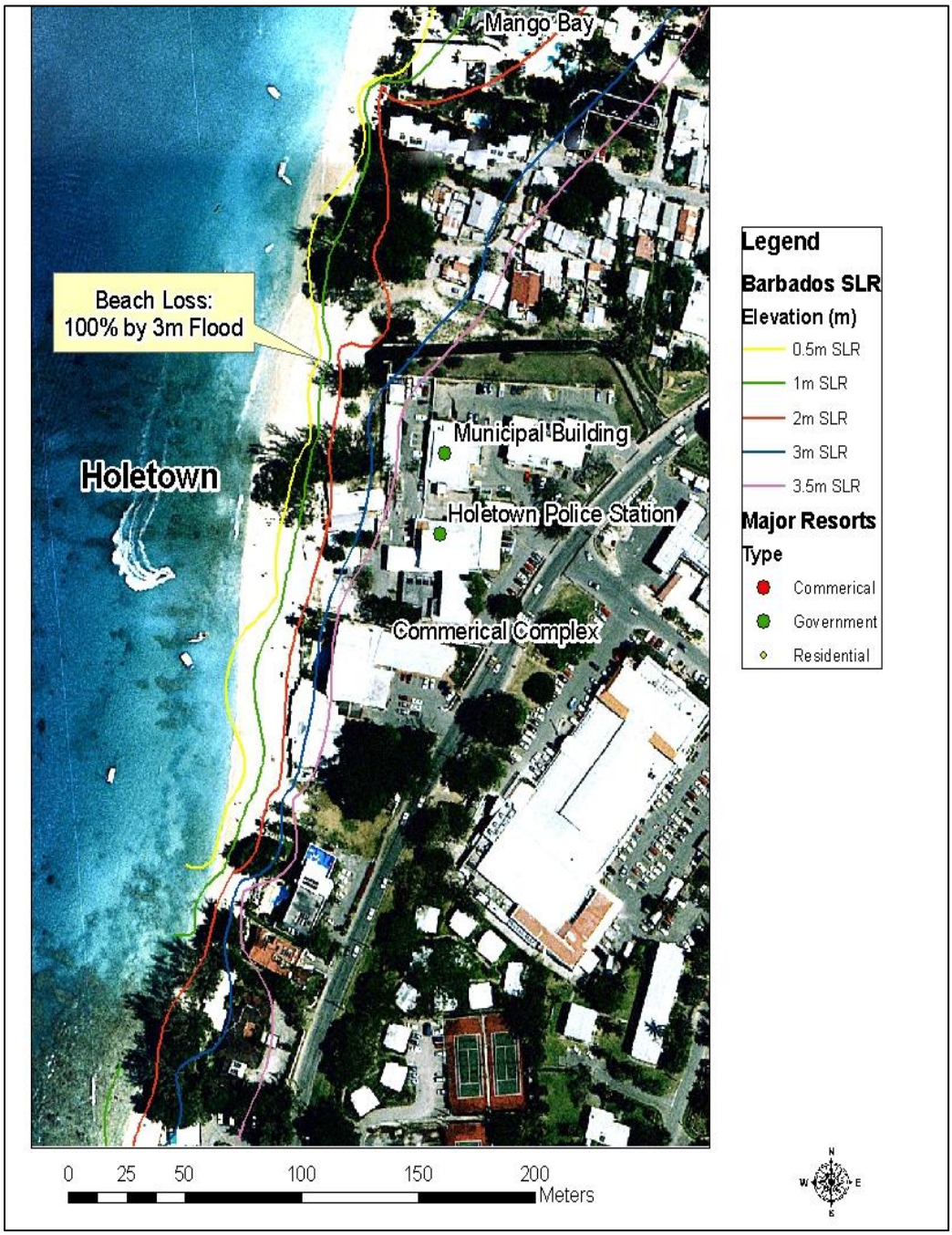
Sea level rise around the island is close to the global mean having risen by 3.1 mm per year (Simpson et al, 2012). Research indicates that continued sea level rise would be more pronounced in the Caribbean due to its proximity to the equator. Although a slow-onset impact of climate change, the projected rise poses a chronic threat to coastal ecosystems and settlements by exacerbating existing vulnerabilities.

Barbados' coastal zones comprise approximately 18% of the land mass and include 37 road networks estimated to a total of 288 km (ECLAC, 2011c). The majority of the population is concentrated within an urban corridor that lies within 2 km of the shore and below 25 m in elevation. These areas of high population density, nationally critical infrastructure and supporting industries are at particular risk and vulnerable to storm surges and sea level rise (Government of Barbados, 2001b). The most vulnerable are low-income families, who have fewer choices in the housing market and are more likely to live in environmental danger zones.

Coastal erosion due to sea level rise will affect the viability of the tourism sector, where value is based on aesthetic qualities such as uninterrupted sea view and beach access. The coastline around Speightstown, Sandy Lane and Holetown are noted to be particularly vulnerable. As shown in Figure 3.1 and Figure 3.2, even under the smallest sea level rise scenario (0.5 m, yellow contour), 37% to 72% of the highly valued beach resources in Sandy Lane and Holetown would be lost. With a 2 m sea level rise (red contour), 65% of Sandy Lane's beach and 97% of Holetown's beach would become inundated. With a 3 m sea level rise, Holetown's beach would be lost entirely, and Sandy Lane's beach would be lost at a 3.5 m sea level rise.

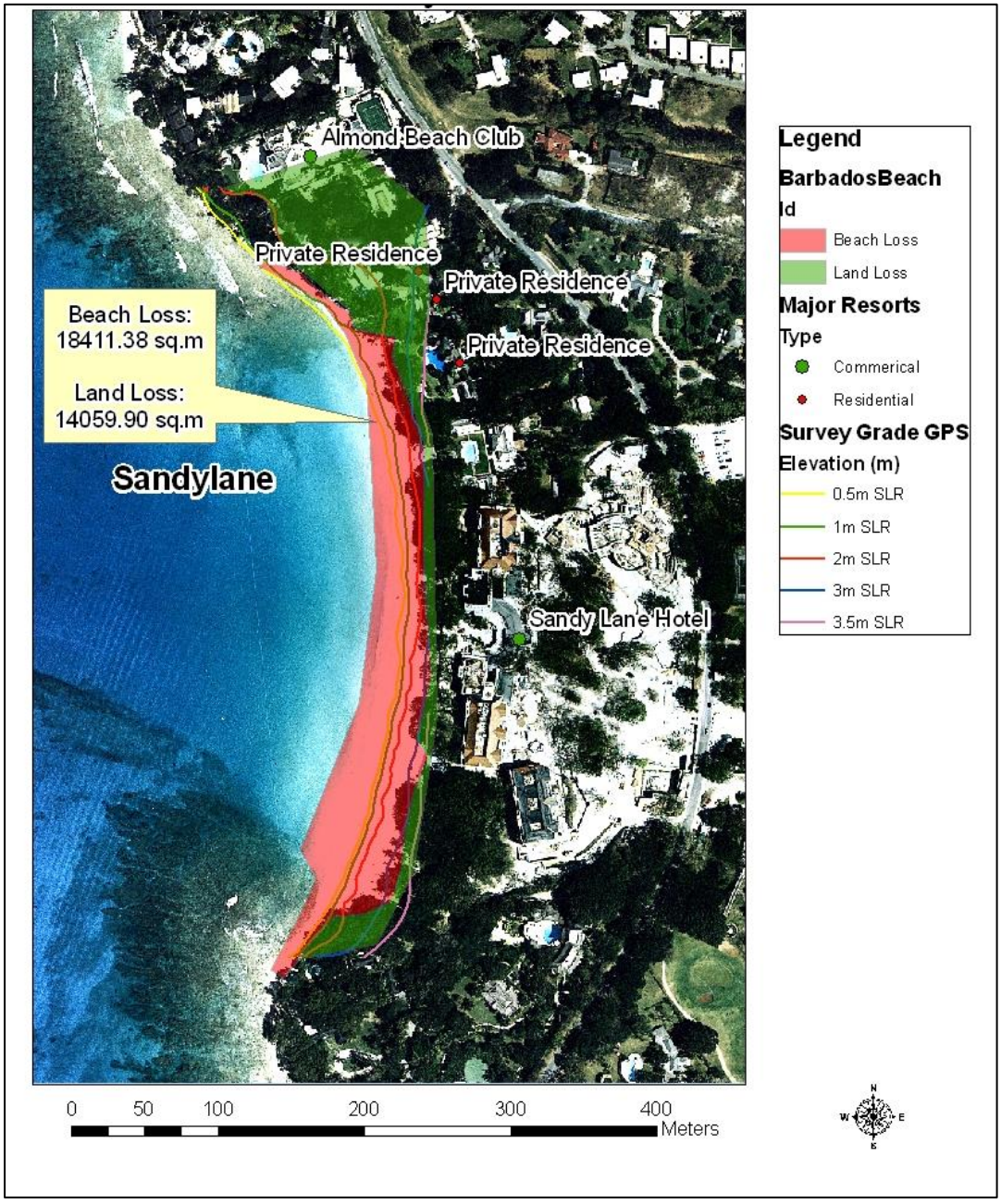
Barbados' main commercial centre, Bridgetown represents another significant low elevation coastal zone that is at risk and this is where most of the country's important service infrastructure is concentrated. Coastal inundation would significantly disrupt economic and social sectors, with knock-on effects including infrastructure damage, business interruptions, and emergency planning and operational expenses (insurance, back-up water and power systems, and evacuations). Roads, power stations, schools, Government buildings, hotels, community amenities, fuel storage systems, harbours, recreation sites and the Bridgetown Careenage are all potentially at-risk. Destruction or damage to the Bridgetown Port would significantly affect the ability to accommodate cruise and cargo ships, putting additional strain on the tourism industry and island's economy on a whole.

Figure 3.1 Projected Land Losses from Sea Level Rise at Holetown, Barbados



Source: Simpson, et al., 2012

Figure 3.2 Projected Land Losses from Sea Level Rise at Sandy Lane, Barbados



Source: Simpson, et al., 2012

The institutional and legislative framework for monitoring and managing developments in the coastal zone is embedded in the Coastal Zone Management Act and the Integrated Coastal Zone Management Plan overseen by the Coastal Zone Management Unit. Between 2002 and 2009, the Inter-American Development Bank (IDB) co-financed a Coastal Infrastructure Programme (providing US$ 17 million of US$ 24 million) through which the Government has implemented successful projects to protect Barbados' coastline including:

- Shoreline stabilisation and erosion control;
- Restoration of coastal habitats
- Improvement of public coastal access
- Institutional strengthening for coastal management
- Coastal adaptation strategies relating to sea level rise.

Presently, Barbados is currently implementing a Coastal Risk Assessment and Management Programme (CRMP) aimed at building resilience to coastal risks through improved monitoring, conservation and management of the coastal zone. This IDB funded programme involves three components:

(i) Coastal Risk Assessment, Monitoring and Management: This component provides updated qualitative and quantitative data on risk in the coastal zone and state-of-the-art tools for routine quantitative assessment, monitoring and management of risk in the coastal zone.

(ii) Coastal Infrastructure: Coastal infrastructure improvements including shoreline stabilisation, increased coastal infrastructure resilience, and improved public beach access. The Holetown waterfront will be provided with coastal revetments, offshore breakwaters and walkways will be constructed. The Holetown Lagoon is to be restored to improve water quality and reduce flooding.

(iii) Institutional Sustainability for Integrated Coastal Management: Government policy is mainstreaming disaster risk management and climate change adaptation into coastal zone management.

According to historical data, Barbados experiences a major flooding event approximately every 12 years. Due to the low-lying geography of many areas, Barbados' infrastructure, settlements and facilities are prone to impacts from these events. Human activities such as vegetation clearance, urbanisation and construction on wetlands exacerbate the impacts of flooding (Government of Barbados, 2001a).

On November 29, 2016, the island experienced severe flooding resulting from a combination of a trough system and the Inter Tropical Convergence Zone which generated intense showers lasting for just a few hours. The rapid onset and speed of travel of water from the central

regions to the coast again provided evidence of the vulnerability of infrastructure and settlements to the impacts of events of irregular intensity. There were several reports of inundation of properties and damage to vehicles where culverts were inadequate to channel this magnitude of storm water along regular courses to outfalls along the shoreline.

The Government of Barbados is currently executing the Water Resource Management and Flood Resilience Climate Change Programme, funded with assistance from the United States Agency for International Development (USAID). The specific objectives of the Programme are to:

- Deliver Barbados' Storm Water Management Plan for the improvement of the management of overland and subterranean storm water flows to reduce flooding and to improve sustainable drainage.
- Improve the storm water management in the flood-prone and severely affected areas of Trents and the Holetown Lagoon in St James.
- Increase the incorporation of climate change adaptation into the national development process.
- Evaluate the quality of storm water and the impacts of run-off on coastal and marine environments.
- Upgrade and expand the hydrometric data collection system.
- Capture rainfall run-off and divert to groundwater storage, improving recharge rates.
- Provide education programmes and tools for water resources mitigation and adaptation.

Tourism

Generally, the tourism product in the Caribbean is noted to be directly dependent on the existing climate, making the industry particularly vulnerable to climate variability and climate change. In Barbados, the tourism industry is one of the largest consumers of potable water. In terms of climate variability, the occurrence of more frequent severe droughts during the dry season would put a strain on the island's water availability. In addition, when beaches and other natural resource assets on which the industry relies undergo negative changes from extreme climate events the appeal of the destination diminishes.

Projected increases in the frequency and/or magnitude of certain weather and climate extremes (e.g. heat waves, droughts, floods, tropical cyclones) will cause infrastructure damage, additional emergency preparedness requirements and higher operating expenses to cover things such as insurance, backup water and power systems, and evacuations. The installation of sea defence structures to reduce risk to storm surges and erosion could be yet another expense to operating in the sector.

Climate change could reduce the means and incentive for long-haul travel and have negative implications for anticipated future growth in tourism in Barbados (Government of Barbados, 2012a). Competition from emerging tourist destinations in the Asia and Pacific regions is likely to become more formidable as the projected impacts of climate change increase.

Barbados' Ministry of Tourism monitors and oversees the development of sustainable tourism development policy within the sector. To this end, it strives to cultivate a clear, rational and consistent policy space which encourages socio-economic development. Over the years policy direction and guidance have been communicated through an array of documents including - the White Paper on Tourism Development in Barbados, the Tourism Master Plan 2014-2023, the Tourism Development Act (CAP. 341) and the Physical Development Plan (PDP).

The Tourism White Paper identifies the overarching policy framework and charts a progressive and sustainable path for the sector. The Tourism Master Plan 2014-2023 advances the policy framework of the Tourism White Paper by outlining more detailed strategies and actions to accomplish the stated tourism goals and, by extension, ensure the balanced and sustainable growth of the sector.

The 2002 Tourism Development Act was amended and approved in October 2014 to allow for expansion of the incentives and investments available for tourism establishments. Some of the amendments make allowance for GHG emissions reduction as well as adaptation actions to be considered by operators in the sector. For example, electric heaters have been removed from the list of approved items while items such air conditioning units and waste water disposal systems may be found.

The Caribbean Hotel Energy Efficiency Action (CHENACT) Project (2009-2010) contained a variety of elements financed either by the IDB, GTZ, CDE, UNEP, BL&P and Government of Barbados. It was implemented by Caribbean Tourism Organization (CTO) with the Technical and Operational Support of the Caribbean Hotel and Tourism Association's Caribbean Alliance for Sustainable Tourism (CHTA/CAST). The project sought to improve the competitiveness of small and medium sized hotels (<400 rooms) in the Caribbean Region through improved use of energy with the emphasis on the integration of renewable energy and micro-generation. A pilot project was undertaken in Barbados and energy assessments were conducted on 64% of all licenced hotels. The savings potential in the hotel industry calculated based on these assessments equates to approximately 27 million kWh total annual savings in electricity consumption and an annual reduction of greenhouse gas emissions of 18,800 tons CO_2e. The assessments also highlighted the potential of hotels to reduce water consumption by approximately 50%. This could increase their adaptive capacity to the existing vulnerabilities of the water sector.

The Barbados Tourism Vulnerability Capacity Assessment Study was a component of a broader regional project on Mainstreaming Adaptation to Climate Change (MACC) implemented by the Caribbean Community Climate Change Centre (CCCCC). The study sought to provide information that would assist in reducing the vulnerability, risk, and losses from climate change in the tourism industry. Speightstown on the west coast of Barbados was used as the case study location. The study's findings later contributed to the development of a national multi-hazard disaster management plan for the tourism sector.

Fisheries

The key findings of the IPCC show that climate change will negatively affect the fisheries sector on a global scale (Pörtner *et al.*, 2014). Such changes may include, but not be limited to:

- fish populations shifting away from tropical to higher latitude;
- high local extinction rates in the tropics and semi-enclosed seas;
- large fish will have a smaller maximum body size due to reduced oxygen capacity of seawater;
- coral bleaching events affecting fisheries biomass of coral reefs, abundance and productivity;
- harmful algal blooms could cause mass die-offs of wild and farmed fish; and
- calcium carbonate-producing organisms harmed by ocean acidification.

The fisheries sector of Caribbean SIDS is suggested to be more vulnerable than in Pacific and AIMS SIDS regions. Within Caribbean SIDS, the Lesser Antilles are amongst the most vulnerable, in part due to the high dependence on marine resources as well as the high vulnerability of fisherfolk and fisheries infrastructure (Monnereau et al., 2015). Consequently, effective adaptation measures for the fisheries sector are particularly critical for the sustainable livelihoods for stakeholders in the sector, improved food security and protection of marine resources. Disaster management in fisheries has been mainly response-oriented with few programmes and interventions aimed at adaptation.

Changes in the availability of fish due to shifting populations and other factors can affect the cost of harvesting, the revenues generated and the choice of target species at any given time. Altered migration and spawning patterns can drive fish populations away completely or towards areas where spatial restrictions are in place such as a neighbouring nations' Exclusive Economic Zone (EEZ). This challenge has been experienced by Barbadian fishermen due to the migration of flying fish into the territorial waters of Trinidad and Tobago. Changes in migration routes and fish distribution may also directly affect fishermen through increased travel time, resulting in increased fuel and ice costs as well as the retail price ultimately charged to the consumer.

Barbados' fisheries industry is largely dominated by the seasonal harvesting of pelagic species (flying fish and dolphin). The abundance and productivity of shallow shelf reef fish (parrotfish, grunts and surgeon fish), harvested by part-time fishers year-round and full-time fishers upon conclusion of flying fish season, are known to be severely reduced by coral bleaching, algal blooms and die-off of calcium carbonate-producing organisms. These shifts in target species, coupled with ecosystem changes and industry related social factors, all influence the redistribution of cost and benefits that accrue to the fisherfolk community. Traditional fishing practices could be altered and alternative livelihoods would have to be created for those affected.

Indirect impacts on the fisheries sector may include damages to fisheries infrastructure during storms and hurricanes, contributing to decreased fishing capacity and access to markets. Storm and severe weather events can destroy or severely damage infrastructure and equipment such as port, landing sites and boats. While infrastructure damages are recoverable, the time necessary for such endeavours can be critical for the fisheries sector.

Several initiatives have been undertaken to assess the impact of climate change on fisheries at the community level and to identify potential adaptation measures. Some of these include the following:

- The Future of Reefs in a Changing Environment (FORCE): An Ecosystem Approach to Managing Caribbean Coral Reefs in the Face of Climate Change. The primary aim of this initiative was to develop a greater understanding of coastal communities in the Caribbean and how changes in coral reefs affect these communities given the current governance context. The Barbados Country Profile report provides a summary of governance and livelihoods research conducted.
- The Climate Change, Coastal Community Enterprises, Adaptation, Resilience and Knowledge (C-ARK) Project. The project was funded by the IDB through their Multilateral Invest Fund (MIF) and implemented by the CARIBSAVE Partnership, to work with fishers (and other micro, small and medium-sized enterprise (MSME) operators in the tourism, craft and agriculture sectors) in the coastal communities of Weston, Holetown and Oistins. Its focus was to not only increase awareness about climate change, but more importantly, increase the capacity of the communities to adapt their livelihoods accordingly. Adaptation plans for each community have been developed. C-ARK also included sector-specific training for MSMEs on small business management and provided small grants to those who qualify to support an adaptive intervention.

- Building Climate Change Resilience in Community Fisheries in Weston, St. James: This project was implemented by the Weston Fisherfolk Association through support from the national Global Environment Facility (GEF) Small Grants Programme (SGP). The overall goal was to increase the capacity of fisherfolk and other MSME operators in the fishing industry in Weston, through a Community-based adaptation approach, so that they can develop new fishing techniques, business opportunities and practices that not only make them more resilient to climate impacts but also reduce their own harmful contributions to climate change and marine pollution.

Insurance

As for most SIDS, a single major weather event can have a massive impact on Barbados' economy and undermine the gains that may have taken decades to achieve. The aggregate economic losses of small island states in the Caribbean region during the period 1979 to 2005 due just to storms were estimated at US$ 16.6 billion (i.e.: US$ 613 million annually). Increased storm activity in the region will place a large portion of the productive assets in Barbados at risk and will also act as downward pressure on the investment climate due to increasing insurance premiums.

Barbados' insurance industry is fairly advanced compared to those in most emerging economies, which reflects the recognised exposure to natural hazards as well as the strength of the tourism industry which requires insurance services to protect its capital investments. Barbados is also a member of the Caribbean Catastrophe Risk Insurance Facility (CCRIF), the world's first index-based, multi-country catastrophe insurance pool (CCRIF, 2013). Within 14 days of Tropical Cyclone Tomas in 2010, Barbados received a pay out of US$ 8,560,247 from the CCRIF. The Government of Barbados also has a catastrophe fund with an approximate balance of US$ 20 million, which was established to assist homeowners whose small timber homes are uninsurable. The fund is financed by contributions to the National Insurance Scheme.

Insurance products are more effective when they are coupled with reward risk reduction measures and Barbados is considering a variety of insurance options that can be used to support enhanced climate resilience. The potential instruments are:

- Sovereign disaster risk transfer
- Agricultural insurance
- Property catastrophe risk insurance
- Disaster micro-insurance to protect low-income households
- Health insurance

Cross-sectoral Actions

Barbados will experience changes in climate over future decades and centuries and it is therefore imperative that priority adaptation strategies are dynamic in nature. Hence, in preparing this SNC, priority adaptation actions were developed in collaboration with a diverse group of stakeholders in order to identify interventions to reduce or avoid possible impacts and/or accelerate existing initiatives for early implementation (See Section 3.6).

Barbados' Draft National Climate Change Policy Framework cites continued research, observations and information gathering as one of its key objectives. Lack of research and data inhibit the effective management of limited resources in addressing climate change. As such, consistent collection of data, as well as monitoring and reporting on relevant actions are prerequisites for effective climate change adaptation and resilience. Steps have been taken towards improving data management mechanisms within Barbados' water and health sectors. The MED has also initiated discussions on the development of a national Monitoring, Reporting and Verification (MRV) system to support the current NDC and other national and international communications obligations as may be necessary.

Education and awareness, and targeted research and development are essential across all sectors of Barbados, but are of particular importance in the water, health, agriculture and tourism sectors, where the impacts of climate change are inextricably linked. Cross-sectoral collaboration is vital to reinforce learning and promote sustainable practices, changes in behaviour and reduced vulnerability.

Integration of Climate Change Adaptation in Development Decisions

Barbados' Physical Development Plan (PDP) codifies the land-use development areas and supporting policy goals and objectives. Accordingly, the Plan is an important instrument in enabling the implementation of adaptation strategies that build climate change resilience into public and private developments. Scheduled reviews and updates of the Plan are informed by national growth and development strategies, vulnerability studies and risk assessments, and extensive public and private sector consultation. Where required, planning decisions are informed by environmental impact assessments that also address climate change concerns. The PDP is currently under review and through this process climate change vulnerability, adaptation and mitigation will be extensively considered for integration into the development planning.

3.6 Summary of Climate Change Impacts, Adaptation Options and Barriers

Table 3-2 below summarises the climate change impacts, adaptation options and barriers for each of the seven priority sectors - Agriculture, Water Resources, Human Health, Coastal Resources and Human Settlement, Tourism, Fisheries and Insurance.

Table 3-2 Climate Change Impacts, Adaptation Options and Barriers for Priority Sectors

Current and Expected Impacts	Adaptation Options	Time Scale[A]	Priority Rating[B]	Difficulties / Barriers to Adaptation
Agriculture				
Reduced yields and quality of produce and livestock due to: - **Rising air temperatures** - **Heat stress** - **Unpredictable rainfall patterns** - **Tropical storms and associated rain and wind** - **Flood events** - **Reduced water availability** - **Prolonged drought conditions** - **Pest and pathogen outbreaks**	1. Enhance prediction and planning to assist farmers in monitoring long-term climate information to make better-informed management decisions that anticipate climate variability and change.	Short	High	Limited availability of effective and efficient communication methods for farmers to adapt and protect their operations and crop viability during unfavourable conditions. Greater education in new technologies is required so that there is local capacity to implement and support the new agricultural policy.
	2. Increase research and development to improve adaptation efforts in the agriculture sector.	Medium	Medium	
	3. Improve stakeholder relations to strengthen cooperation between all stakeholders in agriculture and food production sectors.	Long	Medium	
	4. Improve technological innovation to facilitate all-year production of selected crops and enhance sustainability.	Medium	High	
	5. Improve incentives and support for farmers to encourage adaptive practices.	Long	Medium	
	6. Establish field schools for farmers where they can learn new 'climate-smart' farming methods and technologies in a hands-on manner.	Long	Medium	

Current and Expected Impacts	Adaptation Options	Time Scale[A]	Priority Rating[B]	Difficulties / Barriers to Adaptation
	7. Increase public awareness and education efforts amongst farmers to help combat the effects of climate change. These efforts should promote increased use of technology in agricultural production (to attract and maintain new talent in the sector), and provide updates to farmers on improved farming practices	Short	High	
	8. Promote environmentally sustainable farming practices to ensure that adaptation efforts will benefit the agriculture sector over the long-term.	Long	High	
	9. Make finance and insurance options more available to both large and small producers in the agriculture industry to help secure the future and growth of their operations.	Medium	Low	
Water Resources				
• **Contaminated groundwater after tropical storms or heavy precipitation from soil infiltration or pollutants flushed into aquifers through suck wells or sinkholes.** • **Salt water intrusion into coastal aquifers and sewerage systems due to sea level rise.** • **Long-term changes in**	1. Establish regulations and promote localised recycling schemes on a broader scale to relieve stress on groundwater resources (e.g. wastewater reuse in domestic and commercial establishments).	Long	High	The water sector is limited by financial and technical constraints affecting the efficiency of hydro-meteorological data collection networks and the replacement of ageing infrastructure.
	2. Design and implement a storm water management system for roadways and gullies to increase the volume of water available for aquifer recharge.	Long	Low	
	3. Conduct research to gain a greater understanding of the hydrogeological system and develop a dataset for use in modelling and informing legislation.	Medium	Medium	
	4. Develop and enforce additional measures to protect	Medium	High	

Current and Expected Impacts	Adaptation Options	Time Scale[A]	Priority Rating[B]	Difficulties / Barriers to Adaptation
seasonal weather patterns affecting the consistency of water supply. • **Increased demand for groundwater across sectors due to the effects of increased air temperatures**	water resources from contamination.			
	5. Use public education and awareness to influence changes in stakeholder behaviour in the areas of water governance, supply and usage.	Short	High	
Human Health				
• **Increased incidences of communicable diseases (dengue, leptospirosis), food- and water- borne illnesses (gastroenteritis)** • **Increased incidences of respiratory diseases** • **Increased prevalence of marine bio-toxins** • **Increased deaths, injuries or cases of infectious diseases and psychological disorders.**	1. Improve surveillance and monitoring systems through integrated vector management.	Medium	High	Disease early warning systems can only be developed when the necessary data becomes available.
	2. Establish early warning systems to provide timely detection of the onset of epidemics in vulnerable areas.	Long	High	
	3. Increase efforts in public education and awareness on to inform the general public and health care professionals about potential effects of climate change on health, and about the steps that can be taken to reduce risks.	Short	High	
Coastal Resources and Human Settlements				
• **Increased beach erosion** • **Permanent changes to**	1. Incorporate sea level rise, storm surge and flood zone mapping considerations into the amended Physical	Short	High	There is weak enforcement of existing regulations to manage coastal

Current and Expected Impacts	Adaptation Options	Time Scale[A]	Priority Rating[B]	Difficulties / Barriers to Adaptation
historical beach dynamics • **Damage to coastal property and sea defences** • **Declining coral reef health due to:** - **Rising sea surface temperatures** - **Increases in anomalous hot-water events** - **Accumulated heat stress** • **Increased severity of inundation and flooding as a result of both sea level rise and the intensification of storms.**	Development Plan.			areas. There is as heavy dependence on coastal areas, resources and infrastructure with conflicts of interest between users
	2. Coastal engineering defences must focus on creating resilient coasts	Medium	High	
	3. Amend the Town and Country Planning Act to require climate change considerations for all development.	Medium	Medium	
	4. Diversify livelihood options by developing a programme to help identify, establish, support and encourage economic diversification in coastal areas, promoting approaches that are environmentally friendly and suitable for local communities.	Long	Low	
	5. Develop insurance policies which give greater consideration to the long-term risks to coastal infrastructure to sea level rise and higher intensity of storms.	Long	Medium	
	6. Develop systems to manage and reduce the impact of localised stressors on coral reefs (e.g. activities of marine vessels and surface run-off).	Long	High	
Tourism				
• **Reduced tourist arrivals resulting from increased air temperatures and other perceived and actual climate change risks** • **Destabilisation of investment climates due to risks associated**	1. Promote the adoption of measures such as energy and water efficiency and conservation technologies as a means to reducing vulnerability associated with dependence on national systems.	Medium	High	The perception exists that the responsibility for implementing adaptation measures is that of Governments. Therefore property owners are reluctant to invest in adaptation measures that do
	2. Diversify the tourism market and develop the relevant branding and marketing strategies to counter the	Short	Medium	

Current and Expected Impacts	Adaptation Options	Time Scale[A]	Priority Rating[B]	Difficulties / Barriers to Adaptation
with damage to properties after storm events • **Destruction of ecosystem based tourist attractions (e.g. beaches, coral reefs, forests and gullies)** • **Increased risk of damage to tourism plants situated on coats due to sea level rise and storm surge.** • **Reduced and/or unpredictable rainfall patterns leading to water scarcity and impacting sanitation and health** • **Increased risk to human life due to increased intensity and frequency of storms and hurricanes**	competition from emerging markets.			not directly result in economic gains.
	3. Promote carbon neutrality in the sector in order to achieve zero net contribution of greenhouse gases and support other local sectors that can provide required goods and services.	Medium	High	
	4. Improve evidence-based management by conducting sector specific greenhouse gas inventories for activities such as transportation accommodation, attractions and recreational activities.	Medium	High	
	5. Formulate and adopt a National Adaptation Strategy for the Tourism sector to guide the policy, legal, economic investment, institutional and agency level changes necessary for adaptation to climate change.	Medium	High	
	6. Conduct vulnerability mapping and vulnerability assessments to improve the body of local knowledge utilized in decision-making.	Long	Medium	
Fisheries				
• **Shifting distribution patterns of many marine species towards more northerly regions or into deeper and cooler water.** • **Changes to spawning**	1. Mainstream climate change adaptation into fisheries management and planning through the development and/or implementation of effective governance and enabling policies.	Long	Medium	Appropriate methods to disseminate timely and relevant information to fisher folk.
	2. Strengthen the resilience of fisher folk to climate change impacts by increasing their awareness of the threats and	Long	Medium	Heavy dependence on coastal and marine areas to sustain livelihoods.

Current and Expected Impacts	Adaptation Options	Time Scale[A]	Priority Rating[B]	Difficulties / Barriers to Adaptation
seasons, reduced larval duration and higher mortality rates. • **Shifts in the seasonal migratory patterns of pelagic species.** • **Increased damages to critical property and infrastructure during storm events.**	access to information.			
	3. Reinforce or relocate shore-based fisheries facilities (markets and landing sites) to protect from intensified storm winds, storm surge and/or sea level rise.	Medium	High	
	4. Conduct targeted research to improve the understanding of changes in ocean currents and circulation, salinity, water temperature and chemistry within the Caribbean region, and the subsequent impacts of these changes on production, distribution, and species composition.	Medium	High	
	5. Safeguard coastal ecosystems by strengthening the management of nearshore fisheries and protecting/restoring key habitats.	Medium	Medium	
Insurance				
• **Anticipated increases in climate extremes will lead to higher risk costs and potentially higher costs of catastrophe losses, meaning higher insurance costs, and reduced insurability in the absence of tangible adaptation measures.**	1. The local insurance industry should improve its risk underwriting and ability to discriminate between properties for risk ratings and thereby encourage pre-insurance loss mitigation measures.	Long	High	The linkage between climate change adaptation and risk management is not made by the average citizen. Especially those have not been severely impacted directly by the effects of climate change.
	2. Establish systems for the collection and management of data required to inform societal decisions about risk management.	Long	Medium	
	3. Develop innovative insurance products that are accessible to the most vulnerable individuals and communities in Barbados, most of whom cannot	Long	Medium	

Current and Expected Impacts	Adaptation Options	Time Scale[A]	Priority Rating[B]	Difficulties / Barriers to Adaptation
	access the currently available suite of insurance products.			
	4. The Government of Barbados should adopt strict planning systems and promote safe building standards.	Long	Medium	
	5. Provide financial incentives for risk mitigation, thereby encouraging adaptation by policyholders.	Long	Low	

[A] Timescales for implementation of adaptation options are defined as: short-term, less than three years; medium-term, between 3 and 8 years; and long-term, greater than 8 years.

[B] The priority rating for adaptation options are based on:

- No-regret options, which contribute to sustainable development, create of enhance collaboration among sectors and synergies between initiatives, and avoid maladaptation;
- Interventions aimed at reducing current impacts and/or impacts expected in the near-future;
- Existing initiatives that serve as a basis for likely early implementation of actions; and
- Time-scale of the adaptation option, including the economic saving/protection and the cost for initial investment, including a cost-benefit analysis.

4 CLIMATE CHANGE MITIGATION ACTIONS AND POLICIES

4.1 Introduction

Over the last 30 years, global greenhouse gas emissions have increased by an average of 1.6% per year, with carbon dioxide increasing by 1.9% per year (IPCC, 2007). The increase in emissions is expected to continue. Adaptation actions alone could result in high social and economic costs, and therefore, mitigation policies are essential, even for nations with small emissions, such as Barbados.

The Caribbean region is responsible for significantly less than 0.01% of global greenhouse gas emissions. Nevertheless, Barbados is committed to implementing mitigation strategies to become a sustainable, low carbon economy that is also resilient to the effects of climate change. This relies primarily on diversifying Barbados' primary energy mix, which at present is largely dependent on imported fossil fuels.

Barbados' GDP is forecast to grow at an annual rate of 2% for the next five years (Central Bank of Barbados, 2017). This growth is expected to be realised through key economic strategies to increase the value from tourism, construction, and international business. Barbados' population is expected to increase by approximately 1.5% over the same period. These factors will increase Barbados' energy demand, so must be accounted for in the development towards a low-carbon economy.

The mitigation assessment provides a national-level analysis of Barbados' potential to decrease its greenhouse gas emissions through the enhancement of renewable energy and energy efficient technologies.

4.2 Barbados' Approach to Reducing Emissions

The Government of Barbados has used various approaches to formulate and prioritise programmes containing measures that would realise a decrease in greenhouse gas emissions. This assessment has benefitted from (i) the results of the 2010 National Greenhouse Gas Inventory (presented in Chapter 2 of this report); (ii) the results of the project to prepare a Sustainable Energy Framework for Barbados; (iii) the preparation of a Nationally Appropriate Mitigation Action (NAMA) for renewable energy and energy efficiency in Barbados.

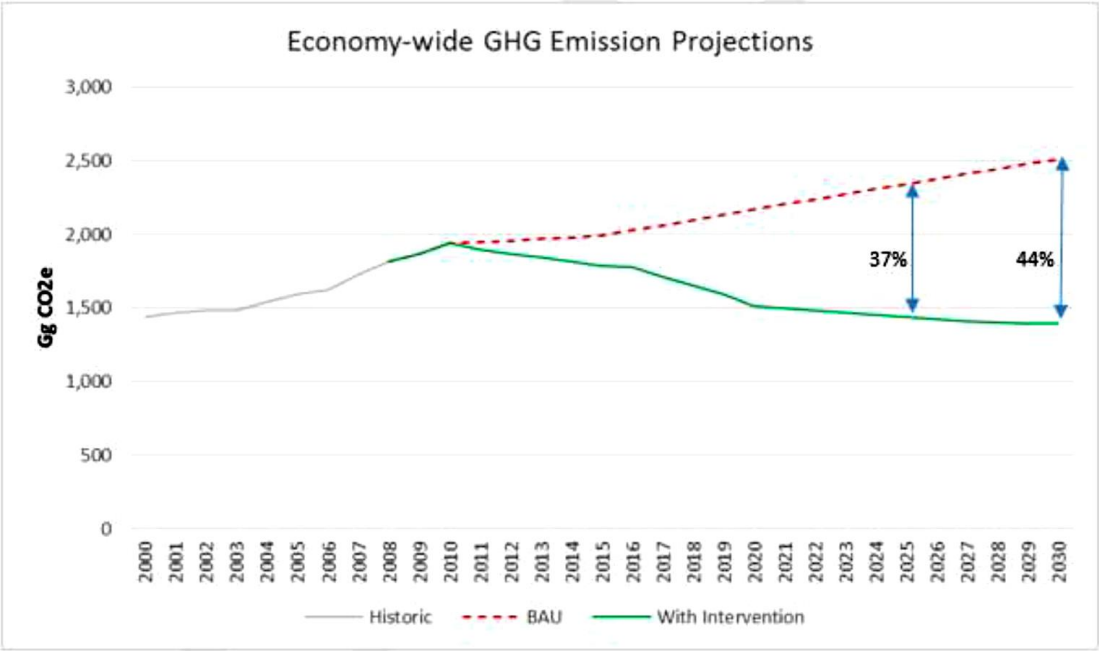
Multi-sectoral stakeholder engagement has been significant in developing the strategies and future opportunities to reduce greenhouse gas emissions. This has provided a strong starting point to create a range of mitigation options as well as to provide screening for current and proposed institutional or national strategies.

Barbados' Nationally Determined Contribution to the UNFCCC

With US$150,000 in support received from the European Union (EU) through the United Nations Development Programme (UNDP), Barbados was able to develop and submit its Intended Nationally Determined Contribution (INDC) to the UNFCCC Secretariat on September 28, 2015 in advance of the 21st Conference of the Parties (COP21) held in Paris, France in December 2015. With the ratification of the Paris Agreement in April 2016, Barbados' INDC became its Nationally Determined Contribution (NDC).

Barbados' NDC has communicated an intent to achieve an economy-wide reduction in greenhouse gas (GHG) emissions of 44% compared to its business as usual (BAU) scenario by 2030, and an interim target of 37% by 2025 (Figure 4.1). In absolute terms, these translate into reductions of 23% and 21% respectively when compared with 2008 as the base-line year. The NDC also highlighted that building climate resilience through adaptation was the priority concern for the country and that realizing the established targets would require technical and financial support from the international community.

Figure 4.1 Projected BAU and 'With Intervention' GHG Emission Scenarios for Barbados



4.3 Mitigation Actions Implemented

Financial Investment and Strategic Programmes for Energy Sustainability and Greenhouse Gas Mitigation

Significant strategies for energy reformation and sustainability have been developed to facilitate investment in sustainable energy initiatives. These strategies have been facilitated by the Government of Barbados and the Inter-American Development Bank (IDB). Programmatic Policy-Based Energy Loans have provided funding for the definition of a Sustainable Energy Framework for Barbados (SEFB) and other initiatives that fall thereunder. These include the Sustainable Energy Investment Programme/Energy Smart Fund; the Public Sector Smart Energy Programme (PSSEP); and the collection and presentation of promising investment opportunities in the more recent Nationally Appropriate Mitigation Actions (NAMA) for renewable energy and energy efficiency.

Barbados has also established a number of tax and duty free incentives to encourage the use of energy efficient and renewable energy technologies. These financial initiatives stimulate the research, analysis and practical implementation of sustainable energy initiatives which have and will continue to deliver greenhouse gas mitigation results as well as wider social, economic and environmental benefits.

Sustainable Energy Framework for Barbados

In February 2009, the Government of Barbados entered into a Technical Assistance Agreement with the Inter-American Development Bank (IDB) to provide assistance to develop a Sustainable Energy Framework for Barbados. The general objective of this project was to promote renewable energy (RE) and energy efficiency (EE) in Barbados, thus (i) reducing the country's dependency on imported fossil fuels, (ii) enhancing security and stability in energy supply, and (iii) improving overall environmental sustainability in the country. The specific objectives of this project, related to the respective project Components described below were:

- To help develop a Sustainable Energy Framework (SEF) for Barbados, and achieve institutional strengthening in the areas of RE and EE (Component 1);
- To help promote EE in the country's key sectors, and to implement energy efficiency pilot projects (Component 2);
- To help identify and promote the most effective alternatives for RE generation, and to implement renewable energy pilot projects (Component 3);
- To ensure wide dissemination of all project activities and results, thus contributing to improving information on sustainable energy practices in Barbados (Component 4).

The SEFB programme was specifically intended to (i) support the formulation of policy and legislation for the promotion of RE and EE and rational and efficient use of energy; (ii) encourage measures to promote the mitigation of GHG emissions as well as initiatives for climate change adaptation in the energy sector; and (iii) support institutional strengthening, capacity building, and public education and awareness to promote sustainable energy and energy conservation initiatives (Government of Barbados, 2010b).

The three key outputs from the SEFB were (i) the Sustainable Energy Investment Programme; (ii) the Public Sector Smart Energy (PSSE) Programme; and (iii) the Nationally Appropriate Mitigation Action (NAMA) for Renewable Energy and Energy Efficiency in Barbados. Collectively these were intended to facilitate the contribution of both the private and public sectors towards the achievement of reducing fossil fuel dependency.

The SEFB proposed that by 2029, 29% of energy consumed would be renewable energy and the remaining 71% would come from fossil fuels. Energy efficient technologies would lead to a 22% reduction of electricity produced by fossil fuels, which would reduce CO_2 emissions by 4.17 million tonnes, reducing the total electricity cost by US$283 million (Government of Barbados, 2010b) and monthly electricity bills by 15% to 20% (Government of Barbados, 2012b). This information proved to be highly valuable in shaping GHG emissions reduction targets arrived at and reported to the UNFCCC in the Barbados NDC document.

Sustainable Energy Investment Programme (Energy Smart Fund)

The establishment of the Sustainable Energy Investment Programme (also known as the Energy Smart Fund) comprised of a package of financial instruments (low-interest loans and grants) and technical assistance targeting small and medium enterprises to address the main market failures that prevent the country from adopting RE and EE (IDB, 2010). The US$10 million Energy Smart Fund was established in February 2011 and was publicly launched on 28 November 2011 with the six facilities detailed below:

- Technical Assistance Facility: provides grants to businesses for pre-investment studies of RE and EE projects to assess their technical and financial viability and support implementation (US$ 0.5 million);
- EE Retrofit and RE Finance Facility: provides subsidized loans to businesses for financing the implementation of viable RE and EE projects (US$6.0 million);
- Pilot Consumer Finance Facility: provides interest rate rebates or rebates on retail prices to selected retailers that offer low-interest hire purchase finance schemes for the purchase of RE and EE equipment (US$0.5 million);
- Compact Fluorescent Lamp (CFL) Distribution Facility: provides grants in the form of free CFLs to residential customers and other marketing strategies (US$0.5 million);
- Air conditioning (A/C) Rebate Trade-in Facility: provides grants in the form of a 50 percent rebate for households and businesses to purchase EE air conditioners, upon disposal of the old unit (US$1.5 million); and
- Discretionary Grant Facility: enables the Government (Energy Division) to undertake activities for institutional support to execute the Smart Fund, including public awareness and education campaigns, data collection, and monitoring of performance (US$1.0 million).

It was anticipated that the implementation of the Energy Smart Fund would promote the generation of at least 1 MW of RE-distributed generation and energy savings of at least 500 megawatt-hour (MWh), in addition to savings on electricity bills. The Energy Smart Fund will also increase self-generation of electricity and its sale to the grid, which, in turn, will lower the energy bills of the end users (IDB, 2010).

Public Sector Smart Energy Programme

The Government of Barbados established a Public Sector Smart Energy Program (PSSEP) designed to promote and implement the use of viable Renewable Energy (RE) and Energy Efficiency (EE) measures in the public sector. The PSSEP was supported by a US$17 million loan under the IDB agreement and a €5.81 million (approximately US$ 7.664 million) grant from the European Union (EU) under the 10th European Development Fund.

The PSSEP was comprised of the following three (3) major components:

- Component 1- Financed the retrofit of approximately 85% of public lights with EE technologies; the retrofit of selected government buildings with EE technologies; and the installation of solar PV systems on these government buildings.
- Component 2 - A pilot project and studies for encouraging the use of RE. This component financed the procurement of a fleet of government electric vehicles powered by RE sources to promote low carbon transportation technologies in Barbados.
- Component 3 - Capacity building, institutional strengthening and public awareness.

The Nationally Appropriate Mitigation Action

The Government has recognised the need to strengthen its capacity to plan and implement an emissions mitigation policy and prioritise mitigation options in the energy sector (Caribbean Network Service of Coalitions, 2011). As such, extensive research and analysis was conducted to develop a list of potential projects and their associated enabling actions to support Barbados' efforts to reduce its dependence on fossil fuels and contribute to climate change mitigation actions. These projects were prioritised and formulated as a NAMA document with the intent of registration with the UNFCCC. The criteria for prioritization and examples of the mitigation options proposed are presented in Table 4-1.

Table 4-1 Renewable Energy and Energy Efficiency Mitigation Options (identified through the NAMA)

Priority Projects	Alternate Projects	Long-Term Projects
• Development of a financing package, with the specific objective of directly or indirectly attracting international finance through the NAMA. • Design of projected emissions reduction plans and monitoring, reporting and verification plans in light of any expected uncertainty of support for the NAMA. • Projects with either sufficient base load to significantly help meet Barbados' renewable energy target or help to transform a sector. • Such as: ➢ Bagasse cogeneration with an option to use alternate feedstock; ➢ Energy efficiency for	• Standardised assessment of climate change impacts and adaptation and mitigation measures, with the objective of completing the description of the portfolio of climate-related projects that Barbados plans for the near and medium term. • Projects will not include a financing package; inclusion may help to attract financing for the priority projects by demonstrating Barbados' current or planned initiatives. • Project information will include a general description of mitigation potential and possible indicators for future monitoring and reporting. • Important projects that lack scale or are already receiving	• A preliminary assessment without a financing package, with the objective of demonstrating how Barbados can build on the priority projects and alternative projects to expand its sustainable development in the long-term, including new technologies. • Projects not currently financially viable, but may become so in the next 10–15 years. • Such as: ➢ Energy storage; ➢ Seawater air conditioning; ➢ Ocean thermal energy conversion; and ➢ Electric transport.

low-income homes, including solar water heating, lighting and appliances; ➢ Pilot of compressed natural gas buses; and ➢ Waste to energy.	significant financing. • Such as: ➢ Hotel EE and RE; ➢ Large-scale solar PV; ➢ Distributed solar PV; ➢ Large-scale wind; and ➢ Landfill gas.

Tax and Custom Duty Incentives

Barbados' energy pricing policy since 2006 has reduced taxes on renewable energy products. Since 2009, all imported renewable energy systems and related equipment (for example wind, solar PV, solar thermal, biomass and hydro systems), have been free of custom duties. Additionally, the duty on compact fluorescent lamps, house and attic fans, ceramic roof coatings and window tints was reduced to 5%. Excise taxes were also reduced from 120% to 46.9% for electric, hybrid and gas-fuelled (whether liquefied propane gases or compressed natural gases) motorised vehicles, as well as for certain diesel engines. Further incentives to encourage energy conservation include:

- A reduction of 20% to the cost of installing renewable energy and energy efficiency technologies over a five-year period, including undertaking energy audits and retrofitting residential or non-residential buildings or installing a system to provide electricity from non-fossil fuel sources (Government of Barbados, 2009a).
- A deduction of 150% of the actual expenditure from the assessable income of an individual or business owner who conducts an energy audit.
- A deduction of the amount spent on renewable energy and energy efficiency systems training and/or the interest paid on loans by a minor or an adult 25 years or under, who is pursuing a course of study in renewable energy or energy efficiency systems at an educational institution. In addition 150% of the interest paid on a loan for the construction of a new facility or the renovation of an existing property to facilitate the generation, supply and sale of electricity from a renewable energy source or energy efficiency products will be deducted (Government of Barbados 2013b).

Barbados Electric Light and Power Act, 2013

The Electric Light and Power Act 2013 (ELPA) is "an Act to revise the law relating to the supply and use of electricity, to promote the generation of electricity from sources of renewable energy, to enhance the security and reliability of the supply of electricity and to provide for related matters". It replaced the original 116 year old Electric Light and Power Act which was passed in 1899 and was further amended 2015. The Act came into full effect after an Intermittent Renewable Energy Penetration Study was conducted to determine the capacity limits for central solar PV and wind. Independent power producers have to apply and be issued with a licence to facilitate grid interconnection.

Between 2013 and 2017, through the ELPA, the Government of Barbados facilitated 27 MW of Installed Capacity of renewable energy to the national electricity grid, producing approximately 37.7GWh. This represents 3.9% of total electricity on the national electricity grid.

Barbados Light and Power Co. Ltd Renewable Energy Rider (RER) Programme

The Renewable Energy Rider (RER) was established to facilitate the sale of surplus electricity generated by Barbados Light & Power Co. Ltd.'s customers through distributed RE systems. The RER was reviewed in July 2016 to address RE suppliers' and installers' concerns regarding the low value of the RER credit, as occasioned by low international fuel prices, and the viability of the RE sector. A decision was made to (i) increase the eligible capacity limit to 500KW per supplier; (ii) use the resource cost approach to determine RER credit, as it adequately disaggregates RE costs from the cost of fossil fuels; and (iii) set the temporary RER credit at $0.416/ kWh for solar PV and $0.315/kWh for wind until such time as a permanent rate may be established. This credit will apply to RE suppliers with capacities up to 500 kW and is subject to Section 13 of the Electric Light & Power Act (ELPA) 2013-21 and Section 46 of the Fair Trading Commission Act.

Other Mitigation Actions

In addition to the national mitigation strategies and actions, Barbados' private sector has implemented a number of other measures that would result in the reduction of the national GHG emissions profile. Among several others, examples of these include the following:

- In June 2009, the Sustainable Barbados Recycling Centre began operations with the objective of diverting waste from the sanitary landfill and has succeeded in diverting approximately 70% of all solid waste to be reused or recycled.
- Biodiesel production: In the first quarter of 2010 Amelot Oil Barbados Limited recycled over 9,500 litres (2,500 gallons) of used cooking oil into biodiesel.

  The Caribbean Hotel Energy Efficiency Action (CHENACT) Project (2009-2010) sought to improve the competitiveness of small and medium sized hotels (<400 rooms) in the Caribbean Region through improved use of energy with the emphasis on the integration of renewable energy and micro-generation. A pilot project was undertaken in Barbados and energy assessments were conducted on 64% of all licenced hotels. The savings potential in the hotel industry calculated based on these assessments equates to approximately 27 million kWh total annual savings in electricity consumption and an annual reduction of greenhouse gas emissions of 18,800 tons CO_2e. These audit reports and estimates of savings are intended to encourage hotel owners to retrofit and upgrade hotel plants to integrate renewable energy (RE) and energy efficient (EE) technology.

The second phase of CHENACT, the CHENACT-Advanced Program has developed and registered a Programme Design Document (PDD) with the UNFCCC Clean Development Mechanism (CDM) through which hotels and other tourism accommodation facilities across the region could formulate their respective Program of Activities (PoA) for funding support.

4.4 Proposed Mitigation Actions

Along with the projects identified in the Barbados Energy NAMA a number of actions have been identified within the energy, transport and waste sectors that could contribute to the further reduction of Barbados' GHG emissions and achieving the mitigation targets communicated in the NDC.

Biomass Cogeneration

The Barbados Cane Industry Corporation (BCIC) is in the planning stages of a proposed action to renovate and upgrade the Andrews Sugar Factory and consolidate all sugar production at this location (Government of Barbados, 2010b). The proposed 25 MW biomass cogeneration system will supply the factory's energy needs and the sale of any excess to the BL&P.

Mangrove-Pond Green Energy Complex

In an effort to manage solid waste and create energy options for the country, the development of the Mangrove Pond Green Energy Complex was approved in 2012. The complex was planned to include:

- A 14 MW municipal solid waste-to-energy facility that would reduce the amount of waste entering the landfill by approximately 72.5% and significantly expand its operational life.
- A landfill gas collection and management system to capture methane from the existing landfill. The NAMA studies estimated that sufficient gas could be captured to generate an average of 1.3 to 1.5MW of energy per year over a period of 10 years.

Renewable Energy Strategies in the Agricultural Sector

The Government of Barbados has recognised that it can expand its agricultural strategy into energy production with the added benefit of GHG mitigation. The following initiatives are being considered to be promoted widely through projects and programmes directed at moving toward energy-based forms of agriculture:

- Generating biogas from livestock manure; and
- Using solar and wind energy to power crop irrigation systems, machinery, poultry farms and cooling systems for livestock.

Some of these initiatives are currently being implemented on a small scale, are valuable contributions toward increasing the agricultural sector's adaptive capacity and self-sufficiency and represent valuable contributions to reducing Barbados' GHG emissions profile.

Renewable and Alternative Energy-powered Streetlights

Renewable energy technologies exist that are highly viable, are inexpensive and are very suitable to replace conventional high-pressure sodium street lights (e.g. spectrally enhanced magnetic induction lighting technology, light-emitting diode (LED) street lighting and LED street lighting with solar panels). The uptake of RE-powered streetlights could help reduce the current government subsidy for street lighting and maintenance (Government of Barbados, 2010b).

Solar PV System Energy Generation

Barbados' leading position in the installation of solar water heating systems should have allowed for greater penetration of solar PV systems on their introduction to the local market. However, solar PV systems have not seen widespread use due to their previously higher cost compared to other options. Fortunately, they are becoming increasingly more viable thanks to changes in the cost and technology (Schwein, 2010). The cost of solar power is expected to continue to decrease.

Wind Energy Generation

BL&P carried out a feasibility study for the establishment of a wind farm and projected that the facility would generate approximately 26 million kWh and would save US$4.6 million annually (Affonso, 2010).

4.5 Constraints and Gaps to Implementation of Mitigation Actions

Capital Investment and Funding

Despite the availability of a variety of renewable energy sources in Barbados, the high initial cost of technology has for a long time constrained the investment required for a comparable level of adoption to that experienced with solar water heating. The Barbados NDC communication recognized this as a significant concern and specifically cited the availability of technology and finance from international sources as pre-conditions to meeting the stated GHG emissions reduction targets.

Technical Capacity Building and Research

To ensure the presentation and enforcement of renewable energy initiatives, it is essential to build an expert and well-trained workforce across the public and private sectors. Appropriate target groups for the required capacity building initiatives would, among others, include project developers, financiers, engineers and technicians, Government policymakers and planners, and utility staff.

As revealed primarily through the GHG Inventory, improving the accuracy and accessibility of national data is a key and necessary requirement to support decisions on the prioritisation, planning and purchase of renewable technologies, as well as the creation of skills for effective monitoring, reporting and verification of actions undertaken. Added to this, continuous national research and development of renewable energy and energy efficient technologies should occur in the tandem with the constant and rapid evolution of the industry at the global level.

Public and Private Sector Partnership

Historically, the bulk of the burden of climate change responses has been with the Government. With the recent renewable energy thrusts, private sector initiatives have emerged that have largely focussed on meeting individual energy needs and offsetting the cost of buying electricity. Meeting the NDC emissions reductions targets can be furthered through effective private and public sector partnerships. Joint public-private renewable energy enterprises and governmental subsidies for private renewable energy projects are actively being pursued by the Government.

Developing New Renewable Energy Technology

Barbados is actively investigating the applicability of some of the newer renewable energy technologies to support its overall goals for the sector. Some of these technologies include:

- Seawater air conditioning (SWAC): Air conditioning is one of the major energy consumers particularly in the tourism sector. SWAC installations can reduce energy usage by up to 85%.
- Ocean thermal energy conversion (OTEC) is a system that uses the differences between surface and deep-water temperature to generate energy via condensation and evaporation. The technology is readily available and has low operation and maintenance costs.
- Wind energy has real potential for Barbados and is being further investigated by Barbados' main energy provider.

If proven to be feasible considerations for Barbados, with the supporting investments it is anticipated that these may feature in the more advanced stages of the diversification of the of the energy production matrix as well as raising the level of ambition for GHG emissions reduction in future NDC submissions to the UNFCCC.

5 OTHER INFORMATION RELEVANT TO THE ACHIEVEMENT OF THE OBJECTIVE OF THE CONVENTION

5.1 Integrating Climate Change into Social, Economic and Environmental Policy

Since the completion of the First National Communication in 2001, the Government of Barbados has been involved in several national initiatives and programmes that have directly or indirectly integrated measures to mitigate or adapt to climate change. This has resulted in the inclusion of climate change considerations into the process of preparation of national policy documents, such as:

- Barbados Sustainable Development Policy;
- National Strategic Plan of Barbados 2006–2025;
- Barbados Growth and Development Strategy 2013–2020.
- Draft National Sustainable Energy Policy;
- Draft National Climate Change Policy Framework;

Additional programmes and initiatives where climate change adaptation and mitigation measures and considerations have been mainstreamed include:

Barbados National Action Programme (NAP) to Combat Desertification and Land Degradation and to Mitigate against the Effects of Desertification, Land Degradation and Drought

Barbados' commitments to UNCCD and its National Action Programme contribute to the effort of climate change adaptation as it focussed on combatting land degradation in the Scotland District, which had been identified as the most critically affected area. The focus of the programme gradually expanded to include preventive measures taken throughout the island and covered four thematic areas: agriculture, settlements, resource use and conservation. Barbados is currently in the process of preparing an updated NAP for submission the UNCCD.

The National Biodiversity Strategy and Action Plan (NBSAP) for Barbados to the United Nations Convention on Biological Diversity (CBD)

Climate change may exacerbate existing threats to biodiversity, including pests and disease, drought, excessive rainfall, pollution, environmental stress and unsustainable practices. Barbados' initiatives under the Convention on Biological Diversity (CBD) aim to produce climate change co-benefits along with maintaining biological diversity, through:

- Ensuring the integrity of important landscapes, seascapes and protected areas;
- Ensuring the effective conservation and improvement of the island's coastal and marine resources;
- Promoting sustainable land management; and
- Promoting the control of natural biological disease vectors.

The National Biodiversity Strategy and Action Plan (NBSAP) and National Reports submitted to the CBD communicated actions to be undertaken to further understand the influence that climate change has been having on local biodiversity resources and to inform the development of appropriate policies and measures in response. These include the following:

- Developing and implementing a consistent monitoring and surveillance programme to document and assess information on the influence of climate change on fish stock lifecycles;
- Assessing the effects of climate change on biodiversity conservation and management; and
- Implementing projects aimed at adaptation that integrates biodiversity conservation and sustainable use, referred to as 'ecosystem-based adaptation'.

Montreal Protocol on Substances that Deplete the Ozone Layer

Since acceding to the Montreal Protocol in 1992, Barbados has taken action to comply with the phase-down and phase-out schedules established to reduce global production and consumption of Ozone Depleting Substances (ODS). Several ODS, such as chlorofluorocarbons (CFCs), halons and carbon tetrachloride have been phased-out nationally and globally in compliance with the 2010 target. ODS are not produced in Barbados.

Currently, the consumption phase-down of the remaining ODS (hydrochlorofluorocarbons-HCFCs) is underway through Barbados' HCFC Phase-out Management Plan (HPMP) Phase 1. The HPMP programme is on target to meet the 35% reduction in HCFC consumption by 2020 defined under the Protocol for developing countries.

The Government of Barbados promotes the use of technologies with low global warming potential (GWP) and high energy efficiency to achieve ODS reduction with climate change co-benefits (UNEP, 2013). In September 2016, the Parties to the Montreal Protocol agreed to the Kigali Amendment to manage the growth in production and the ultimate phase-out of Hydrofluorocarbons (HFC) as a consequence of their being highly potent GHGs. As a party to both the Protocol and the UNFCCC Barbados has initiated steps to ratify the Kigali Amendment and undertake the domestic measures required for compliance with the provisions for developing countries.

White Paper on the Development of Tourism in Barbados and Tourism Master Plan

The 2012 White Paper on the Development of Tourism in Barbados was prepared to inform the Tourism Master Plan 2014–2023, including implementing the government's vision for a more sustainable tourism industry. One component of the White Paper focuses on sustainable and responsible tourism, recognising that it requires planning and management to promote and sustain the efficient use of resources while minimising the effects of climate change and other natural hazards. Significantly, the White Paper indicates, inter alia, the government's recognition of the economic importance of the coastline and its commitment to managing and preserving this resource from the risks associated with climate change and other natural disasters (Government of Barbados, 2012a).

Barbados' Green Economy Scoping Study

In alignment with the National Strategic Plan of Barbados 2006-2025, in 2010 the Government of Barbados formalized a partnership with the United Nations Environment Programme for 'Building a Resource-Efficient Green Economy in Barbados'. In collaboration with the University of the West Indies, Cave Hill Campus, the GOB and UNEP commissioned a Green Economy Scoping Study to undertake a macro analysis of Barbados' economy to consider the necessary steps to move towards a greener economy and the net benefits that might accrue. The priority sectors examined included – agriculture, fisheries, building/housing, transportation and tourism and considered the cross-cutting issues of waste, water, energy and land resources. The scoping study resulted in the presentation of policy, investment and governance options for consideration as Barbados furthers the integration of environmental considerations into social and economic policies (Moore et al., 2012).

Global Environment Facility (GEF) Small Grants Programme (SGP)

Through the national GEF SGP, between 2004 and 2010, 28 projects were undertaken by civil society organisations (CSO's) in Barbados with a total investment of approximately US$1.24 million (GEF SGP, 2013). In the 2010–14 GEF programme cycle, the Government of Barbados allocated US$1 million of its GEF Trust Fund resources provided for by the System of Transparent Allocation of Resources (STAR) to support all focal areas of the national GEF SGP programme. As of December 31st 2016, SGP Barbados achieved a cumulative commitment of US$1,965,455.62 for Operational Phase 5 for 52 projects.

Some of the community based climate change projects engaged in over 2010 to 2015 include:

- Building Climate Change Resilience in Community Fisheries in Weston, St. James (2014– 15);
- Coastal Conservation Education: Protecting Barbados' Coral Reefs (2014–15);
- Community-Based Solar Cooled Greenhouse Research Project (2013–15);
- Greening Micro, Small and Medium-Sized Enterprises in Coastal Communities in Barbados (2013–15);
- Promoting Renewable Energy Production in Farming Communities in Barbados (2013–15);
- Solarisation of the Baird's Village Aquaponics Facility (2010–11).

Climate Smart Community Disaster Management Programme

In order to promote and build capacity for integrating climate change adaptation into community disaster management in the Caribbean, the Caribbean Disaster Emergency Management Agency (CDEMA) formulated the Climate Smart Community Disaster Management Programme, 2009–2011. This programme contributed to, and complemented, the policy framework set out in 'Climate Change in the Caribbean: A Regional Framework for Achieving Development Resilient to Climate Change 2009–2015' which was produced by the Caribbean Community Climate Change Centre and endorsed by the CARICOM Heads of Government (CDEMA, 2011). Through this initiative Barbados developed its Comprehensive Disaster Management (CDM) Climate Smart Country Work Programme (CWP) document with the Department of Emergency Management as the national lead agency.

Needhams Point Bridgetown Declaration, 2013

In August 2013, at the inter-regional preparatory meeting for the Third International Conference on Sustainable Development of Small Island Development States, the ministers and heads of delegations agreed to the Needhams Point Bridgetown Declaration The declaration reaffirmed the special need for sustainable development in SIDS due to their unique vulnerabilities, including suffering from the adverse impacts of climate change. The declaration commits the countries to address climate change by implementing targeted actions and mobilising resources.

5.2 Activities Related to Technology Transfer

The Barbados NDC cites access to appropriate technologies as a vital precursor to meeting the reported GHG emissions reduction targets and adaptation needs. In the face of high costs associated with the generation of energy from fossil fuels and national commitment to integrate renewable energy sources into the energy production matrix, Barbados has engaged in several regional and global initiatives aimed at facilitating technology development and transfer in the renewable energy sector. Some of these are highlighted below.

Sustainable Energy for All

The Barbados Declaration on Achieving Sustainable Energy for All (SE4All) in Small Island Developing States, 2012 recognised the collective capacity of SIDS to develop renewable energy to meet existing and future needs. The Declaration affirms the commitment by SIDS to work towards continued development and implementation of policies and plans to ensure the transformation of the current fossil fuel based energy sector to a modern, affordable and efficient renewable energy sector. This follows Barbados' commitment to becoming a green economy and its plan to increase the share of energy generated from renewable sources. The Declaration also acknowledges the role of the International Renewable Energy Agency (IRENA) of which Barbados is a member, in supporting SIDS in their efforts to accelerate renewable energy deployment including access to the technologies required to do so.

Small Island Renewable Energy Knowledge and Technology

The Cave Hill Campus of the University of West Indies (UWI) collaborated with universities from Germany, Fiji and Mauritius on an information exchange and networking initiative called the Small Developing Island Renewable Energy Knowledge and Technology Transfer Network (DIREKT) project. Funded by the European Union, the project was aimed at strengthening the science and technology capacity in the field of renewable energy within certain SIDS in Africa, the Caribbean and the Pacific.

In 2012, DIREKT established the Renewable Energy Demonstration Facility within the Faculty of Pure and Applied Sciences at the Cave Hill Campus. Its mission was to transfer innovative knowledge on renewable technologies to the university community, decision makers, private sector, other educational institutions and wider society. The responsibilities of the demonstration facility include:

- Conducting tests on selected renewable energy technologies to evaluate their performance in the Barbadian and Eastern Caribbean;
- Demonstrating the operation of different renewable energy technologies to stakeholders; and
- Building capacity in the renewable energy sector through training.

Tests have been performed at the facility on fixed solar PV systems; single-axis tracking PV systems; vertical axis wind turbines; and simpler renewable energy technologies such as solar cookers, dryer stills, solar water heaters and solar mobile generators.

5.3 Climate Research and Systematic Observations

The National Climate Change policy Framework references the conduct of climate research as one of its main objectives. This recognized the high national data needs for climate science investigations and policy formulation, as well as the limited local capacity historically allocated for data capture, data management, and interpretation and reporting. The following represents several of the ongoing national and regional initiatives in climate research that could facilitate improvements in the current condition.

Participation in activities and programmes of national, regional and global research networks and observing systems

The Barbados Meteorological Service (BMS) has responsibility for monitoring and prediction, data processing, weather services, climate services, hydrological services, and research. Research includes national and regional meteorology and climate studies. The island's climatological network consists of two main climatological stations located at the BMS and the Caribbean Institute of Meteorology and Hydrology (CIMH). The CIMH serves as the clearinghouse for current and archived meteorological and hydrological data from member countries of the Caribbean Meteorological Organisation. Data records at the BMS and CIMH date back to about 1930 and 1970 respectively and have therefore been used to identify trends in climate parameters as well as inputs to climate models.

Barbados' S-band Doppler Weather Radar, obtained in 2008 through the Caribbean Meteorological Organisation (CMO), CARIFORUM Project, is one of the six S-band Doppler radars that constitute the CMO Weather Radar Network. The S-band Doppler Weather Radar is used for the observation of severe storms and hurricanes in the tropics. Information from the S-Band Doppler weather radar in Barbados is important in national forecasts and warnings issued

by the meteorological and hydro meteorological services of the Caribbean Meteorological Council. It complements other surface and satellite-based weather observing platforms as part of the regional early warning system.

Automatic weather stations (AWS) are deployed across Barbados which increases the number and reliability of surface weather observations. The AWSs transmit real time weather data on rainfall, air, dew point temperature, relative humidity, wind speed, wind direction and solar radiation. Additionally, BMS has a radiosonde AWS used to simultaneously measure and transmit meteorological data while ascending through the atmosphere.

The BMS is a participant in the Global Sea Level Observing System, which coordinates global monitoring of the sea surface. The Coastal Zone Management Unit in collaboration with BMS installed and calibrated a global positioning system to collect local sea surface data, which is submitted to the United States National Oceanic and Atmospheric Administration (NOAA) for processing.

The SIDS-Caribbean Project: Preparedness to Climate Variability and Global Change in Small Island Developing States of the Caribbean Region

The SIDS-Caribbean Project was undertaken in 2000 with the main objective of providing tools for better planning for sustainable development in the Caribbean region. The project provided a cooperative approach for the uptake of new skills and tools for National Meteorological and Hydrological Services (NMHS) and Disaster Management Agencies (DMA) for further development the Multi-Hazard Early Warnings Systems (MHEWS) in the region. It strengthened the capacity of these entities to generate information needed for planning at the national and international level and the necessary expertise that would assist countries with the fulfilment of commitments to agreements such as the UNFCCC, UNCCD, the CBD and the Vienna Convention for the Protection of the Ozone Layer. Some of the major achievements under the project were:

- Improvement of the Emergency Managers Weather Information Network, a regional telecommunication system;
- Rehabilitation and upgrade of the Automatic Weather Station observation network;
- Renovation of the regional laboratory at CIMH to ensure the accurate calibration and maintenance of instruments;
- Upgrade of the climatological database information system for meteorological services around the world (CLIDATA);
- Implementation of data rescue programmes; and
- Provision of training activities and awareness building campaigns.

Strengthening Hydrometeorological Operations and Services in the Central America and the Caribbean (SHOCS-II)

SHOCS-II was formulated in 2013 to implement a set of activities that would best complement the on-going work in the region. Barbados participated in the second phase of the project with the aim of enhancing the role and strengthening the capacity of National Meteorological Hydrological Institutions and Disaster Management agencies. Under the Project, one of the three SmartMet workstations was setup in Barbados, which enhanced the suite of tools for weather forecast production. In 2014 the project resulted in improved operational capacity of the Caribbean NMHS weather observation network, in which hardware and software were designed for data retrieval, data quality control and metadatabase.

Caribbean Drought and Precipitation Monitoring Network

The CIMH, through the Caribbean Drought and Precipitation Monitoring Network (CDPMN), has undertaken drought monitoring for the Caribbean Basin and at the national level in Barbados. The goal of CDPMN is to create a culture of rainfall monitoring to combat the negative impacts of climate extremes and future climate change. The CDPMN monitors climatic and biological indicators, which aid in predicting drought conditions and inform appropriate preparation and response actions and resource mobilisation. The Standard Precipitation Index and deciles are calculated for one-, three-, six- and 12-month intervals, which allows for prediction and assessment of short, medium and long term impacts of drought. Only rainfall indices have been used for monitoring in the Caribbean Basin.

The CDPMN also facilitates the collection and compilation of relevant climate information by CIMH from Caribbean meteorological offices as well as from the European Centre for Medium-Range Weather Forecasts, the International Research Institute for Climate and Society and the United Kingdom Meteorological Office.

Caribbean Regional Climate Outlook Forum

In 2010, CIMH established the Caribbean Regional Climate Outlook Forum (CariCOF) in collaboration with 18 national weather services to assess shifts in the amplitude and phases of seasons. In 2012, CariCOF produced its first region-wide, consensus-based, seasonal climate outlooks. These outlooks include tercile rainfall forecasts, sea and air surface temperature forecasts, and drivers of seasonal climate variability in the region, such as El Niño Southern Oscillation or tropical Atlantic and Caribbean sea temperatures. Statistical models, such as canonical correlation analysis run with the Climate Predictability Tool, provide tercile rainfall forecasts at the weather station scale and are used in the preparation of national and regional forecasts.

Climate Modelling, and Impact and Economic Modelling Implementation Plan (2011–21)

Various research institutions in the Caribbean region are collaborating on the Climate Modelling, and Impact and Economic Modelling Implementation Plan (2011–21). Its outputs will assist decision-makers in the public and private sectors in understanding predicted changes in climate, their impacts, and socio-economic effects in the region. The University of West Indies is conducting 25-kilometre simulations using the Providing Regional Climates for Impacts Studies (PRECIS) modelling system, in the small islands in the Eastern Caribbean (Charley and Nurse, 2014; Caribbean Community Climate Change Centre, 2011).

Caribbean Cluster on Natural Risks and Risks from the Sea

Since 2013 the CMO has been collaborating with the Meteorological Service of France under the European Union funded project, "Caribbean Cluster on Natural Risks and Risks from the Sea (Carib Risk Cluster)". A major component of the Carib Risk Cluster is the implementation of SHERPA, which is a secured web exchange platform in real time to share and make available products and information useful to the analysis and to the forecasting of potentially dangerous meteorological phenomena in the Caribbean. The first international seminar was held in 2014 where a cooperative agreement to address risk reduction across the region was signed between the General Council of Martinique and the CDEMA.

5.4 Education, Training and Public Awareness

There have been national initiatives in the areas of environmental education and public awareness headed by the Ministry responsible for the environment through the Environmental Education Committee. This committee was constituted to create and implement public relations strategies to support the interaction of the ministry with various audiences on issues related to the environment, including climate change. It has been actively involved in planning and executing the 'Environment Month Celebration' each year, and the Minister of Environment Award to "*recognise and reward the excellent achievements that organisations and individuals have made in the facilitation of environmental works, innovation and enterprise, that have helped protect and sustain the environment and the natural resources of Barbados*" (Government of Barbados, 2010c).

In 2006, the Ministry responsible for the environment conducted a climate change knowledge survey to determine the level of knowledge of, and concern about, climate change. The results from the survey showed that:

- 90% of respondents had heard about climate change, although 20% of the children surveyed stated they had not heard of it;
- 57% of both adults and children defined 'climate' as synonymous with 'weather' and did not distinguish between the two concepts in terms of time frames and patterns;
- More than 40% of children interviewed seem to be partially or poorly informed about climate change, and most children said they learned about climate change at school;
- 44% of respondents stated that the government should deal with climate change; and
- 26% of respondents stated that climate change should be dealt with by everybody.

The Barbados Government Information Service has increased public awareness through public service announcements conveying information on climate change and other environmental issues. Presentations have also been delivered through interactive activities including hikes, coastal walks and bus tours. In the formal education system there is no established curriculum on climate change, although the curricula for geography and integrated science contain some related material. However, various environmental clubs have been established within schools around the island which have developed relationships government entities and NGOs which provide information on and opportunities to participate in climate change related regional and international initiatives. Upon requests, the MED delivers climate change presentations to a broad range of national stakeholders.

Caribbean Youth Environment Network

The Caribbean Youth Environment Network (CYEN) offers opportunities for education and training on climate change. Its website hosts a number of training modules, accessible to the public. The CYEN hosted a regional event in partnership with 350 organisations entitled the 'Day of Action Campaign', to raise awareness of climate change in the media and influence the political process prior to the Conference of the Parties to the UNFCCC in Copenhagen in December 2009. The organisation also executed the 'Caribbean Youth Climate Change Mitigation Project' to bring awareness to Caribbean youth about the impacts of climate change on national development (CYEN, 2014).

The Barbados Chapter of the CYEN holds membership on the National Climate Change Committee and is one of the most active CSO groups on the island. The group is well known for the innovative public education and awareness exercises that they conduct each year to draw attention to climate change and other environmental management concerns of relevance to Barbados. With assistance provided by the MED, national CYEN representatives have participated in the youth forums at a number of the UNFCCC Conference of the Parties.

5.5 Capacity Building, Information Sharing and Networking

Since August 2005, the CCCCC has been the main regional institution responsible for providing information on climate change and support for the Caribbean region's response to its challenges. The framework document 'Climate Change and the Caribbean: Regional Framework for Achieving Development Resilient to Climate Change (2009-2015)' defines CARICOM's strategic approach for coping with climate change. It is guided by five strategic elements and twenty goals designed to significantly increase the resilience of the CARICOM Member States' social, economic and environmental systems. The Implementation Plan (IP) that supports the framework, 'Delivering transformational change 2011-21: Implementing the CARICOM Regional Framework for Achieving Development Resilient to Climate Change' advanced the following as its main operational features:

- Establishing how regional and country bodies will work together;
- Securing investment to support the action plan;
- Proposing a monitoring and evaluation system; and
- Obtaining buy-in from Governments and relevant funders across the region.

Barbados has participated in several regional exercises that address common regional capacity needs, including:

- Enhancing existing knowledge and skills in advocacy and awareness on climate change;
- Improving knowledge and skills in integrated water resource management;
- Improving community disaster risk response;
- Promoting the practical application and use of renewable energy; and
- Use of Caribbean Climate Online Risk and Adaptation Tool (CCORAL).

The CCCCC has been mandated through the IP to analyse and disseminate information and promote the sharing of resources, technical cooperation and information exchanges with other global climate change initiatives, particularly in SIDS and the Americas. Its website serves as a clearinghouse for such information.

6 CONSTRAINTS AND GAPS, AND RELATED FINANCIAL, TECHNICAL AND CAPACITY NEEDS

6.1 Constraints and Gaps

In addition to the information presented in sections 2.8, 3.6 and 4.5, the following information highlights the constraints and gaps identified during the process of preparing this SNC. Many of these are similar to those identified in the FNC and highlights the significant constraints under which SIDS are required to operate.

Financial Needs

Barbados' small economy requires that access to domestic climate finance directly competes with the needs to support other national development programmes and is therefore severely limited relative to the urgency of the response needs. In this regard, efforts are ongoing to enhance the domestic framework and capacity to engage with the many international climate finance mechanisms that are available with a view towards improving access for the purposes of expediting the actions to meet the NDC targets and enhance the resilience of the economy to climate change.

Lack of Data and Information on Critical Sectors

Barbados lacks sufficient protocols for the collection and storage of environmental data to ensure consistent quality. Data is often stored in various formats at many different locations, making it difficult to assimilate in order to inform and guide decision making. In addition, this significantly limits the ready availability of key variables and/or indicators required to inform

analysis of (i) the impacts of climate change on critical sectors; (ii) sectoral contributions to the national greenhouse gases emissions profile, and (iii) the timely development (or adjustment) of policies and programmes.

Greenhouse Gas Inventory

Several gaps in data required to establish national emissions factors and more accurate emissions estimates to inform the National Greenhouse Gas Inventory were highlighted. In response to this, a Greenhouse Gas Inventory Management Framework and User Guide was developed in order to assist with the development of local expertise to establish systems for data collection, management and storage and the compilation of future inventories.

Mitigation Actions

Several policies and mechanisms to support actions aimed at reducing Barbados dependence on energy derived from fossil fuels have been developed. However, there is still a need for further research on technology associated with alternative sources of energy, their suitability and feasibility for implementation giving consideration to the current social and economic environment.

Adaptation Actions

Barbados has identified through its submitted Nationally Determined Contribution that Adaptation is its priority and as such, there is a need for a mechanism to be established to facilitate regular comprehensive vulnerability assessments of key social and economic sectors. The resulting information from these assessments would be critical for the development of adaptation plans to build the resilience of these sectors to the effects of climate change.

6.2 Technology and Capacity Needs

The implementation and execution of projects and programmes associated with climate change adaptation and mitigation strategies for Barbados depends on a local pool of skill and expertise to manage and maintain relevant technology. In addition to the information presented in sections 2.8, 3.6 and 4.5, this section highlights the technology and capacity needs required to efficiently address climate change related issues and satisfy the objectives of the Convention. These needs should be addressed with significant emphasis on continuous skill development and institutional strengthening.

Monitoring, Reporting, Verification and Evaluation

There is a lack of institutional capacity to fully support the implementation and monitoring of adaptation and mitigation measures nationally. Currently, a monitoring, reporting and verification (MRV) system is being designed to support the implementation of measures contributing towards emissions reduction targets communicated though Barbados' Nationally Determined Contribution to the UNFCCC, as well as to capture key information on adaptation measures and finance flows to gauge the extent to which progress is being made to build climate resilience into the economy.

Climate Change Policy and Legislation

Although some progress has been made to strengthen the policy and regulatory framework for implementing adaptation and mitigation practises to climate change (e.g. the amended Physical Development Plan), there are still critical inadequacies hindering widespread implementation. Though there is no dedicated climate change legislation, diverse opportunities are available to address mitigation and adaptation actions. These may be discerned from the sectoral statues and associated policies that are available in-so-far as these address sound and responsible management.

6.3 Financial resources and technical support received

Over the course of the reporting period covered in this SNC Barbados has engaged in several local, regional and international projects that were supported by grant and non-grant financing from international sources. Several of these are detailed in the tables that follow.

Local Climate Change Related Projects

Table 6.1 Local projects relevant to climate change supported by international funding

Title	Project Status	Start	End	Value (US$)	Funding Sources
Coastal Infrastructure Program	Completed	10/09/2002	02/26/2010	16,937,657	Inter-American Development Bank
National Capacity Self - Assessment for Global Environmental Management	Implementation	07/19/2005		184,500	GEF Trust Fund
Sustainable Energy Framework for Barbados (SEFB)	Completed	02/03/2009	10/27/2012	999,441	Inter-American Development Bank

Title	Project Status	Start	End	Value (US$)	Funding Sources
Preparation of the Coastal Risk Assessment and Management Program	Completed	05/10/2010	10/06/2011	4,030,600	Inter-American Development Bank
Support for Sustainable Energy Framework for Barbados (SEFB) I	Completed	10/10/2010	11/24/2010	45,000,000	Inter-American Development Bank
Support to the Sustainable Energy Framework for Barbados	Completed	10/10/2010	02/12/2015	1,000,000	Inter-American Development Bank
Climate Change Adaptation to Protect Human Health	Completed	2010	2014	550,000	GEF Special Climate Change Fund
Sustainable Energy Investment Program (Smart Energy Fund)	Implementation	02/07/2011	06/07/2017	10,000,000	Inter-American Development Bank
Coastal Risk Assessment and Management Program	Implementation	02/07/2011	02/07/2019	30,000,000	Inter-American Development Bank
Support the Preparation of the Support for Sustainable Energy Framework for Barbados Program- Phase II	Completed	05/23/2011	12/23/2015	967,186	Inter-American Development Bank
Support for Sustainable Energy Framework For Barbados (SEFB) II	Completed	11/16/2011	12/07/2011	70,000,000	Inter-American Development Bank
Green Business Barbados	Completed	10/01/2012	10/15/2015	145,817	Inter-American Development Bank
Climate Change Enabling Activity (Additional Financing for Capacity Building in Priority Areas)	Approved	11/21/2012		100,000	GEF Trust Fund
Capacity Building Ecosystem Services Valuation ICZM Best Practice Dissemination	Implementation	11/14/2013		600,000	Inter-American Development Bank
Support for the Public Sector Smart Energy Program	Implementation	11/15/2013	11/05/2018	5,810,000	Inter-American Development Bank; European Union
Public Sector Smart Energy Program (PSSEP)	Implementation	11/15/2013	11/05/2018	17,000,000	Inter-American Development Bank
Water Resource Management & Flood Resilience Climate Change Adaptation Program	Completed	11/18/2013	09/30/2017	5,300,000	USAID
Disaster Risk and Energy Access Management (DREAM): Promoting Solar Photovoltaic Systems in Public Buildings for Clean Energy Access, Increased Climate Resilience and Disaster Risk Management	Implementation	07/01/2014	12/30/2018	1,726,484	GEF Trust Fund
Continuation of Support (SEFB) and Development of New Technologies: SG & RE	Implementation	05/01/2015		950,000	Inter-American Development Bank

Regional and International Climate Change Related Projects

Barbados has received financial and/or technical support for actions relating to climate change mitigation and adaptation as a result of participation in a number of regional and international projects. These projects are presented in Table 6.2 below.

Table 6.2 Barbados' participation in regional and international projects relating to climate change adaptation and mitigation

Project Title	Project Duration	Funding and Partner Agencies
Caribbean Planning for Adaptation to Climate Change (CPACC) Project	1997-2001	CARICOM; World Bank
Adaptation to Climate Change (ACCC) Project	2001-2004	CARICOM; World Bank
Mainstreaming and Adaptation to Climate Change (MACC) Project	2004-2007	Global Environment Facility; CCCCC; World Bank; Government of Canada; NOAA
The CARIBSAVE Climate Change Risk Atlas (CCCRA) Project	2009-2011	CCCCC; Australian Agency for International Development; UK Department for International Development
Caribbean Hotel Energy Efficiency Action (CHENACT)	2009-2010	Inter-American Development Bank; German Organisation for Technical Cooperation; Center for Development of Enterprise ; United Nations Environment Programme; Barbados Light and Power Company Ltd
Review of the Economics of Climate Change in the Caribbean	2010-2011	CCCCC; UN ECLAC; UK Department for International Development; Commonwealth Fund for Technical Cooperation
Caribbean Regional Resilience Development Implementation Plan (IP)	2011-2016	CCCCC; UK Department for International Development; Climate Development Knowledge Network
Intra-ACP GCCA Caribbean Support Project	2011-2015	CCCCC; European Union
Caribbean Hotel Energy Efficiency Action Advance Program (CHENACT-AP)	2011-2017	Inter-American Development Bank

ANNEX – GHG INVENTORY REPORTING TABLES

Annual Greenhouse Gas Sources and Sinks by Sector and Activity (2000–2010)

Table A.1 Greenhouse Gas Sources and Sinks by Sector and Activity, 2000–2002

Sectors and Activities	Greenhouse Gas Emission or Absorption by Year (Gg CO_2e)		
Year	**2000**	**2001**	**2002**
Total [A]	1474	1492	1501
Energy (excluding Domestic Transport) [A]	**1060** (698)	**1088** (723)	**1065** (694)
Energy Industries	588	637	618
Manufacturing Industries and Construction	18	28	19
Domestic Transport	362	265	371
Commercial and Residential	88	54	54
International Aviation [B]	509	503	498
International Shipping [B]	81	74	67
Industrial Processes [A]	137	132	162
Cement Production	133	124	148
HFC and SF6 Consumption	4	8	15
Agriculture [A]	90	81	75
Enteric Fermentation	39	36	33
Manure Management	32	30	26
Soils and Indirect Emissions	20	17	17
Waste [A]	232	236	244
Landfill	187	191	199
Wastewater	45	45	44
LULUCF [A]	-45	-45	-45
Changes in Forest and Other Woody Bio-stocks	-14		
Forest and Grassland Conversion			
Abandonment of Managed Lands	-23		
CO2 Emissions and Removals from Soils	-8		

[A] The sum of the component parts may not equal the Sector or Total values due to rounding.

[B] Not included in the greenhouse gas Inventory assessment, following UNFCCC Guidelines.

Table A.2 Greenhouse Gas Sources and Sinks by Sector and Activity, 2003–2005

Sectors and Activities	Greenhouse Gas Emission or Absorption by Year (Gg CO_2e)		
Year	**2003**	**2004**	**2005**
Total [A]	1999	1551	1599
Energy (excluding Domestic Transport) [A]	**1046** (666)	1076 (684)	**1117** (711)
Energy Industries	619	636	661
Manufacturing Industries and Construction	12	12	13
Domestic Transport	380	392	406
Commercial and Residential	34	34	36
International Aviation [B]	496	505	496
International Shipping [B]	61	55	65
Industrial Processes [A]	174	183	188
Cement Production	153	152	154
HFC and SF6 Consumption	21	31	34
Agriculture [A]	72	76	67
Enteric Fermentation	30	27	24
Manure Management	26	26	24
Soils and Indirect Emissions	16	23	19
Waste [A]	253	262	272
Landfill	208	217	226
Wastewater	45	44	46
LULUCF [A]	-45	-46	-46
Changes in Forest and Other Woody Bio-stocks			-16
Forest and Grassland Conversion			-4
Abandonment of Managed Lands			-26
CO2 Emissions and Removals from Soils			-7

[A] The sum of the component parts may not equal the Sector or Total values due to rounding.

[B] Not included in the greenhouse gas Inventory assessment, following UNFCCC Guidelines.

Table A.3 Greenhouse Gas Sources and Sinks by Sector and Activity, 2006–2008

Sectors and Activities	Greenhouse Gas Emission or Absorption by Year (Gg CO_2e)		
Year	**2006**	**2007**	**2008**
Total [A]	1627	1728	1820
Energy (excluding Domestic Transport) [A]	**1137** (725)	**1221** (796)	**1304** (868)
Energy Industries	674	741	807
Manufacturing Industries and Construction	13	15	16
Domestic Transport	413	424	436
Commercial and Residential	36	39	42
International Aviation [B]	498	473	479
International Shipping [B]	75	78	81
Industrial Processes [A]	197	204	203
Cement Production	152	150	143
HFC and SF6 Consumption	45	54	60
Agriculture [A]	60	61	62
Enteric Fermentation	21	21	21
Manure Management	22	22	23
Soils and Indirect Emissions	17	17	18
Waste [A]	280	290	299
Landfill	235	244	252
Wastewater	45	46	47
LULUCF [A]	-47	-48	-49
Changes in Forest and Other Woody Bio-stocks			
Forest and Grassland Conversion			
Abandonment of Managed Lands			
CO2 Emissions and Removals from Soils			

[A] The sum of the component parts may not equal the Sector or Total values due to rounding.

[B] Not included in the greenhouse gas Inventory assessment, following UNFCCC Guidelines.

Table A.4 Greenhouse Gas Sources and Sinks by Sector and Activity, 2009–2010

Sectors and Activities	Greenhouse Gas Emission or Absorption by Year (Gg CO_2e)	
Year	**2009**	**2010**
Total [A]	1872	1930
Energy (excluding Domestic Transport) [A]	**1382** (939)	**1460** (1011)
Energy Industries	874	941
Manufacturing Industries and Construction	18	19
Domestic Transport	443	449
Commercial and Residential	45	48
International Aviation [B]	404	410
International Shipping [B]	92	103
Industrial Processes [A]	177	168
Cement Production	113	101
HFC and SF6 Consumption	64	67
Agriculture [A]	59	59
Enteric Fermentation	21	21
Manure Management	23	23
Soils and Indirect Emissions	15	15
Waste [A]	305	295
Landfill	260	248
Wastewater	45	47
LULUCF [A]	-50	-51
Changes in Forest and Other Woody Bio-stocks		-18
Forest and Grassland Conversion		-4
Abandonment of Managed Lands		-29
CO2 Emissions and Removals from Soils		-8

[A] The sum of the component parts may not equal the Sector or Total values due to rounding.

[B] Not included in the greenhouse gas Inventory assessment, following UNFCCC Guidelines.

Annual Greenhouse Gas Sources and Sinks by Sector and Gas (2000–2010)

Table A.5 Greenhouse Gas Sources and Sinks by Sector and Gas, 2000–2002

Sectors and Gases	Greenhouse Gas Emission or Absorption by Year (Gg CO_2e)		
Year	**2000**	**2001**	**2002**
Total [A]	1474	1492	1501
Energy (excluding Domestic Transport) [A]	**1060** (698)	**1088** (723)	**1065** (694)
CO_2	1045	1073	1049
N_2O	3	3	3
CH_4	12	12	12
Industrial Processes [A]	137	132	162
CO_2	133	124	148
HFC / SF_6	4	8	15
Agriculture [A]	90	81	75
CO_2	0	0	0
N_2O	34	30	29
CH_4	57	53	48
Waste [A]	232	236	244
CO_2	1	1	1
N_2O	5	6	6
CH_4	228	230	237
LULUCF [A]	-45	-45	-45
CO_2	-45		

[A] The sum of the component parts may not equal the Sector or Total values due to rounding.

Table A.6 Greenhouse Gas Sources and Sinks by Sector and Gas, 2003–2005

Sectors and Gases	Greenhouse Gas Emission or Absorption by Year (Gg CO_2e)		
Year	**2003**	**2004**	**2005**
Total [A]	1499	1551	1599
Energy (excluding Domestic Transport) [A]	**1046** (666)	**1076** (684)	**1117** (711)
CO_2	1030	1060	1100
N_2O	3	4	4
CH_4	13	13	13
Industrial Processes [A]	174	183	188
CO_2	153	152	154
HFC / SF_6	21	31	34
Agriculture [A]	72	76	67
CO_2	0	0	0
N_2O	27	34	29
CH_4	45	43	39
Waste [A]	253	262	272
N_2O	6	6	6
CH_4	246	255	267
LULUCF [A]	-45	-46	-46
CO_2			-46

[A] The sum of the component parts may not equal the Sector or Total values due to rounding.

Table A.7 Greenhouse Gas Sources and Sinks by Sector and Gas, 2006–2008

Sectors and Gases	Greenhouse Gas Emission or Absorption by Year (Gg CO_2e)		
Year	**2006**	**2007**	**2008**
Total [A]	1627	1728	1820
Energy (excluding Domestic Transport) [A]	**1137** (725)	**1221** (796)	**1304** (868)
CO_2	1120	1203	1286
N_2O	4	4	4
CH_4	13	14	14
Industrial Processes [A]	197	204	203
CO_2	152	150	143
HFC / SF_6	45	54	60
Agriculture [A]	60	61	62
CO_2	0	0	0
N_2O	26	26	27
CH_4	34	35	35
Waste [A]	280	290	299
N_2O	6	6	6
CH_4	274	282	292
LULUCF [A]	-47	-48	-49
CO_2			

[A] The sum of the component parts may not equal the Sector or Total values due to rounding.

Table A.8 Greenhouse Gas Sources and Sinks by Sector and Gas, 2009–2010

Sectors and Gases	Greenhouse Gas Emission or Absorption by Year (Gg CO_2e)	
Year	**2009**	**2010**
Total [A]	1872	1930
Energy (excluding Domestic Transport) [A]	**1382** (939)	**1460** (1011)
CO_2	1364	1441
N_2O	4	4
CH_4	14	15
Industrial Processes [A]	177	168
CO_2	113	101
HFC / SF_6	64	67
Agriculture [A]	59	59
CO_2	0	0
N_2O	24	24
CH_4	35	35
Waste [A]	305	295
N_2O	6	7
CH_4	299	288
LULUCF [A]	-50	-51
CO_2		-51

[A] The sum of the component parts may not equal the Sector or Total values due to rounding.

Greenhouse Gas Emissions and Sinks – Uncertainties by Sector

Table A.9 Uncertainty Estimates by Sector

Sector	Source	GHG	Activity Data Uncertainty	Emission Factor Uncertainty
Energy	Domestic transport	CO_2	2%	5%
Energy	Domestic transport	CH_4	10%	49%
Energy	Domestic transport	N_2O	10%	39%
Energy	Public power	CO_2	8%	7%
Energy	Public power	N_2O	8%	150%
Energy	Public power	CH_4	8%	100%
Energy	Commercial/institutional/residential	CO_2	20%	7%
Energy	Commercial/institutional/residential	N_2O	20%	75%
Energy	Commercial/institutional/residential	CH_4	20%	100%
Energy	Agriculture	CO_2	2%	5%
Energy	Agriculture	N_2O	10%	49%
Energy	Agriculture	CH_4	10%	39%
Industrial Processes	SF6 and halocarbons	HFCs	75%	75%
Industrial Processes	SF6 and halocarbons	SF_6	75%	75%
Industrial Processes	Cement	CO_2	30%	3%
Agriculture	Enteric fermentation	CH_4	7%	40%
Agriculture	Manure management	CH_4	7%	40%
Agriculture	Manure management	N_2O	7%	75%
Agriculture	Soils	N_2O	25%	3%
Agriculture	Precursor emissions	N_2O	5%	50%
Agriculture	Soils	CO_2	50%	20%
Waste	Solid waste	CH_4	75%	40%
Waste	Wastewater	N_2O	7%	40%
Waste	Wastewater	CH_4	7%	40%
LULUCF	Changes in Forest and Other Woody Biomass Stocks	CO_2	14%	75%
LULUCF	Forest and Grassland Conversion	CO_2	14%	75%
LULUCF	Abandonment of Managed Lands	CO_2	14%	75%
LULUCF	Emissions and Removals from Soil	CO_2	14%	75%

Aggregate combined uncertainty for the inventory as a percentage of the total national emissions in 2010 is +/- 12%.

BIBLIOGRAPHY

Affonso, S. 2010. Confronting the Energy Security Dilemma of the Caribbean. International Public Policy Review 6(1), 104-29.

Alleyne, M. 2011 Vulnerability Assessment of Holetown, Barbados, to Sea Level Rise and Storm Surge. Master's thesis submitted to the Centre for Resource Management and Environmental Studies, University of the West Indies, Cave Hill Campus.

Amarakoon, D., Chen, A., Rawlins, S. and Taylor, M. 2004a. Dengue Epidemics – Its Association with Precipitation and Temperature and its Seasonality in Some Caribbean Countries. West Indian Medical Journal 53; (suppl 2): 60.

Amarakoon, D., Stennett, R. and Chen, A. 2004b. Climate Variability and Disease Patterns in Two South-Eastern Caribbean Countries. Kingston, Jamaica: Climate Studies Group, Department of Physics, University of the West Indies, Mona Campus.

Auth, K., Konold, M., Musolino, E., and Ochs, A. 2013. Caribbean Sustainable Energy Roadmap (C-SERMS), Phase 1: Summary and Recommendations for Policymakers. Georgetown, Guyana: Caribbean Community (CARICOM).

Barbados Audit Office. 2012. Special Audit of the Barbados Water Authority. Bridgetown: Barbados Audit Officer.

Barbados Government Information Service. 2013. gisbarbados.gov.bb, Accessed on 17 July 2013.

Barbados Hotel and Tourism Association (BHTA). 2009. A Study of the Competitive Tourism Environment Which Barbados Faces: Its Challenges and Solutions. Bridgetown: Barbados Hotel and Tourism Association.

Barbados Light and Power Company Limited (BL&P). 2012. The Barbados Light and Power Company Limited: Integrated Resource Plan: Responses to Comments from Stakeholder. Bridgetown: BL&P.

Barbados Meteorological Services. 2012. Barbados Weather. www.barbadosweather.org. Accessed September 2012.

Barbados Statistical Service. 2012. www.barstats.gov.bb. Accessed August 2012.

Bodmer, E., Clarke, R., and Reddick, C. 2011. Economic Viability, Financing and Contracts for Renewable Energy Project in CARICOM: Findings, Recommendations and Documentation: Volume 1 Report. United Nations Development Programme, Global Environment Facility.

Brewster, L. and Mwansa, J. 2001. Integrating Management of Watersheds and Coastal Areas in Small Island Developing States of the Caribbean: The Barbados National Report. Barbados: Caribbean Environmental Health Institute and United Nations Environment Programme.

Caribbean Catastrophe Risk Insurance Facility (CCRIF). 2016. Covered Area Rainfall Event: Tropical Cyclone Matthew Excess Rainfall Event Briefing-Barbados. Grand Cayman, Cayman Islands: CCRIF.

Caribbean Community (CARICOM). 2007. CARICOM Energy Policy. Georgetown, Guyana: CARICOM Secretariat.

Caribbean Community (CARICOM). 2011. Regional Food and Nutrition Security Action Plan (RFNSAP). Georgetown, Guyana: CARICOM Secretariat

Caribbean Community Climate Change Centre (CCCCC). 2011. Delivering Transformational Change: A plan to achieve development resilient to Climate Change in the Caribbean. Belmopan, Belize: CCCCC.

Caribbean Disaster Emergency Management Agency. 2012. Situation Report 1 – Tropical Storm Tomas impacts Barbados, strengthens to Category 1 Hurricane and impacts Saint Vincent & the Grenadines, Saint Lucia and Dominica. Accessed 3 April 2013.

Caribbean Journal. 2012. Barbados Planning to Award Offshore Oil Drilling Licenses to BHP Billiton

Caribbean Network of Service Coalitions. 2011. Support to the Preparation of a Programme for the Support for the Sustainable Energy Framework for Barbados.

Cashman, A., Nurse, L. and Charlery, J. 2010. Climate Change in the Caribbean: The Water Management Implications. Journal of Environment and Development 2010(19), 42–67.

Central Bank of Barbados. 2010. Conference on Alternative Energy: Pathway to a Sustainable Future in Barbados. Bridgetown, Barbados: Central Bank of Barbados.

Central Bank of Barbados. 2017. Review of Barbados' Economic Performance for 2016. Bridgetown, Barbados: Central Bank of Barbados. Retrieved March 2017 from: http://www.centralbank.org.bb/news/article/9141/review-of-barbados-economic-performance-for-2016

Centre for Resource Management and Environmental Studies (CERMES). 2012. The Impact of Climate Change on Water Resources in Barbados. Barbados Water Authority and the Caribbean Community Climate Change Seminar. Bridgetown: Centre for Resource Management and Environmental Studies, University of the West Indies, Cave Hill Campus.

Church, J. A., White, N. J., Coleman, R., Lambeck, K. and Mitrovica, J. X. 2004. Estimates of the Regional Distribution of Sea-Level Rise over the 1950–2000 Period. Journal of Climate 17(13), 2609–25.

Climate and Development Knowledge Network (CDKN). 2012. Inside Stories on Climate Development: Seizing the sunshine; Barbados' thriving solar water heating industry. Retrieved March 2017 from https://cdkn.org/wp-content/uploads/2012/09/Barbados-InsideStory_WEB.pdf.

Economic Commission for Latin America and the Caribbean (ECLAC). 2009. A Study on Energy Issues in the Caribbean: Potential for Mitigating Climate Change. Port of Spain, Trinidad and Tobago: ECLAC.

Economic Commission for Latin America and the Caribbean [ECLAC]. 2010. Regional Report on the Impact of Climate Change on the Tourism Sector. Port of Spain: Subregional Headquarters for the Caribbean, Economic Commission for Latin America and the Caribbean.

Economic Commission for Latin America and the Caribbean [ECLAC]. 2011a. An Assessment of the Economic Impact of Climate Change on the Macroeconomy in the Caribbean. Sub-regional Headquarters for the Caribbean: Economic Commission for Latin America and the Caribbean.

Economic Commission for Latin America and the Caribbean [ECLAC]. 2011b. Caribbean Development Report, Volume 3: The Economics of Climate Change in the Caribbean. Port of Spain: Subregional Headquarters for the Caribbean, Economic Commission for Latin America and the Caribbean.

Economic Commission for Latin America and the Caribbean [ECLAC]. 2011c. An Assessment of the Economic Impact on the Coastal and Human Settlements Sectors in Barbados. Port of Spain: Subregional Headquarters for the Caribbean, Economic Commission for Latin America and the Caribbean.

Emmanuel, K. and Spence, B. 2009. Climate Change Implications for Water Resource Management in Caribbean Tourism. Worldwide Hospitality and Tourism Themes 1(3), 252–68.

Food and Agricultural Organization [FAO] and Government of Barbados. 2012. Country Programming Framework (2012–2016). Christ Church, Barbados, and Rome: Food and Agriculture Organization and the Government of Barbados.

Food and Agricultural Organization [FAO]. 2001. Land Resources Information Systems in the Caribbean. Proceedings of a subregional workshop held in Bridgetown, 2–4 October 2000. Bridgetown: Food and Agriculture Organization.

Food and Agricultural Organization [FAO]. 2005. Barbados Country Profile. Rome: Food and Agriculture Organization. Retrieved 4 August 2013 from: http://www.fao.org/fi/oldsite/FCP/en/BRB/profile.htm.

Food and Agricultural Organization of the UN: Statistics (new version). 2013. Retrieved 21 May 2013 from: http://faostat3.fao.org/home/index.html#HOME.

Geneva Association. 2009. The Geneva Report: Risk and Insurance Research Number 2: The Insurance Industry and Climate Change-Contribution to the Global Debate. Geneva: International Association for the Study of Insurance Economics. Retrieved 4 August 2014 from:

https://www.allianz.com/v_1339671717000/media/responsibility/documents/insurance_industry_and_climate_change.pdf.

Gischler, C., and Janson, N. 2011. Perspectives for Distributed Generation with Renewable Energy in Latin America and the Caribbean. Santo Domingo, Dominican Republic: Complete Caribbean.

Global Water Partnership. 2009. Better Water Resources Management: Greater Resilience Today, More Effective Adaptation Tomorrow. Presentation to the Fifth World Water Forum, Istanbul, March 2009. Stockholm: Global Water Partnership. Retrieved 4 August 2014 from: http://www.gwp.org/Global/The%20Challenge/Resource%20material/Roberto_Lenton_Adaptation.pdf.

Government of Barbados. 2001a. State of the Environment Report. United Nations Environment Programme.

Government of Barbados. 2001b. Barbados First National Communication to UNFCCC. Bridgetown: Ministry of Physical Development and Environment.

Government of Barbados. 2002a. International Financial Services Act, Chapter 325.

Government of Barbados. 2002b. Barbados National Action Programme to Combat Desertification and Land Degradation and to Mitigate against the Effects of Desertification, Land Degradation and Drought. Bridgetown: Government of Barbados.

Government of Barbados. 2002c. The National Biodiversity Strategy and Action Plan for Barbados. Bridgetown: Government of Barbados.

Government of Barbados. 2003. Strategic Plan for Health 2002–2012. Bridgetown: Ministry of Health. Retrieved 3 August 2014 from: http://www.nationalplanningcycles.org/sites/default/files/country_docs/Barbados/barbados_strategic_plan_for_health_2002–2012.pdf.

Government of Barbados. 2004a. National Sustainable Development Policy for Barbados. Bridgetown: National Commission on Sustainable Development.

Government of Barbados. 2004b. Barbados Fisheries Management Plan 2004–2006 Schemes for the Management of Fisheries in the Water of Barbados. Bridgetown: Fisheries Division, Ministry of Agriculture and Rural Development.

Government of Barbados. 2006. Economic and Financial Proposal for the Government of Barbados. Bridgetown: Government of Barbados.

Government of Barbados. 2007. The National Strategic Plan of Barbados 2006–2025. Bridgetown: Ministry of Finance and Economic Affairs.

Government of Barbados. 2008a. Draft Road Map Towards Integrated Water Resources Management Planning for Barbados.

Government of Barbados. 2008b. Barbados-European Community: Country Strategy Paper and National Indicative Programme for the Period 2008–2013. Bridgetown: Government of Barbados.

Government of Barbados. 2009a. Income Tax Act Amendment 2009. Bridgetown: Government of Barbados.

Government of Barbados. 2009b. National Report to the United Nations Commission for Sustainable Development: Chemical, Mining, Transport, Waste Management: The Ten Year Framework for Programmes on Sustainable Consumption and Production Patterns. Bridgetown: Ministry of Environment, Water Resources and Drainage.

Government of Barbados. 2010a. Barbados HIV/AIDS Surveillance Report. Bridgetown: HIV/AIDS Programme, Ministry of Health. Retrieved 3 August 2014 at: http://www.colesxmedia.com/flipbooks/HIV/index.html#/1/zoomed.

Government of Barbados. 2010b. Sustainable Energy Framework for Barbados Volume 1 and 2. Bridgetown: Government of Barbados and Inter-American Development Bank.

Government of Barbados. 2010c. Barbados National Assessment Report of Progress in Addressing Vulnerabilities of SIDS through Implementation of the Mauritius Strategy for Further Implementation (MSI) of the Barbados Programme of Action. Barbados: Government of Barbados.

Government of Barbados. 2011a. Barbados Economic and Social Report 2010. Bridgetown: Division of Economic Affairs, Ministry of Finance and Economic Affairs.

Government of Barbados. 2011b. Terms of Reference (UNDP PIMS no. 3361). Ministry of the Environment and Drainage.

Government of Barbados. 2012a. White Paper on the Development of Tourism in Barbados. Bridgetown: Ministry of Tourism.

Government of Barbados. 2012b. Barbados Project Profile: Second Generation of Reforms in Support for Sustainable Energy Framework for Barbados (SEFB) I. Bridgetown: Government of Barbados; Inter-American Development Bank.

Government of Barbados. 2012c. Barbados Growth and Development Strategy, 2013–2020. Bridgetown: Economic Affairs Division, Ministry Finance and Economic Affairs.

Government of Barbados. 2013a. Barbados Economic and Social Report 2013. Bridgetown, Barbados: Government of Barbados.

Government of Barbados. 2013b. Income Tax Act Amendment 2013. Bridgetown: Government of Barbados.

Government of Barbados. 2013c. Internal Document: Strengthening of the Service Delivery Capacity of the Ministry of Agriculture, Food, Fisheries and Water Resource Management – Development of a Strategy for Agriculture and Fisheries. Bridgetown: Ministry of Agriculture, Food, Fisheries and Water Resource Management.

Government of Barbados. 2015. Barbados' Intended Nationally Determined Contribution to the UNFCCC.

Government of Barbados. 2016. Barbados Economic and Social Report 2015. Bridgetown: Division of Economic Affairs, Ministry of Finance and Economic Affairs.

Head, H. 2007. Chronic Disease Research Centre. Bridgetown: Government of Barbados.

Holden, A. 2000. Environment and Tourism. London and New York: Routledge.

Inter-American Development Bank [IDB]. 2010. Barbados: Sustainable Investment Programme: Smart Fund. Washington DC: Inter-American Development Bank.

Intergovernmental Panel on Climate Change [IPCC]. 1996. Revised 1996 Guidelines for National Greenhouse Gas Inventories. Reference Manual (Volume 3)

Intergovernmental Panel on Climate Change [IPCC]. 2004. IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.

Intergovernmental Panel on Climate Change [IPCC]. 2006. Guidelines for National Greenhouse Gas Inventories

Intergovernmental Panel on Climate Change [IPCC]. 2007. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom: Intergovernmental Panel on Climate Change, Cambridge University Press.

Intergovernmental Panel on Climate Change [IPCC]. 2013. Climate Change 2013: The Physical Science Basis. Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom: Intergovernmental Panel on Climate Change, Cambridge University Press.

Lewis, J. B. 2002. Evidence from Aerial Photography of Structural Loss of Coral Reefs at Barbados, West Indies. Coral Reefs 21(1), 49–56. doi: 10.1007/s00338-001-0198-1.

Little, V. 2011. Praedial Larceny: Its Consequences for Caribbean Agriculture. CARICOM View, July, pp. 6–11.

Medeiros, D., Hove, H., Keller, M., Echeverría, D. and Parry, J.-E. 2011. Review of Current and Planned Adaptation Action: The Caribbean. Adaptation Partnership and International Institute for Sustainable Development.

Mimura, N., Nurse, L., McLean, R., Agard, J., Briguglio, L., Lefale, P. et al. 2007. Small Islands: Climate Change 2007: Impacts, Adaptation and Vulnerability. In M. Parry, O. Canziani, J. Palutikof, P. Van der Linden and C. Hanson (eds), Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (pp. 687–716). Cambridge UK and New York: Cambridge University Press.

Ministry of Agriculture, Food, Fisheries and Water Resource Management (MAFFW). 2012. Scotland District Development: The Soil Conservation Unit. Bridgetown: Ministry of Agriculture. Retrieved 29 August 2013 from: http://www.agriculture.gov.bb/agri/index.php?option=com_content&view=article&id=77:scotland-district-development&catid=54:scotland-district-development&Itemid=92.

Ministry of Physical Development and Environment (MPDE), Barbados. 2001. State of the Environment Report 2000. Nairobi: United Nations Environment Programme.

Ministry of Tourism. 2011. Preparation of the Tourism Master Plan for Barbados 2012–2021. Bridgetown: Ministry of Tourism. Retrieved 17 July 2013 from: http://www.tourism.gov.bb/tourism-master-plan.html.

Monnereau, I., R. Mahon, P. McConney, L. Nurse, R. Turner and H. Vallès. (2015). Vulnerability of the fisheries sector to climate change impacts in Small Island Developing States and the Wider Caribbean. Centre for Resource Management and Environmental Studies, University of the West Indies, Cave Hill Campus, Barbados. CERMES Technical Report No. 77: 88pp

Moore, W., Alleyne, F., Alleyne, Y., Blackman, K., Blenman, C., Carter, S. et al. 2012. Barbados Green Economy Scoping Study-Synthesis Report. Prepared by the University of the West Indies, Cave Hill Campus, in association with the United Nations Environment Programme.

Nam, V. 2009. 2000 Round of Population and Housing Census Sub-Project: National Census Report Barbados. Guyana: CARICOM

Nurse, L. A. 2011a. The Implications of Global Climate Change for Fisheries Management in the Caribbean. Climate and Development, 3(3), 228–241.

Nurse, L. A. 2011b. Climate Change Impacts and Adaptation: A Challenge for Global Ports. Bridgetown: University of the West Indies, Cave Hill Campus

Nurse, L. A., McLean, R., Agard, J., Briguglio, L. P., Duvat, V., Pelesikoti, N., et al. 2014. Small Islands. In Field, C. B., Barros, V. R., Dokken, D. J., Mach, K. J., Mastandrea, M. D., Bilir, T. E. et al. (eds), Climate Change 2014: Impacts, Adaptation and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge UK and New York: Cambridge University Press.

Nurse, S. 2011. Variability in Barbados' Rainfall Pattern: An El Nino/La Nina Perspective. Bridgetown: Barbados Meteorological Service.

Oxenford, H. A. 2010. Caribbean Corals in Crisis: Record Thermal Stress, Bleaching and Mortality in 2005. PLoS One 5(11):1–9. Retrieved 3 March 2015 from: http://dx.plos.org/10.1371/journal.pone.0013969.

Oxenford, H. A., Roach, R. and Brathwaite, A. 2008. Large-Scale Coral Mortality in Barbados: A Delayed Response to the 2005 Bleaching Episode. Bridgetown: Centre for Natural Resource Management and Environmental Studies, CZMU, Ministry of Family, Youth Sports and Environment.

Pan-American Health Organization [PAHO]. 2007. Countries: Barbados Health in the Americas. Volume II. Washington DC: Pan American Health Organization.

Pan-American Health Organization [PAHO]. 2008. Health Systems Profile Barbados: Monitoring and Analysing Health Systems Change/Reform. Washington DC: Pan American Health Organization.

Pan-American Health Organization [PAHO]. 2012. Health in the Americas. 2012 edition. Washington DC: Pan American Health Organization.

Parker, C. and Oxenford, H. A. 1998. Barbados: CARICOMP-Caribbean Coral Reef, Seagrass and Mangrove Sites. Coastal Region and Small Island Papers. Paris: United Nations Educational, Scientific and Cultural Organization.

Perry, A., Low, P. J., Ellis, J. R. and Reynolds, J. D. 2005. Climate Change and Distribution Shifts in Marine Fishes. Science 308(5730), 1912–15.

Rahmstorf, S. 2007. A Semi-empirical Approach to Projecting Future Sea Level Rise. Science 315 (2810), 368-70.

Rawlins, G. C. 2003. Analysing SIDS-Specific Needs in Multilateral Liberalisation in the Agricultural Sector: Case Study: Barbados. Geneva: United Nations Conference on Trade and Development.

Rosenzweig, C., Iglesias, A., Yang, X. B., Epstein, P. R. and Chivian, E. 2001. Climate Change and Extreme Weather Events: Implications for Food Production, Plant Diseases and Pests. Global Change and Human Health 2(2), 90–104.

Schwein, A. 2010. Solar Market Study: Analysis of the Potential Solar Energy Market in the Caribbean: Caribbean Renewable Energy Development Programme (CREDP). Castries, St. Lucia: Caribbean Environmental Health Institute.

Simpson, M., Scott, D., New, M., Sim, R., Smith, D., Harrison, M. et al. (2009). An Overview of Modelling Climate Change Impacts in the Caribbean Region with Contribution from the Pacific Islands. Barbados: United Nations Development Programme.

Simpson, M. C., Clarke, J. F., Scott, D. J., New, M., Karmalkar, A., Day, O. J., Taylor, M., Gossling, S., Wilson, M., Chadee, D., Stager, H., Waithe, R., Stewart, A., Georges, J., Hutchinson, N., Fields, N., Sim, R., Rutty, M., Matthews, L., and Charles, S. 2012. CARIBSAVE Climate Change Risk Atlas (CCCRA) - Barbados. DFID, AusAID and The CARIBSAVE Partnership, Barbados, West Indies.

Springer, B. 2008. Barbados: Public-Private Sector Partnership. Santiago, Chile: Economic Commission for Latin America and the Caribbean.

Springer, C. A. 2012 Barbados National Report on Ageing (2007-2011). Barbados. Government of Barbados.

St John, V. S. 2010. Heat Stroke Kills Broilers. Bridgetown: Ministry of Agriculture. Retrieved 8 February 2013 from: http://www.agriculture.gov.bb/agri/index.php?option=com_content&view=article&id=524%3Aheat-stroke-kills-broilers&Itemid=101.

Stoute, S. 2010. Report of the Caribbean Water, Drought and Precipitation Monitoring Workshop. Bridgetown: Caribbean Institute of Meteorology and Hydrology.

Town and Country Development Planning Office (TCDPO). 2013. Town and Country Development Planning Office. Bridgetown. Retrieved 11 July 2013 from: http://www.townplanning.gov.bb/index.aspx.

Trotz, U. 2008. Climate Change and Development in the Caribbean Sub-region. Belize: CCCCC.

Turley, C et al, 2010. Ocean Acidification: the Other CO2 Problem. Plymouth: Plymouth Marine Laboratory.

Udika, R. 2009. Climate Change and Vulnerability: Responding to Climate Change Impacts on the Coastal Urban Corridor, Barbados. 45th ISOCARP Congress. Retrieved 5 August 2014 from: www.isocarp.net/Data/case_studies/1510.pdf.

United Nations [UN]. 2004. Sanitation Country Profile - Barbados.

United Nations Development Programme (UNDP). 2012. Readiness for Climate Finance: A framework for understanding what it means to be ready to use climate finance. UNDP.

United Nations Development Programme (UNDP). 2016. Human Development Reports: Barbados. Retrieved March 2017 from http://hdr.undp.org/en/countries/profiles/BRB.

United Nation Environment Programme [UNEP]. 2011. Mainstreaming Climate Change Adaptation into Development Planning: A Guide for Practitioners. Nairobi: United Nations Environmental Programme.

United Nations Environment Programme [UNEP]. 2013. Renewable Energy. United Nations Environmental Programme.

United Nations International Strategy for Disaster Reduction. 2005. The Hyogo Framework for Action 2005–1015: Building the Resilience of Nations and Communities to Disasters. Geneva: United Nations Strategy for Disaster Reduction.

University of the West Indies (UWI). 2007. The Worthing Lagoon Monitoring Project: Water Quality and Seagrass Monitoring Report. Bridgetown: University of the West Indies, Cave Hill Campus.

University of the West Indies (UWI). 2012. Barbados Country Assessment of Living Conditions 2010 Volume 1: Human Development Challenges in a Global Crisis: Addressing Growth and Social Inclusion. Barbados: Sir Arthur Lewis Institute of Social and Economic Studies (SALISES), UWI.

Van den Akker. 2011. Caribbean Renewable Energy Development Programme (CREDP). UNDP/GEF

Vermeiren, J. 2000. Risk Transfer and Finance Experience in the Caribbean. In A. Kreimer and M. Arnold (eds), Managing Disaster Risk in Emerging Economies (pp. 166–74). Washington DC: World Bank.

Watson et al, 2001. Low Cost Housing in Barbados: Evolution or Social Revolution.

World Bank Group. 2001. Catastrophe Risk Management: Using Alternative Financing and Insurance Pooling Mechanisms. In Pollner J. (ed), Latin America and the Caribbean Region, Finance and Private Sector and Infrastructure Sector Unit. Washington DC: World Bank.

World Bank Group. 2012. Implementation Completion and Results Report: Caribbean Catastrophe Risk Insurance Facility. Sustainable Development Department, Caribbean Country Management Unit, Latin America and the Caribbean Region

World Bank Group. 2013. Data: Indicators: Agricultural Land (% of land area). Washington DC: World Bank. Retrieved 9 August 2013 from: http://data.worldbank.org/indicator/AG.LND.AGRI.ZS/countries.

World Economic Forum. 2015. Travel & Tourism Competitiveness Index 2015 Ranking: The Americas - Table 3, pg. 22

World Health Organization (WHO). 2013. Climate Change and Health: Climate Change Adaptation to Protect Human Health: Barbados Project Profile. Retrieved June 19, 2013 from: http://www.who.int/globalchange/projects/adaptation/en/index1.html

Worrell, D., Belgrave, A., Grosvenor, T. & Lescott, A. 2011. An Analysis of the Tourism Sector in Barbados. Bridgetown: Central Bank of Barbados. Retrieved August 04, 2014 from: http://www.centralbank.org.bb/Publications/March2011ER/7-An%20Analysis%20of%20the%20Tourism%20Sector%20in%20Barbados.pdf.