ANTIGUA AND BARBUDA

THIRD NATIONAL COMMUNICATION

2015

Prepared on behalf of
The Government of Antigua and Barbuda
Department of Environment
Ministry of Health and Environment

ANTIGUA & BARBUDA
THIRD NATIONAL COMMUNICATION ON CLIMATE CHANGE
Under the United Nations Framework Convention on Climate change

Antigua and Barbuda is a small island developing state (SID) located in the Eastern Caribbean. The country became a member of the United Nations Framework Convention on Climate Change (UNFCCC) on February 2nd, 1993. It also subsequently ratified the Kyoto Protocol to the UNFCCC on November 3rd 1998. As a developing country, Antigua and Barbuda is categorized as a Non-Annex I Party to the UNFCCC. According to Articles 3.2 and 4.8 of the UNFCCC, the country falls within a range of characteristic criteria which is recognized as being particularly vulnerable to the impacts of climate change and deserving of the support of the international community to address climate change impacts.

To determine the impact at which international agreements such as the UNFCCC, and Rio+20, amongst others influence development, the country has undertaken internal and regional assessments. The results of the assessments so far conclude that most of the countries in the Caribbean, including Antigua and Barbuda, are middle-income, and do not have sufficient access to concessional resources and technical assistance. In the last decade weather-related disasters have also put the countries of the Caribbean to the test, with serious implications for the economies of the region. Additionally, with specific reference to climate change, the small size of the country's economy is a further impediment to its ability to afford necessary mitigation and adaptation technologies on its own.

Antigua and Barbuda's environmental resources create the foundation for social and economic development. Primary resources include a very agreeable climate, outstanding land and seascapes, extensive areas of high ecological value, an engaging history, democratic governance, a well-educated and healthy population, and significant natural resources (beaches, agricultural lands and fish stocks). Although the country's natural resources were of primary economic importance throughout much of its history, the other resources previously mentioned, coupled with the ease of accessibility to North America and Europe, have led to a thriving tourism industry. This industry accounts for more than half of the country's gross domestic product (GDP). With tourism as the main GDP contributor, heavily dependent on healthy environmental resources, the country is significantly vulnerable to the impacts of climate change.

In an effort to address its vulnerability and show its commitment to the ongoing international discourses on climate change, the Government of Antigua and Barbuda has undertaken many strides to enable climate resilient development. Since the last report to the UNFCCC, the Government has enacted its Environmental Protection and Management Act 2015, the National Physical Development Plan, an Energy Policy, and publicly made a commitment through the UNFCCC's Copenhagen Accord in 2010 to reduce the country's green house gas emissions by 25% of its 1990 levels by 2020. Additionally, the Intended Nationally Determined Commitments (INDC) have also been submitted in preparation for the COP21 Paris agreements. It is in this light, that the Third National Communication (TNC) has been prepared to document the country's progress to mitigate and adapt to global climate change.

National Circumstances presents information on the existing status of the islands' environmental resources that would be impacted by climate change, namely, marine resources such as sea grass, coral reefs, beaches, and mangroves. While the island has experienced significant coastal erosion, particularly along the Northwest coast, associated with storm surge and other extreme weather events, watersheds and water resources are continuously impacted by an increase in drought conditions. This has resulted in the increased use of desalination plants which often accounts for 60 -95% of water supply. An overview of land use patterns highlight trends relevant to food and water security as well as urban sprawl. The economic profile examines the

main sectors of economic contribution, such as, agriculture, manufacturing, tourism and the financial services sector. The health sector has seen an increased emergence of vector borne diseases. This has implications for the economy as health advisory warnings deter tourists to the island.

GHG Inventory for the country's major emitted gasses is provided through a detailed methodology and data collection. In 2006, ***945.544Gg*** of CO_2 were reported; 7% from Land Use Change and Forestry and 92% from Fuel Combustion in the Energy Sector. However, since the Initial and Second National Communications, data quality and collection has improved and may account for the sharp increase. In 2000, there was very little data available for the Land Use Change and Forestry Sector but in 2006 there was substantially more data available hence the increase in emissions from that sector.

Methane, Nitrous Oxide and Non-methane Volatile Organic Carbon (NMVOC) emissions decreased when comparing 2000 and 2006 GHG Inventories. In 2000, the methane emissions reported were 6.6Gg; Nitrous Oxide emissions were 0.159Gg; and NMVOC emissions were 2.Gg.

However, Hydrofluorocarbon (HFC) emissions increased when the 2000 and 2006 GHG inventories were compared. In 2000, the HFC emissions reported were 0.0037 Gg compared with 114.034Gg in the 2006 GHG Inventory. In the latter case, greater efforts were made in collecting data from that sector than in the previous GHG inventory, hence the significant increase. It is important to note that there are efforts in place to significantly reduce the GHG emissions by 2020. Additionally, data from this Inventory may be used to provide evidence of the present day situation so that solutions can be encouraged to reduce emissions and point the way forward towards Renewable Energy Sources and Energy Efficiency.

2006 National GHG emissions are as follows:

Carbon Dioxide	945.544Gg
Methane (CH_4)	0.639Gg
Nitrous Oxide (N_20)	0.079Gg
Non-Methane Volatile Organic compounds (NMVOC)	0.035Gg
Hydroflurocarbons (HFC)	114.034Gg

Policy and Measures This chapter discusses the country's efforts to address climate change adaptation and mitigation under the UNFCCC convention. It looks at efforts undertaken to meet national commitments under the Copenhagen Accord and the recent COP21 Paris INDCs. It also highlights efforts to mainstream climate change mainstreaming nationally.

Vulnerability, Assessments, Climate Change impacts and adaptation details the major sectors requiring urgent intervention through stakeholder consultation and various studies. Biodiversity, agriculture, health, and water are highlighted as priorities in an overview of climate hazards and disasters experienced on the twin island state. Chronic drought conditions and impacts currently being experienced are discussed and highlight the need for large scale capital investment projects in renewable energy.

Other Information relevant to research and systematic observation, education, training, and awareness. The chapter also highlights regional partnerships to achieve its objectives under the Convention.

Gaps and Constraints This chapter summarises major constraints provided throughout the report. These constraints hinder the country's progress in meeting the obligations of the Convention. These relate to data collection and availability, inadequate infrastructure, limited private and public sector engagement, and the island's transportation profile.

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GLOSSARY

AMO	Atlantic Multi-decadal Oscillation
AOSIS	Alliance of Small Island Developing States
APC	Antigua Power Company
APUA	Antigua Public Utilities Authority
BAU	Business as Usual (Scenario)
CARIBSAVE	Caribbean Sectoral Approach to Vulnerability and Resilience
CBH	Central Board of Health
CCCCC	Caribbean Community Climate Change Centre
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon Dioxide
DCA	Development Control Authority
DoE	Department of Environment
EIA	Environmental Impact Assessment
EIMAS	Environment Information Management and Advisory System
EPMA	Environmental Protection and Management Act
GOAB	Government of Antigua and Barbuda
GDP	Gross Domestic Product
Gg	Gigagram
GHG	Greenhouse gas
Ha	Hectare
HCFC	Hydrochlorofluorocarbons
HFCs	Hydrofluorocarbons
IPCC	Inter-governmental Panel on Climate Change
Kg	Kilogram
MEA	Multilateral Environmental Agreements
MSW	Municipal solid waste
NAMA	Nationally Appropriate Mitigation Actions
N_2O	Nitrous Oxide
NOx	Nitrogen Oxides
NMVOC	Non-methane volatile organic compounds
NOx	Nitrogen Oxides
NPDP	National Physical Development Plan
NSWMA	National Solid Waste Management Authority
OECD	Organization for Economic Co-operation and Development
PFC	Perfluorocarbons
REGATTA	Regional Gateway for Technology Transfer and Climate Change Action in Latin America and the Caribbean
PPM	Parts per million
SIDS	Small Island Developing State
SIRMZP	Sustainable Island Resource Zoning Plan
SF6	Sulphur hexafluoride
SNC	Second National Communication
SO2	Sulphur dioxide
UNFCCC	United Nations Framework Convention on Climate Change
WIOC	West Indies Oil Company

1 NATIONAL CIRCUMSTANCES

Antigua and Barbuda is a twin island state located in the Caribbean Sea with an exclusive economic zone of 110,071 sq. km. The precise coordinates of Antigua is 17°10' latitude, 61°55' longitude, Barbuda is 28 miles north of Antigua at latitude 17°35' and longitude 61°48', see *Image 1*. There are several tiny uninhabited islands surrounding Antigua; Redonda (0.6 sq. miles or 1.6 sq km) being the largest. Antigua is roughly round and has an area of 108 sq. miles (280 sq. km) and Barbuda 62 sq. miles (160 sq. km).

Antigua (*Map 1*) has three topographic zones. The first zone considered is the mountainous southwest volcanic region, which is home to the highest point of 1,319ft (402m), Mount Obama, in addition to other steep slopes. This region is comprised of hard igneous rocks in the uplands and sedimentary material in associated valleys. The valley systems of this volcanic region consist of sandy loams or loams of near neutral ph which is conducive to tree growth.

The second zone is the relatively flat central plains that consists of heavy clays which are not readily drained and near neutral ph. Calcareous clays may also be found in some parts of this region. In general, these soils are hard to work.

Antigua and Barbuda - Non-Annex I Party

Area:	108 Sq. Miles 62 Sq.Miles
Capital	St. John's
Population:	86,000
Population Density	205 per sq. km
Head of State	Queen Elizabeth II
Prime Minister	Hon. Gaston Browne
Governor General	H.E. Dr. Rodney Williams
Annual GDP (2014)	US$1,200, 289,519
Currency	Eastern Caribbean Dollars (EC$)
Language	English
Electorate Term	5 years
Highest Point	Mount Obama (1,319ft)
UNFCCC Ratification	22nd February 1993
Kyoto Protocol	November 1999
Copenhagen Accord	2009

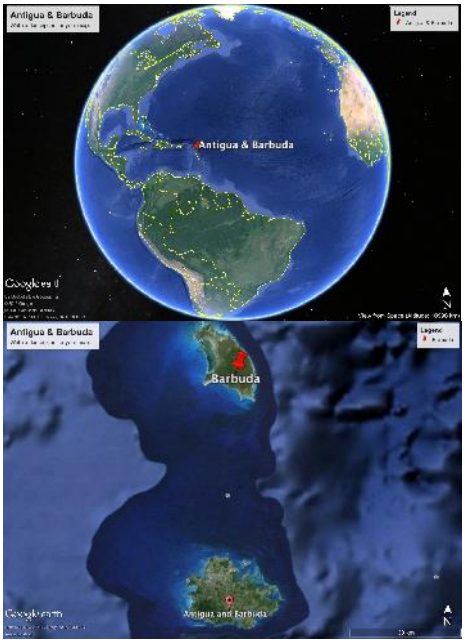
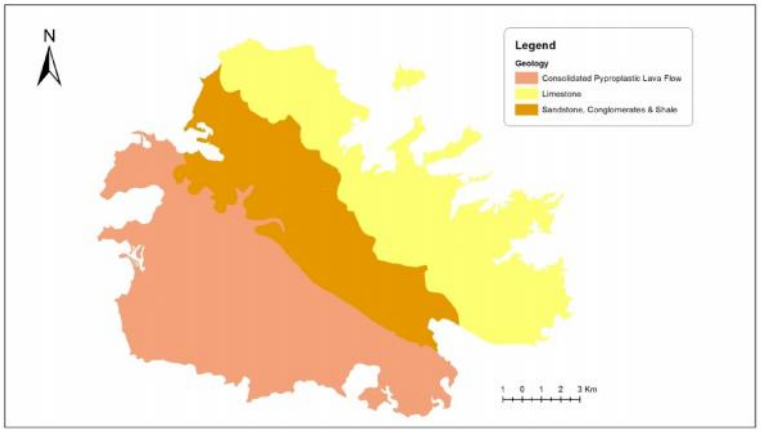


Image 1: Antigua and Barbuda within the global context. Source: Google Earth

content but possess good structure and have a high base structure and high base saturation with a ph of 8.2. Overall, these soils are generally productive. However, the limestone areas in the East consist of complex shallow and deep calcareous soils and the drier climate restricts productivity.

Barbuda is relatively flat with some low-lying hills rising to just under 125ft (40m) in the Highlands area, see *map 2*. Slope gradients are often less



Map 1: Antigua Geological Profile

Map 2: Barbuda topographic map

The third zone can be described as the rolling limestone hills and valleys of the North and East. The limestone areas in the North have high clay

than 2 degrees which increases the island's vulnerability to climate induced coastal inundation. Barbuda is dominated by coralline limestone rocks. On the western side of the island

is the Codrington Lagoon averaging about one and a half miles in width and separated from the sea by a narrow spit of sand. Barbuda's topography is relatively uniform, sand dunes are present but the land is generally covered by limestone and sand.

Barbuda can also be divided into three topographic zones, although, they are not as marked as those in Antigua. The first zone consists of highland limestone areas, which consists of hard limestone riddled with caverns and sink holes.

The soil in this zone is a reddish clay loam. The second zone is the Codrington limestone region which comprises of sandy and fossiliferous sediments less crystalline than the Highland limestone. The soil is a brown clay loam. The third zone is the Palmetto Point Series that overlies the Highlands and Codrington formations in coastal areas and is composed of beach sands and ridges with shelly horizons. The soil in this region is dark coloured montmorillonitic clay.

1.1 ENVIRONMENTAL CONTEXT

Since the last report to the UNFCC, data is now available up to 2010 on environmental resources including current land use patterns for the country.

Antigua and Barbuda's economic and social development is heavily dependent upon its environmental resources and the inter-related ecological functions. In Antigua and Barbuda, the inter-relationships of these ecological functions and physical processes result in a number of ecosystems. These include:

1) Marine and Coastal Ecosystems - Sandy beaches, rocky shores, coastal lagoons, sea grass beds, coral reefs and oceanic islands and rocks.
2) Watersheds
3) Salt pond Ecosystems
4) Evergreen forests
5) Xerophytic (dry) forests
6) Scrubland Ecosystems
7) Grassland Ecosystems
8) Mangrove forest Ecosystems
9) Herbaceous swamp Ecosystems

Ecosystem variety is further enhanced by the presence of caves in many sections of the island, and by natural seasonal drainage channels and ponds.

The following sub-sections will highlight the status of key environmental resources and potential impacts of climate change on these resources.

1.1.1 MARINE RESOURCES

The key marine resources of the island include coral reefs, mangroves, seagrass, and various beach types. These resources contribute to both the tourism sector and food security of the island.

1.1.1.1 Coral Reefs

Coral reefs are found around both islands of Antigua and Barbuda and the estimate coverage varies from a high of 25.4519 km^2 to a low of 15.820 km^2. Antigua and Barbuda sits on a shallow rock-floored 'shelf' covered by a variety of reefs. The edge of the 'shelf' is at depths of 90 – 180 m where it drops to oceanic depths. Along the south coast of Antigua, the shelf is very narrow; it drops to over 305 m within a mile (1.6 km) of the shore. There are approximately 25.24 sq. km of reef coverage around Antigua. On the windward east coast there is better reef development due to the high wave energy providing circulation of nutrients and flushing with absence of fine muddy sediment. However, on the leeward west coast the reefs are poorly developed because of lack of circulation and abundance of fine sediment.

There are four main types of coral reefs found in Antigua and Barbuda. The first type is the Barrier reef located on the Southern shore of Antigua

parallel to a steep slope at the edge of the narrow shelf. The second type is the Bank Barrier reef that is predominant off shore Antigua and located on the North eastern and Southwestern flanks. The Fringing reefs are the third type and is found protecting the eastern, northern and southern coast. Patch reefs are mainly found in Barbuda.

Coral reefs contribute to the formation and protection of beaches. However, Antigua and Barbuda's reefs are under continuous stress both from natural and human forces. A large percentage of the islands reefs are now dead particularly due to the frequent passage of hurricanes and storms. In addition to hurricanes, the improper discharge of untreated sewage into the sea, sediment loading due to land erosion, fertilizers, dredging and boating activities have further added to the stress of coral reefs.

Photo 1: Dead and dying coral reefs along the North coast of the island. *Courtesy Chere Reade, 2007*

The optimal temperature for reef growth is 29°C (Brown 1989). Presently sea surface temperatures of approximately 30°C have been found around Antigua and Barbuda. It is at temperatures of 30°C and above that bleaching of the corals takes place. Prolonged exposure to high temperatures can result in irreversible bleaching of the corals.

1.1.1.2 Seagrass

There are extensive areas of sea grass beds in shallow waters around the coasts of Antigua and Barbuda. Turtle grass (***Thalassiatestudinum),*** manatee grass (***Syringodiumfilforme)*** and shoal grass (***Halodulewrightii***) are common in these shallow coastal areas (less than 20 m deep). The grasses provide shelter for commercially important juvenile queen conchs (***Strombusgigas***) and spiny lobsters (***Panulirusargus)***. Sea grasses also act as a source of food for some herbivores and also provide surfaces for epiphytic plants upon which other species may graze. Calcareous algae (***Halimedaspp***) are found among sea grasses and are believed to be a major source of white sand.

The sea grass beds have many functions one of which is to stabilize loose sand and retard coastal erosion. After intense storm surge from hurricanes in the region it is not uncommon for some of this sea grass to appear washed up on the seashores. These systems are thought to be under severe stress and will continue to be so as the impacts of climate change increase as in the case of Coral Reefs.

1.1.1.3 Mangroves

Antigua and Barbuda has some of the most extensive mangrove wetlands in the Eastern Caribbean. During the 1980s through to 1991, mangroves occupied approximately 12 percent of the twin island's total land mass with an estimated 4,900 hectares (ha) of mangroves found.

There are thirty-six (36) mangrove sites in Antigua and nine (9) sites in Barbuda. In Antigua, the sites range from very small single layer stands of trees to large, complex swamps. In Barbuda, there is the luxuriant 352 ha fringe mangrove of Codrington Lagoon and narrow scrubby borders of mangroves around salt ponds. Four kinds of mangroves exist in Antigua and Barbuda. They are *Rhizophora mangle* (red), *Avincennia germinan* (black), *Laguncularia racemosa* (white) and *Conorcarpus erectus* (buttonwood). It is estimated that in the 1980s approximately 11% of Antigua and Barbuda was covered with

wetlands. In 2001, a survey of sites estimated that mangrove wetlands covered only 3% of the land area in Antigua and 22% in Barbuda.

Mangroves are vital to maintaining healthy beach and reef systems. They act as natural breakers and buffer zones that protect the coastline from erosion during storms. Additionally, the mangroves act as sediment traps, protecting the reefs from being smothered by eroded soil and other geological material from upland. Finally, they act as nurseries, breeding and feeding grounds that provide a habitat for both marine and terrestrial wildlife.

Figure 1 highlights the fluctuation of how the frequency of extreme weather events impacts mangroves. Climate Change will significantly disrupt the mangrove ecosystem, especially, since these areas are already under stress from natural (hurricanes, droughts) and anthropogenic sources (pollution & destruction caused by dredging and filling).

IWCAM (Integrating Watershed and Coastal Areas Management) projects have sought to examine effective methods of addressing the impacts of land based sources of pollution on the mangrove systems particularly on the north west coast of the island. In some cases, work completed over the last three to four years has resulted in the reintroduction of mangroves in some critical sites such as the Mckinnons Pond. This on-going work, since the last report to the UNFCCC, is aimed at ensuring the country undertakes activities geared towards improvements in resilience to climate change in the most vulnerable areas; habitat/nursery sites and the coastal zone.

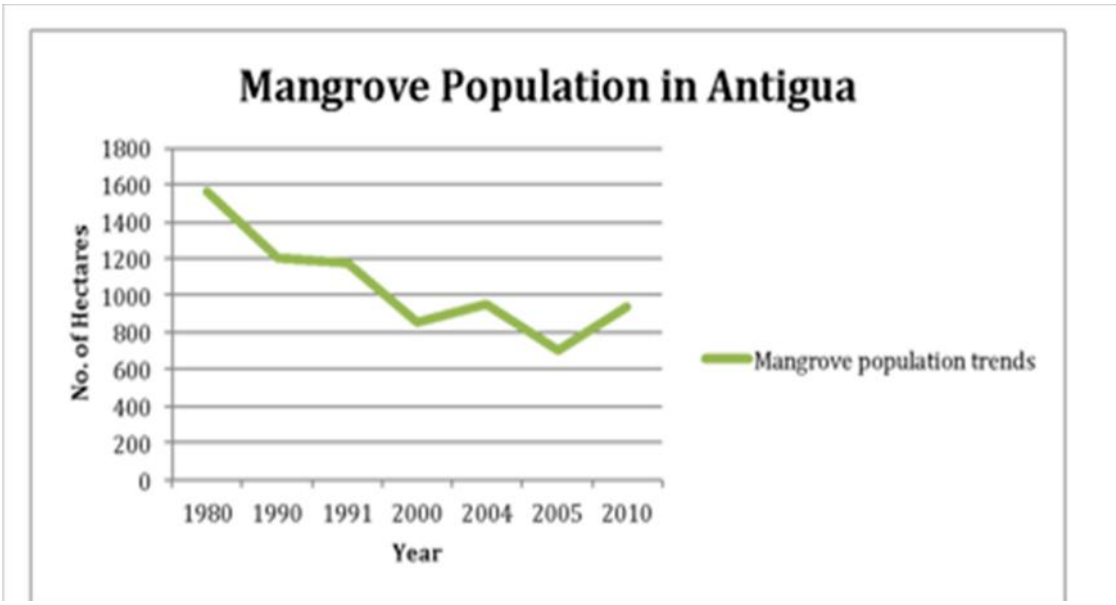


Figure 1: Mangrove population trends

Recent work undertaken through a number of projects, including the SIRMM (Sustainable Island Resource Management Mechanism) and GEF

1.1.1.4 Beaches

Antigua and Barbuda is known for the quantity and quality of its beaches. The island boasts 365 beaches and is a prominent feature of its tourism industry and culture for local communities. The beaches of Antigua and Barbuda remain attractive to hotel development and residential realty, increasing the contribution to the nation's GDP.

Photo 2: Concrete buildings previously built too close to the shoreline on the Northwest Coast, Antigua. *Photo Courtesy of the EAG*

Beaches and sand bars provide a major barrier to the constant force of coastal erosion. The beaches provide a habitat for nesting turtles and other animals and plants. Unfortunately, the beaches are illegally used as a source of fine aggregates in construction; therefore, sand mining is a significant concern in addition to the potential impacts of Sea Level Rise and other climate influenced coastal erosion events. Another major source of coastal erosion is the building of concrete structures too close to the shoreline and the use of poorly designed and unregulated sea defenses. Consequently, the island's beaches are now under threat given both the development challenges and climate change related events. An example of this can be seen below.

The photo above illustrates the levels of coastal erosion along the northwest coast. Beach monitoring reports conducted by the Fisheries Division show that between 2006 and 2008, the Dickenson Bay shoreline experienced significant rates of erosion. The profile area had decreased by 2.24m^2 and the profiles were narrowing at an average rate of 1.09m/yr[1].

Further along the north west coastline, the shoreline at Fort James also showed major

[1] **Fisheries Division. Analysis of Beach Changes in Antigua and Barbuda (2009)**

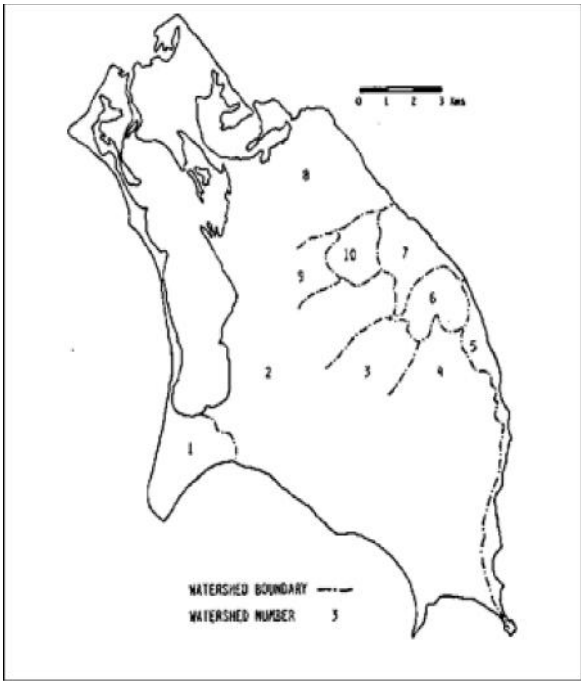
erosion with both beach profile during 2006 - 2008 with a decreased area - 17.86m^2 and width (-3.39 m/yr). However, for the period 2004 – 2006 corresponding values of + 19.65m^2 and + 4.10m were observed, respectively.

1.1.2 WATERSHED AND WATER RESOURCES

Antigua has 86 watersheds that were recognized by the Halcrow study (Halcrow 1977). These watersheds were later grouped by McMillan (1985) into 13 larger watershed groups, see ***map 3***. The two largest watersheds are Potworks (1) and Big Creek (2). The Potworks Watershed drains the northern slopes of the southwest volcanic region. The Big Creek Watershed drains main parts of the Central Plain to the east and west. These six watersheds occupy 43 percent of the land area and contain 80 percent of the groundwater supplies and 90 percent of surface water storage. Within these watersheds are found 50 percent of the island's forestland, 90 percent of its crop production, 60 percent of livestock production and 70 percent of the population (Fernandez, 1990). In Antigua, all the watersheds are quite short, the largest being not more than 11 km in length. The two largest have areas of 4000 ha and 3,160 ha respectively.

Many of these watersheds are close to the coast, and saltwater intrusion is a major concern factor in the quality of surface storage and ground water supplies in aquifers.
There is also surface water storage in the form of 10 medium to small reservoirs, 550 ponds and earth dams with the combined capacity of 6 Mm3 (6000 acre-feet/1.6 billion imperial gallons). Most households have cisterns and other water storage containers. Additionally, there are two Desalination Plants located on the northeast coast and a recently commissioned Reverse Osmosis Plant in the southwest[2]. However, due to the expensive nature of desalinated water it is prioritized for domestic and tourism sectors, leaving the agricultural sector with an inadequate supply. Additionally, during drought, desalination accounts for 60 to 95% of water supply. Moreover, there are growing concerns on sea level rise and saltwater intrusion of fresh water supplies.

Barbuda's primary source of freshwater is shallow aquifers that underlie 650 ha of sand in the Palmetto Point Area. However, the removal of sand deposits in the Palmetto Area has raised the effective water table by several feet and exposed part of the shallow fresh water aquifer and as a consequence some of the aquifer is drying out.



Map 3: Watershed groupings in Barbuda

It should also be noted that the sand mining activities have increased the vulnerability of the island to saline intrusion and impacts of storm surges. Recently, there has been a desalination plant installed in Barbuda to meet the needs of the domestic and tourism sectors.

[2] http://www.apua.ag/ffryes-beach-reverse-osmosis-plant/

While there has been an observed increase in drought risk globally since the 1970s (Sheffield and Wood, 2008), regional analysis of changes in drought characteristics as a result of climate change have not been researched in great detail (Mishra and Singh, 2010). Further, data collection on watershed and water resources only began in 2001, which limits the scope of temporal analysis.

1.1.3 LANDUSE CHANGES

In 2012, the Sustainable Island Resource Zoning Plan (SIRMZP), which serves as the National Physical Development Plan (NPDP), was adopted by Parliament for implementation. The SIRMZP not only highlights anthropogenic and natural forces that threaten the country's resources but also provides a framework to steer national sustainable development given the country's environmental situation.

The environmental situation in Antigua and Barbuda is of course directly related to its geographical location, its climate, its topography as well as its geology and its economic history. As such, the country has acknowledged the current and potential threats that climate change will have on its natural resources. This is even more important as the climatic parameters that combine with the topography of the islands are largely responsible for the existing rich and diverse biodiversity habitats that sustain the islands. Conversely, this increases the country's vulnerability to climate change impacts in addition to existing developmental challenges. These challenges include:

- Unplanned housing, hotel and industrial development;
- Uncontrolled Livestock grazing;
- Unsustainable farming practices;
- Poor Watershed Management
- Fires;
- Pollution;
- Dredging;
- Sewage - Disposal;
- Sand Mining;
- Boating Activities;
- Drought; and
- Hurricanes and storm surges

Droughts and extreme weather events such as Hurricanes have recently increased, becoming areas for national concern. Temperature rise have led to more severe drought conditions and devastating hurricanes. The adjacent table now highlights the trends in land use types.

As illustrated in the adjacent *table 1*, critical land usage pertinent to climate change adaptation in Antigua through food security are decreasing in pursuit of economic development. Because of this, the environment in Antigua and Barbuda requires a concerted effort and international support to both reduce impacts and reverse existing negative trends. Recent land use patterns have been captured in *table 1.*

Table 1:Land-use Trends in Antigua & Barbuda

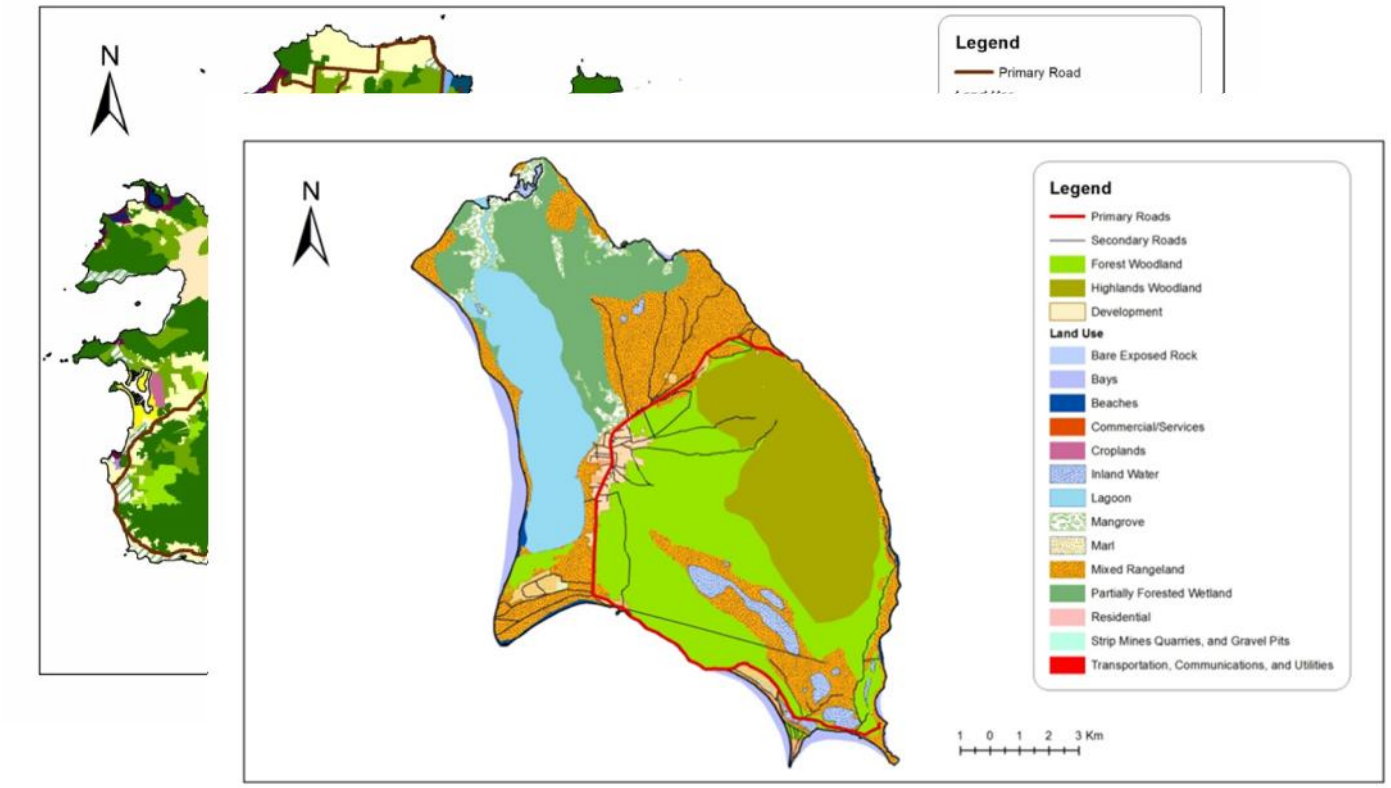
Land use type	1985 - 1995 (Acres)	2010 (Acres)	Trend
Antigua			
Agricultural crops	5,501 - 7,740	6,855	Decreasing
Agricultural grazing	26,252 - 13,482	17,349	Increasing
Rural Areas	17,189	16,177	Decreasing
Swamp & Mangrove	2,164 – 2,142	2,161	Stationary
Invasive crop	N/A	345	Unknown
Industrial development	584	778	Increasing

Recreation and Historic Areas	1,558	400	Decreasing
Airport and Military	763	829	Increasing
Barbuda			
Settlement (and related uses)	269	882	Increasing
Cropland, trip mine quarries, gravel pits	N/A	269	Unknown
Dry Forests	N/A	3,896	Unknown
Mangrove and Swamps	N/A	14,468	Unknown

1.1.4 CLIMATE PROFILE

Antigua and Barbuda experiences a moderately arid tropical maritime climate. There is a marked wet (July – November) and dry (December – April) season. There is little variation in daily seasonal temperatures. Average monthly temperatures are 29.6°C maximum and 23.9°C minimum. Over a thirty year period, the average temperatures of the coolest month (February) and the hottest month (August) were compared but very little change was noted.

The 30-year average temperature for Antigua and Barbuda is 29.9°C (1981-2013). Trend analysis of average temperatures by the Department of Meteorological Services has shown a generally upward projection, approximately +0.6°C. Additionally, in the 40-year timescale provided in



Map 5 Barbuda Land Use Patterns

the data, the ratio of above/below average temperature years was 15/25, but more importantly 11 of those years occurred within the last twenty of the timescale, *see Figure 2.*

The Antigua Barbuda Meteorological Department uses an adjusted version of the decile (DI) method developed by Gibbs and Maher (1967). Rainfall periods of three months or more are assessed to determine whether they fall below

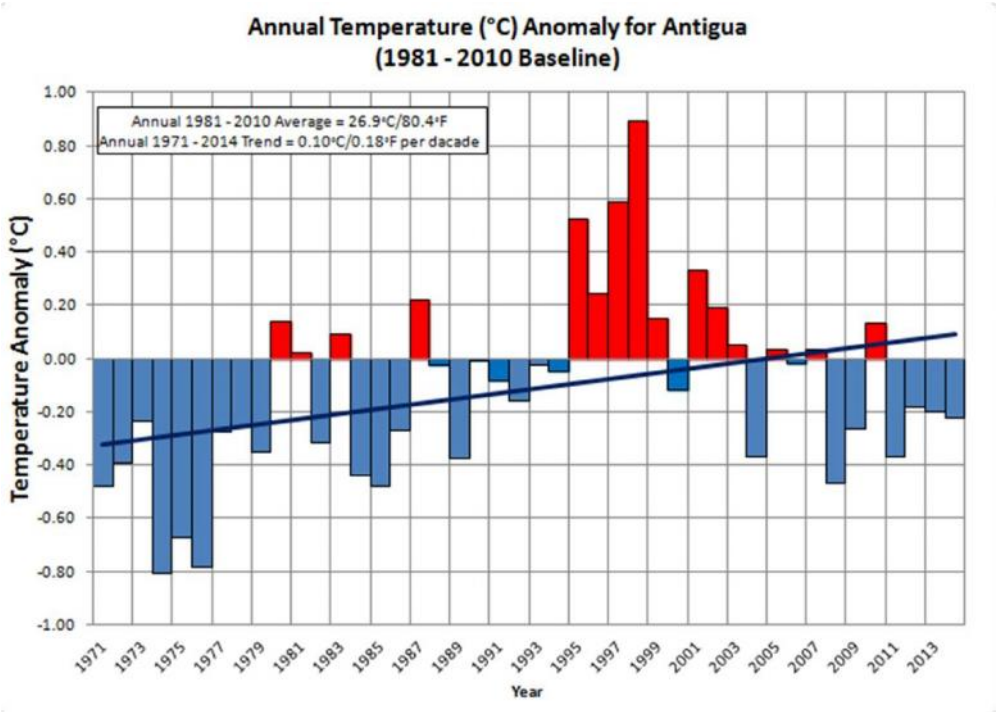


Figure 2: Annual Temperature Anomaly for Antigua (1981 - 2013)

1.1.4.1 Rainfall

Rainfall tends to be variable, with severe droughts occurring every 5 – 10 years. Evapotranspiration rates are high. The average rainfall across the island in the direction of prevailing northeast trade winds is about 33 inches in the northeast to over 50 inches per year in the southwest. The average rainfall per year (1961-1990) is approximately 46.30 inches. Pan evaporation averages are about 77 inches per year and open water evaporation is estimated at 65 inches per year. Barbuda has a lower rainfall average. Recently, the country has been suffering from the impacts of a chronic and intensifying drought for the last 24 months (June 2013 – June 2015).

the 30th percentile of historical records. This system of measurement is similar to that of the Australian Drought Watch System.
Drought severity indices will be captured later in the chapter on vulnerability.

Based on *Figure 3 and 4*, it can be seen that this twin island state has long been accustomed to insufficient rainfall. However, the occurrences of drought are becoming more frequent. Heavy rains after periods of severe droughts lead to removal of topsoil, formation and deepening of gullies and general soil erosion.

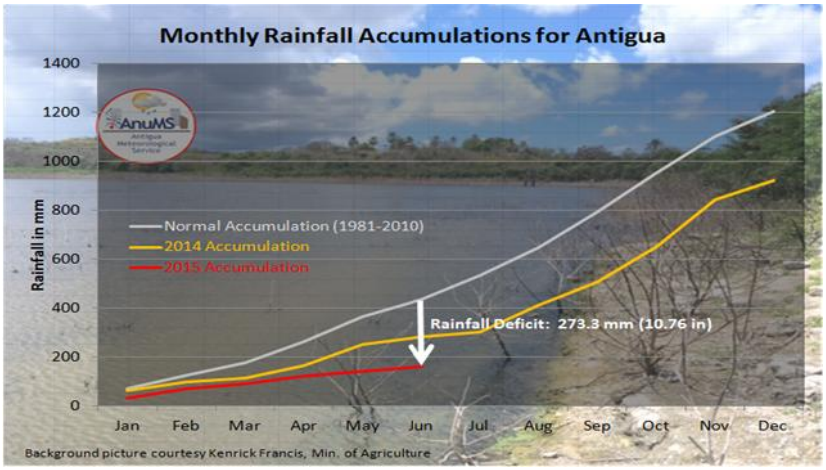


Figure 3: Monthly rainfall accumulation trends (1981 - 2015

During the droughts of 1983 – 1985, less than 1000mm of rain occurred over 21 months. All surface reservoirs had dried up and the supply of groundwater produced only 1/6th of national demand, water had to be imported from neighboring islands. More recent droughts have been nearly as severe but the availability of desalinized water has made the impact less visible.

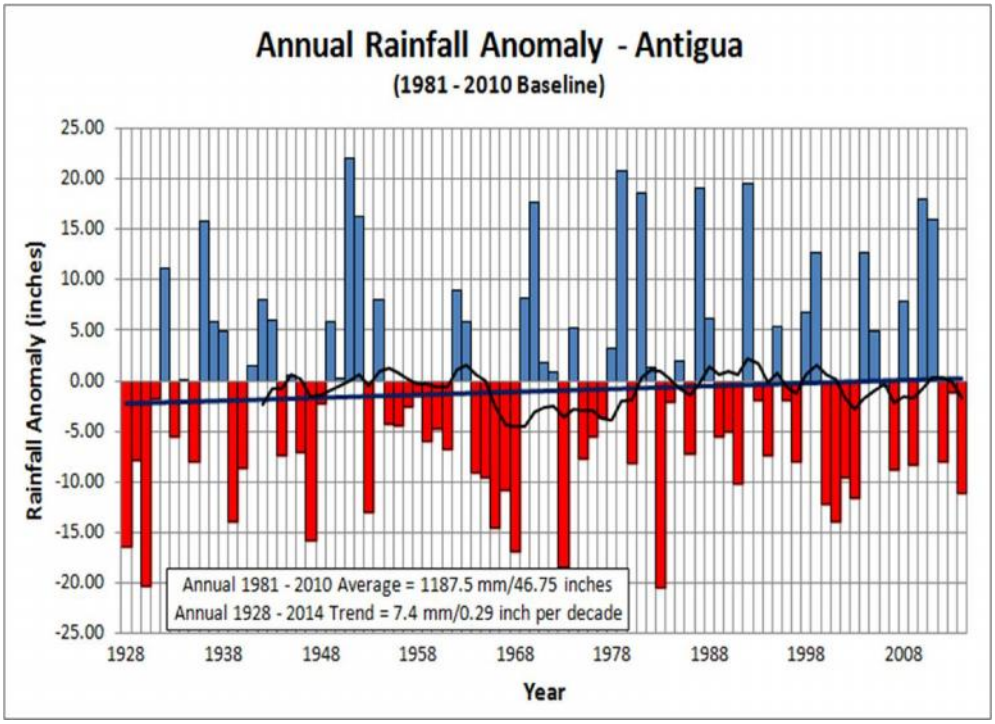


Figure 4: Rainfall Anomaly for Antigua 1981 -2010

The impact is greatest on land previously cleared for human consumption. The resulting eroded material is in turn deposited downstream causing siltation and further degradation of coastal areas, watercourses, marine and aquatic breeding areas.

1.1.4.2 Climate Hazards and Disasters

Drought, tropical waves, depressions, storms and hurricanes are relatively common in this region.[3,4] The storms form just off the coast of Africa during the Hurricane season (June – November) and usually pass somewhere through the leeward island chain on a north westerly course depending on the atmospheric conditions. Even if the islands do not receive direct hits the storm surge is usually enough to create significant damage to the coastal regions.

Antigua and Barbuda had a forty-five-year reprieve of direct hits by dangerous storms. In 1950, two severe hurricanes struck these islands in the space of twelve days causing great damage. In 1995, Category 4 Hurricane Luis devastated Antigua on the 4th - 5th Sept. to be followed ten days later by Category 1 Hurricane Marilyn. The damage was in the millions of dollars.

The forty-five year reprieve led to little attention being paid to design standards and development in known hazardous areas. There was closure and loss of revenue in all major tourism facilities along the coast; 17% decreases in tourist stay over arrivals, see figure; and 7000 persons were left unemployed. The total cost of damages was EC$ 346.54 million or 30.49% of the GDP at factor cost in 1994. In 1998, Category 2 Hurricane Georges struck Antigua and Barbuda causing damage estimated atEC$200 million. In 1999, Category 2 Jose hit Antigua in October and Hurricane/Tropical Storm Lenny hit in November, the combined estimated damage was EC$ 247.43 million.

Since 1999[5], Antigua and Barbuda has gone 12 straight years without a hurricane making landfall. This, however, does not mean that Antigua and Barbuda has been without its challenges. In 2011, Antigua and Barbuda encountered 3 tropical storms, namely Irene, Maria and Ophelia. Although tropical storms do not bring substantial winds, the rainfall and coastal erosion associated with them can at times wreak significant damage. In recent years, tropical storm Omar (2008) cost US$18 million in damage[6]. Direct impact on the tourism arrival however was minimal. The number of cruise ship arrivals was not as affected since accommodations were not required and it was less expensive for the supporting tourist related activities to get off the ground again than for the hotels to be rebuilt.

Additionally, the mobility of cruise ships and hence their flexible routes allows them to avoid storm warning zones and impacted destinations where the level of damage has compromised excursion facilities. Also note in ***Chart 3*** the sudden drop off in both stay over and cruise visitors that occurred just after the 9/11 Terror attacks. In recent years however, this fragile industry has seen some improvement with an increase in stay over visitors for the year 2012 when compared to 2011. As persons begin traveling again to the islands for vacation it is even more important to ensure that the sun, sea and sand that they return for year after year, is preserved as much as possible. Further discussions and analysis on the impact of climate change on the country's tourism industry is highlighted in *figure 5*

[3]National Office of Disaster Services, Govt. of Antigua & Barbuda
[4] Cordell Weston, Hurricane the Greatest Storm on Earth, (Antigua Archives Committee) pp 4-8
[5] Destin, D (2012) The Atlantic Hurricane Season Summary – 2011 Special Focus on Antigua and Barbuda, Antigua and Barbuda Meteorological Service.http:www.antiguamet.com/Climate/HURRICANE SEASON/HurricaneSeason 2011.pdf
[6]Antigua and Barbuda Meteorological Services (2008) The Atlantic Hurricane Season Summary – 2008Special Focus on Antigua and Barbudahttp://www.antiguamet.com/Climate/HURRICANE_SEASONS/2008/Hurricane_Season2008.pdf

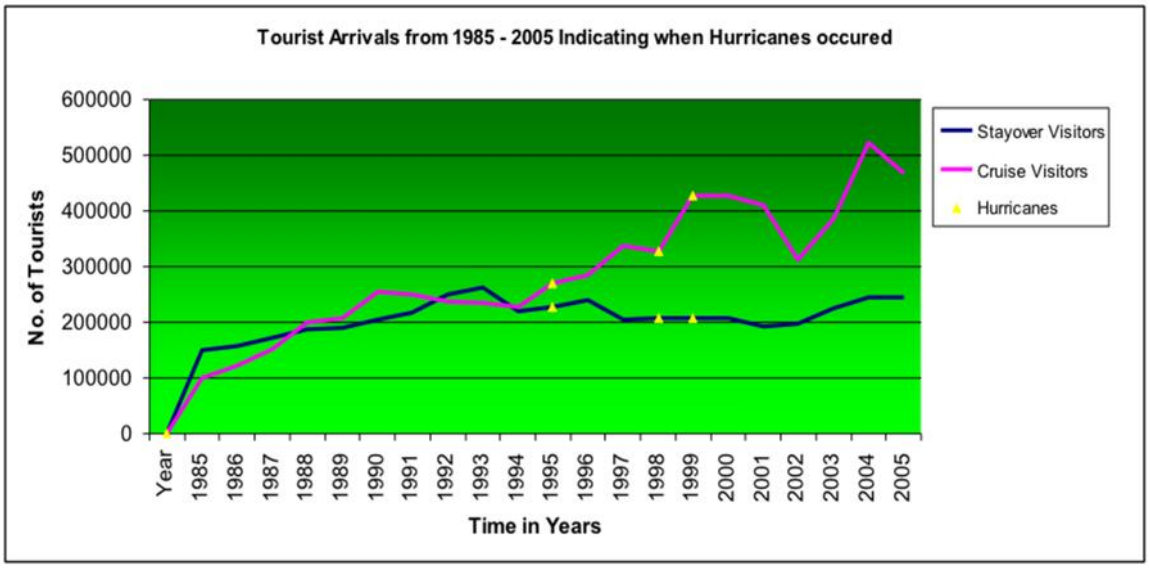


Figure 5: Tourist arrival trends from 1985 -2005 indicating when Hurricanes occurred

1.2 DEMOGRAPHIC PROFILE

The National Statistics Office conducts a national census every ten years. In 2001, the estimated population was 76,886 with a projected increase of 9.7% by 2007 reaching a maximum of 84,330. However, following the 2011 Census, Antigua and Barbuda had a combined population of 87,774 which shows a population growth of 15.6% between 2001 and 2011.

Individually, Antigua has 86,159 people while and Barbuda has a total of 1,615 people. In terms of gender ratio, Barbuda maintained its unique feature of having 110 males to every 100 females on the island but cumulatively the gender ratio is 91.4 males to every 100 females. Information on the age structure of the population may be see in *Table 2.*

Table 2: Age Structure of national population

Age	% of Population
0 – 4years	7.7%
5 -14 years	16.1%
15 – 44	47.4
45 -64	21%
Over 64	7.7%

As shown in *Image 2*, the urban Parish of St. John's house the greatest total population (P) and households (H) while Barbuda has the least number of people in the largest land area. Male (M) to female (F) ratio are also highlighted.

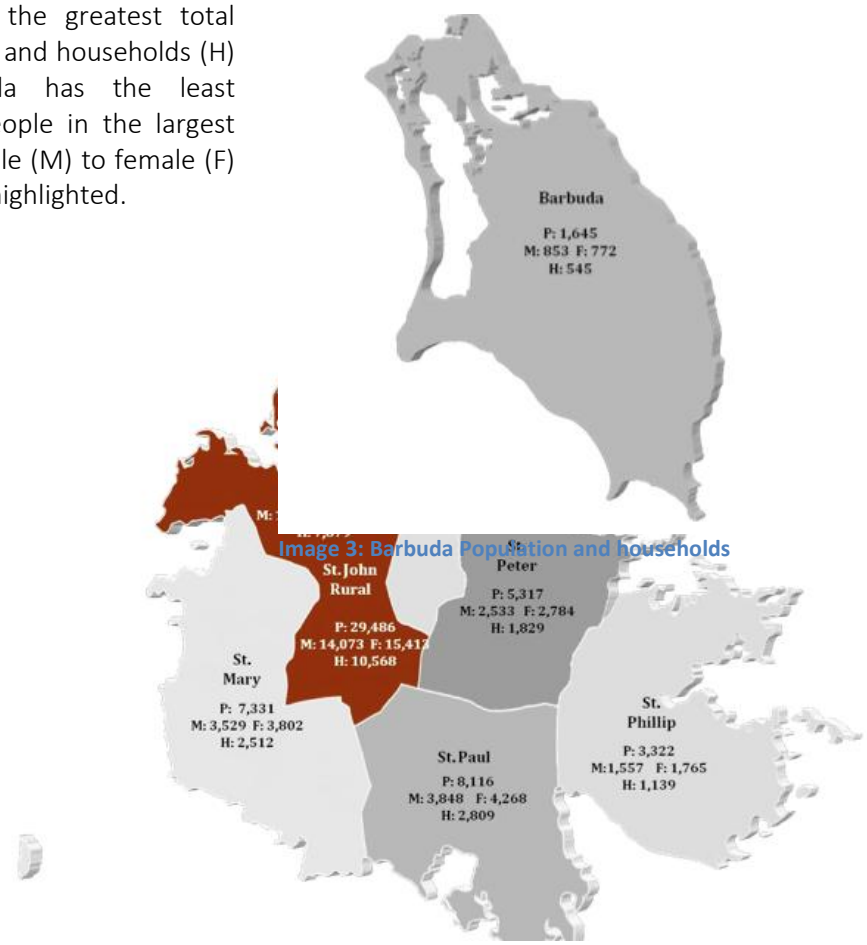


Image 3: Barbuda Population and households

Image 2: Antigua Population and housing by Parish. Sourced from the Antigua and Barbuda 2011 Population and Housing Census: book of statistical tables.

1.2.1 SOCIO-ECONOMIC INDICATOR

Antigua and Barbuda has a labour force of 45,260 people. There are more persons employed within the Tourism sector and its related services, than any other sector. The estimates for this sector vary seasonally based on industries such as yachting, which brings employment during special yachting events and through seasonal usage of the docks. The Construction sector also has a high level of workers which would correlate with the increase of the contribution to the GDP by this sector. Also, as expected, Agriculture has one of the lowest numbers of workers. The following sections expand on the social indicators for the country with emphasis on poverty levels, health care, education and other social amenities.

1.3 POVERTY ESTIMATES

The indigent population was estimated at 5% of the population, constituting 4.4% of the households in the country. An indigent person was defined as someone whose expenditure was below EC$2,449 (US$917) per annum, since this amount should provide an adult male with 2400 kilocalories per day. The Poverty Line was estimated at EC$6318 (US$2366) per annum (adjustments made for non-food expenditure). 18.4% of the population fell below the poverty line, indicating that 18.4% of the population is unable to meet basic needs. However, it is customary to include into the poverty line, the percentage of vulnerable persons, that is, persons who are likely to be at risk of falling into poverty if there is a shock to the economy, which may occur with climate change.

Therefore, it is estimated that the cumulative total of 28.3% of the population is estimated to be at risk. These results are amongst the lower range when compared to other Caribbean countries. Spatial differentials in poverty are also evident in Antigua and Barbuda. The poorest districts are St. John's City (22%) and St. John's rural (18%); followed by St. Philip (26%); St. Paul (16%); St. Peter (15%); St. Mary (14%); St. George (12%); and Barbuda (11%).

The Government of Antigua and Barbuda is developing its social safety net but the burden of the fallout of the international economic crisis and rising debt that is over 100% of GDP makes the situation worrying. It is obvious that major social and economic transformation is required. Based on the current developments involving climate change and its impact on the country's most vulnerable, such issues will have to be addressed on the basis of current climate change discussions.

1.4 HEALTHCARE

Antigua has one main public hospital with 164 beds, which struggles to meet the growing demands of the public. Barbuda also has one public hospital. However, the increases in public primary care clinics in many of the villages and rural parishes around the island are helping with

the load of patients requiring assistance. Antigua also has four private clinics that are able to hospitalize patients and at least two other outpatient clinics that can provide X-rays, MRIs and Cat Scans at a cost. WHO (2012)[7] indicates that the average per capita total expenditure on health is approximately US$700. There are many private doctors and specialist in a wide variety of fields. Many medical laboratories exist that can carry out a large number of diagnostic test and the option to ship samples to specialized

[7] **http://www.who.int/gho/countries/atg.pdf?ua=1**

laboratories overseas is always readily available. The variety of health care available to Antiguans and Barbudans has enabled this country to have a reasonable life expectancy rate at 72 years for males and 74 years for females. The top two causes of death within the islands for the years 2000-2004 were Malignant Neoplasms and Heart Diseases. In addition to dealing with health problems, the Government operates a preventive medicine programs and promotes healthy lifestyles

Within the last two years, outbreaks of vector borne diseases have impacted the tourism industry as health advisory warnings deter visitors from the island.

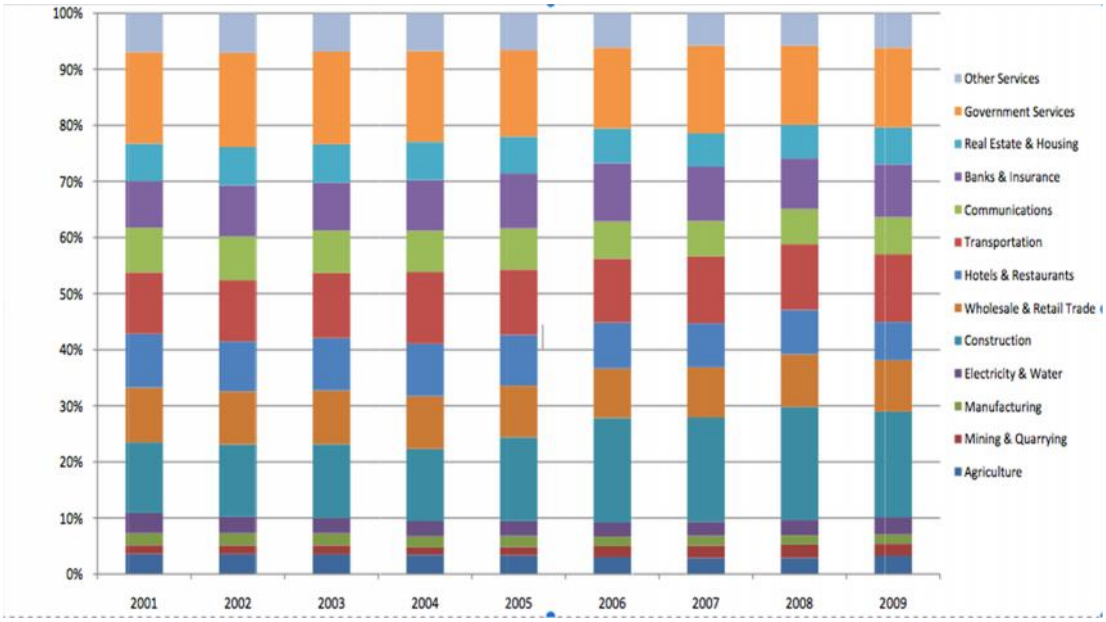


Figure 6: GDP Contribution 2001 -2009

Studies have shown that climate variability have a direct impact on the epidemiology of vector-borne diseases[8]. Mosquitoes are the primary agents for the transmission of most vector borne diseases, and are sensitive to temperature changes. Increases in water temperature shortens the time taken for mosquito larvae to mature and increases the capacity of reproduction. Also, in warmer climates, female mosquitoes digest blood more rapidly thereby increasing the frequency for feeding and transmission.

Like the rest of the Caribbean islands[9], Antigua and Barbuda has seen an increased emergence of vector borne diseases. Most recently, there has been an increase in Chikungunya, and Dengue cases on the island which has both economic and social ramifications.

1.5 ECONOMIC PROFILE

The economy of Antigua and Barbuda is service based. Tourism and government services represent the key sources of employment and income. Tourism accounted for more than half of the GDP in 2005 and is also the principle earner of foreign exchange. The situation has not changed much for 2011 to 2012. However, the tourism industry is significantly vulnerable to climate hazards as previously mentioned. As such, with the forecasted increases in hurricane intensity, the island's economy is also vulnerable to both direct and indirect impacts of climate change.

Antigua and Barbuda's economic performance has fluctuated significantly. In the 1980's average

[8] **WHO (2000) Climate Change and Vector Borne Diseases: regional analysis. http://www.who.int/bulletin/archives/78(9)1136.pdf**

[9] **http://carpha.org/Portals/0/articles/documents/CARPHAContinuesBattleDengueChikVZika.pdf**

growth was estimated at about 7%, while in the 1990's growth slowed to approximately 3.3% and then between 2000-2004 it further decreased to about 2%. This was as a result of several devastating hurricanes between 1995 – 1999, which led to a declined economic growth rate. However, the growth rate seems to be on an upward swing again. In 2005, Antigua and Barbuda had a GDP of US$ 874.9 million, with a growth rate of 7.07 and an inflation rate of 2.10.

Between 2005-2008, growth averaged 7.1% primarily as a result of activities related to the hosting of the Cricket World Cup. From 2009-2011 with the onset of the global financial crisis, the economy experienced an average contraction of 7% per annum. In 2011[10] there was an improvement in the GDP which was USD$1.125 billion, with a growth rate of (0.98)%. The projected GDP for 2012 by the ECCB was US$1.18 billion with a growth rate of 4.03%. Efforts to diversify the economy by encouraging growth in transportation, communications, internet gambling and financial services may have acted as a catalyst to the renewed economic growth.

GDP per capita for 2011 was made up of contributions from various sectors as follows: Transportation and Communications (11.89%); Wholesale and Retail (14.17%); Construction (8.9%); Financial and Business Services (10.28%); and Hotels and Restaurants (13.49%). Comparatively, the Agriculture sector contributed only 1.15% to the value of GDP in 2011continuing a steady increase since 2007. The main direct and indirect contributor to GDP is tourism which is the most significant economic driver for the economy. Like many other SIDS in the Caribbean, the economy of Antigua and Barbuda has transitioned from an agrarian to a more service oriented economy within the last 25 years, but the economy lacks diversity and therefore resilience. The projected growth for 2012 is predicated on expected expansion in some key sectors such as construction, transportation, and hotels and restaurants. The hotels and restaurants sector, which contributes 15.6% to the GDP, is expected to grow by about 2.0% which correlates to an almost 3.0% increase in stay-over arrivals. Activity in the construction sector is projected to increase by 1.6 percent in 2012. One factor that has helped to improve performance in this sector is the Construct Antigua Barbuda Initiative (CABI), which offers concessions and incentives for residential construction.

As of May 2011, the Government mandated the elaboration of a Medium-Term Strategic Development Plan (MTSDP) as an update to the National Strategic Development Plan (NSDP). The MTSDP will be underpinned by the following strategic objectives:

- Fiscal Balance
- Education for All
- Enhancing our Social Development Agenda
- Preserving our environment and building a stronger physical infrastructure
- Economic sustainability
- Antigua and Barbuda – the Best Brand

Despite all the challenges between 2005 to 2010 however, in 2011, Antigua and Barbuda was ranked 60th on UNDP's Human Development Index making it the highest ranked in the OECS as Saint Kitts and Nevis which was ranked 54th in the previous report has now fallen to the 72nd place. This high human development rank is based on a life expectancy at birth of 72.6 years and GDP per capita of US$15,521 in 2011. The country also has a literacy rate of 99.0% based on a 2008 survey completed by the World Bank. Such a high standard of living makes the twin island one of the three most attractive places for intra-regional migrants within the GEF SGP's sub-regional programme area, with the others being Barbados and Saint Lucia.

[10]ECCB GDP data 2000-2014

1.5.1 TOURISM AND THE ECONOMIC GROWTH

Tourism is Antigua's most important productive sector, and was in 2007 estimated to account for 40 % of all employment, 85 % of foreign exchange earnings, 52 % of total investment and 70 % of GDP (directly and indirectly). In 2012, the Index Mundi showed that tourism accounted for almost 60% of the country's GDP and 40% of investments. Total earnings, and tourist arrivals saw a strong growth in 2007 (up 26.5% from 2006), but has since declined with the economic crisis. For Antigua and Barbuda, economic growth in the medium term will continue to depend on income growth in their tourist markets, the US and UK. There are signs of recovery however. April 2012 saw the highest hotel occupancy rates (63.8%) since 2008 surpassing 2010 (58.4%) and 2011 (61.3%) for the same period.

1.5.2 AGRICULTURE AND THE ECONOMY

Agriculture at one time was one of the major contributors to the GDP because of large scale sugar production along with its by-products, molasses and rum. Several factors caused its decline namely the shrinking international market, inadequate water (severe droughts), destructive hurricanes and the inability of the sector to lure labour forces away from the tourism sector which proved more immediately lucrative. However, some agriculture production still occurs. Antigua and Barbuda's agricultural sector accounted for 3.3% of GDP in 2007, in 2010 this had decreased to between 2.5 and 3 %.

Agricultural production is focused on the domestic market and is further constrained by a shortage in labour. A labour force survey from 2004 found near full employment, at approximately 4% unemployment. This has changed however. Recent information on the GATE[11] website shows that The "Unemployment figures in Antigua and Barbuda currently stand at an estimated eleven percent (11%) and of this eleven percent, 19.9% represent youth ages 15-24". Not many of these individuals seem interested in the agriculture sector however as the tourism and construction sectors compete with higher wages. Furthermore, local production has not been able to meet local demand all year round. There are less than 300 acres of sea island cotton under production. The major crops produced are vegetables, food crops, vine fruits and tree fruits. The Local Antigua Black Pineapple is one of the tourist favorites. However, the market for most agricultural products is domestic. Livestock production (5000 cattle, 28,000 goats, 15,000 sheep)[12] is difficult because of severe droughts and low international market value of the animals even though they are organically grown. Owners have taken to allowing their animals to stray unimpeded. This practice has lead to severe environmental damage; goats have debarked and destroyed trees on hillsides and sheep have overgrazed. The combined effects have lead to land slippage and loss of top soil during heavy rains.

Fisheries make the greatest contribution to the agricultural sector with its Lobster and fish exports. The fishing sub-sector grew by almost 5 % from 2006 to 2007, reflecting new facilities for fisheries in St. John. The sub-sector contributed almost 52 % of the sector's output. Barbuda depends significantly on its fishery sector as a source of income. In an effort to protect this sector and also address the issues affecting the sector as a result of climate change the government has sought to integrate this sector into its biodiversity protection plan.

[11] **GATE: Government Assisted Technology Endeavour: http://gateantigua.ag/ictcadets_background.php**

[12] **Veterinary & Livestock Division, Ministry of Agriculture, Govt. of Antigua & Barbuda, June 2007**

Box 1. Vulnerability and Adaptive Capacity Issues within the Fisheries Sector (adapted from *Nurse, 2008)*

- Pressure from fishing and other marine activities
- Coastal development, particularly the development of hotels and marinas
- Pollution both from land based and marine sources
- Fluctuation within the global economy and market conditions
- Increasing incidents of foreign vessels fishing within the EEZ without the necessary permissions
- Observed and projected negative impacts on the sector due mainly to stresses on critical habitats such as coral reefs, mangroves and sea grasses
- Linkage between ocean warming, the proliferation of harmful algal blooms and various diseases
- Dependence of fisher folk on the sector for employment, revenue generation and human well-being
- In Antigua and Barbuda, many fishers reside and operate in vulnerable, low-lying coastal areas which exposes their physical assets (e.g. boats, gear, homes) to climate-related events such as hurricanes, storm surge and sea-level rise
- While the fisheries sector has demonstrated considerable resilience to climate variability in the past, factors such as lack of consistent governmental control, access to capital on reasonable terms, weak fisher folk organizations and consequently low bargaining power will compromise adaptation capacity in the future
- Lack of insurance and other institutional support to enable the sector to rebound in the aftermath of extreme events, which are projected to become more frequent and/or intense in the

1.5.3 MANUFACTURING AND THE ECONOMY

GDP statistics from the ECCB showed that manufacturing is declining. In 2010 this sector contributed 2.54% of GDP and 2.57% in 2011. However, in 2012 there was an estimated decrease to 2.32% partly due to high cost of production (mainly labour utilities and high port and shipping charges), small local market and intense regional and international competition. Most of the raw materials for manufacturing have to be imported. However, paints, furniture, household fitting and garments are still manufactured along with soft drinks, water rum, and a nascent cottage agro processing sub sector.

1.5.4 FINANCIAL SERVICES SECTOR AND THE ECONOMY

Antigua and Barbuda, like other Caribbean islands, has a high financial sector ratio relative to its size (10 per 100,000 inhabitants, particularly in the case of insurance)[13]. The sector contributes an estimated 10.28% of the GDP (2011). There are approximately 60 institutions that make up the local sector. These institutions include banks, credit unions, insurance companies, pension funds, and any other firms whose main or partial operations involve financial intermediation. Additionally, there are significant off-shore financial services through which Antigua and Barbuda domiciles over 4,200[14]companies. Although Antigua and Barbuda enjoys a very stable currency as a member of the Eastern Caribbean Currency Union (ECCU) which is regulated by the Eastern Caribbean Central Bank (ECCB) there have been challenges recent years which have put considerable strain on the national economy and its growth projections.

As is characteristic of SIDS, Antigua and Barbuda experiences a disproportionate level of risk from natural disasters including those related to climate change. To this extent the countries of the Caribbean along with the support of some development partners established the Catastrophe Risk Insurance Facility in 2007. Experiences by various SIDS have shown that major catastrophic events can easily cause direct losses in excess of 100% of GDP (eg. Hurricane Ivan cost Grenada 203% of GDP in 2004 and earthquake in Haiti cost 114% of GDP in 2010)[15].

Globally, the financial services sector has seen rising additional costs brought on by extreme climate events[16]. Private property and health insurance rates have increased globally due to the negative effects of climate change such as flood damage, hurricane damage to property and land, storm surge damage to coasts and increased temperatures causing health problems such as hyperthermia in both humans and animals.

Nationally, research highlights that Antigua and Barbuda's financial services sector is marginally aware of climate change risks however, the sector is significantly vulnerable owing to the role of reinsurance, risk assessment methodologies and minimal government and political engagement[17]. An increase in insurance premium levels is the usual response to an increased frequency of extreme weather events. Specifically, in discussions with Sagicor[18], one of the leading insurance companies in Antigua and Barbuda, between 1989 and 1995 when a series of hurricanes impacted the islands, rates went from as low as EC$4/1000.00 for concrete

[13] **IMF (2013) Caribbean small states: challenges of high debt and low growth. https://www.imf.org/external/np/pp/eng/2013/022013b.pdf**

[14] **Source: 2013 Budget Statement (2012), Ministry of Finance, Antigua and Barbuda**

[15] **Implementation Completion and Results Report (P108058) on a Grant to the Caribbean Catastrophe Risk Insurance Facility" (2012) World Bank**

[16] **Barthel and NeuMayer (2011) A trend analysis of normalized insured damage from natural disasters. Climate Change, 113:215 -223**

[17] **Andrew (2015) Analyzing the responses of the financial services sector to climate change risks in the Caribbean: a case study of Antigua and Barbuda. MSc dissertation, University of Exeter, U.K.**

[18] **Telephone Interview with Mr. Keith Herbert, Manager Sagicor General Insurance Company**

structures to EC8.00/1000.00. This increased to up to EC$18.00/1000.00 by 2000 for concrete structures and up to EC$28 for wooden structures. However, during 1989 through to 2005 when the island experienced a consecutive series of hurricanes, and storm surges, some reinsurers retracted coverage for the island, which led to the closure of some local insurers, and the inability of other insurers to meet claims. This not only left the sector vulnerable but also affected the affordability and availability of insurance as local insurers adopted discriminate policies as a means of adaptation.

The country has not been in the direct path of any major hurricanes or natural events and as such rates have actually decreased to an average of EC$13/1000.00 currently. It is expected that given the island's annual threat to hurricanes, and storm surges, the cost of insurance could become a serious impediment to investments and the financial sector.

1.6 POLITICAL STRUCTURE AND GOVERNANCE

Antigua and Barbuda is a constitutional monarchy with a British-style parliamentary system of government. The country has a bicameral parliamentary system comprising a Senate (Upper House) and a House of Representatives (Lower House). Modern Antigua and Barbuda achieved its full independent status in 1981. The Queen of England like in many Commonwealth Countries is the Head of State and is represented by the Governor General who is a citizen of the country.

Presently there are 17 seats in the House of Representatives with 14 (including 1 from Barbuda) controlled by the ruling Antigua Labour Party, and 3 controlled by the leading opposition party, the United Progressive Party.

The island of Barbuda is governed by the Barbuda Council which takes its mandate from the Barbuda Local Government Act CAP.44 of the Laws of Antigua and Barbuda.

The government has three branches, which are the Legislative, the Executive and the Judicial Branch. The Legislative Branch consists of the House of Representatives and the Senate. The House of Representatives has seventeen members and is responsible for introducing legislation. The seventeen-member Senate reviews and gives assent to proposed legislation. The members of the House of Representatives are elected by popular vote (constitutionally mandated every five years, while the members of the Senate are appointed. The Governor General appoints the members of the Senate. Eleven of the members of the Senate are appointed under the advice of the Prime Minister, who is the leader of the party that holds the majority of support of members in the House of Representatives. One of the eleven must be a native Barbudan. Four members of the Senate are appointed under the advice of the leader of the Opposition who is recognized constitutionally, one member of the Senate is appointed under the advice of the Barbuda Council, and one member of the Senate is appointed as an independent member representing business at the sole discretion of the Governor General.

The Executive Branch is derived from the Legislative Branch. This branch consists of the Cabinet headed by the Prime Minister. The members of Cabinet are appointed by the Prime Minister and must be members of either the House of Representative or the Senate. The Judicial Branch is independent of the other two branches, with judges and appeal court judges appointed by an independent judicial commission as part of a sub-regional judiciary serving all the members of the O.E.C.S. The magistrates will shortly be appointed by this regional commission replacing the present arrangement of their appointment by the Attorney General who is a member of the Executive Branch.

The judiciary consists of the Magistrates Court for minor offences and the High Court for major offences. Beyond the High Court is the Eastern Caribbean States Supreme Court, whose members are appointed by the OECS. The final court of appeal for Antigua and Barbuda is the Judicial Committee of the Privy Council, located in London. However, the Caribbean Court of Justice has been proposed to replace the Judicial Committee of the Privy Council as the final court of appeal. The Court was created in 2003 under the 2001 Revised Treaty of Chaguaramas of the Caribbean Community (CARICOM). The treaty is an instrument for the establishment of the Caribbean (CARICOM) Single Market and Economy (CSME) and was signed by the various CARICOM heads of government.

In addition to these formal governmental structures, Civil Society is represented by a number of interest -based organizations, varying from service clubs to Non- Governmental Organisations and Community Based Organisations and in certain cases Faith Based Organisations. According to the records from the Community Development Division there are 129 currently registered groups within Antigua and Barbuda. Of that number 47 are service clubs. This represents a significant increase in NGO/CBO activity as in 2004 a survey conducted by the University of the West Indies only identified 20 groups.

At the regional and international level, Antigua and Barbuda is a member of the Organisation of Eastern Caribbean States, the Caribbean Community, the Eastern Caribbean's Regional Security System, the Commonwealth of Nations, the United Nations, the Organization of American States, and the World Trade Organization.

Antigua and Barbuda is also party to several Conventions apart from the UN framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol. These conventions are the United Nations Conventions to Combat Desertification (UNCCD), the Convention on Biological Diversity (CBD), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Vienna Convention and its Montreal Protocol on Substances which deplete the Ozone Layer and the Basal Convention on the Transboundary Movements of Hazardous Wastes.

1.6.1 POLICY, LEGAL AND INSTITUTIONAL FRAMEWORK

Technological changes and increasing globalization require countries to review and update the legal and judicial framework needed to effectively compete internationally, meet the requirements of multilateral agreements and inspire the population to go beyond compliance toward leadership. Since Johannesburg, the country has been moving towards developing overarching coordinating legislation (instead of repealing current legislation and thus having to deal with the difficult situation of the institutional fallout).

In the area of the Environment, prior to 2015, the existing legislative framework consisted of over forty pieces of legislation, which governed various areas of sustainable development. It naturally follows that the institutional arrangements were also fragmented. An additional factor of this design was that the institutional arrangements were such that in several key areas of natural resource usage the legislation was designed to give power to agencies that are the major resource users to regulate themselves. This framework of legislation did not provide any criteria that considers sustainability, environmental, economic or social protection, by which these resources should be exploited. Consequently, this compounds the vulnerability of the island to climate change impacts in addition to its developmental challenges.

To resolve this issue, the Government decided not only to keep current legislation and institutions in place but to create a new institution that will be responsible for coordination. This creates a flexible and robust system that will allow for the integration of new policies both at the national and international level into national plans and programs and more importantly into the national budgetary process.

The policy and legislative mandates were integrated into various policy documents. These include the SIRMZP and its enabling legislation, the NBSAP, National Environmental Management Strategy (NEMS), the Environmental Protection and Management Act 2015, the Sustainable Island Resource Fund (SIRF) and the medium term economic development strategy. As it specifically relates to the issue of Climate change it is worth noting that this issue commands an entire section of the newly enacted Environment Protection and Management Act (EPMA) 2015.

The SIRMZP is supported by the Physical Planning Act (2003) and the NEMS by the EPMA 2015. These documents also contain provisions for the integration and implementation of MEAs but are conditioned upon sustainable and adequate international financing, as is the case of the country's Intended Nationally Determined Contributions (INDCs) for the COP21 Paris agreements, which will be discussed later in the report.

1.7 ECONOMIC AND POLITICAL CHALLENGES

The economic and political challenges are many, but the major ones can be identified as follows:

- The lack of economic resilience caused by the dependence on one primary driver for the economy, i.e., tourism;
- The national debt as a percentage of GDP is well in excess of 100% and is way above the recommended level of 60%;
- The increase in violent crime;
- The impacts of poverty;
- The rising occurrences of environmental deterioration in both the terrestrial and marine environments;
- Vulnerability to natural disasters, in particular annual hurricanes; and
- The unpredictability of sustainable international financing to implement MEAs.
- The need to build and nurture a stronger relationship between the people of Antigua and Barbuda.

These challenges though not insurmountable, can only be addressed with an aggressive integrated plan of action driven by a shared vision of development and a people centered approach to sustainable development.

1.8 STRATEGIC APPROACHES

Based on the existing economic and policy issues as well as the growing problems with increasingly scarce resources including land availability, the government had decided to develop a strategy that optimizes resource usage for agricultural and forestry development. This forms part of its economic diversity efforts as well as a means to address climate change issues. Towards this end, an agro-forestry strategy to integrate agriculture and forestry as mutually compatible and complementary is being considered. It therefore provides a scope for joint development that can bring about mutual benefits. The approach will bring about a larger productive base for agriculture and forestry and allow for a wider range of agro-forestry enterprise mix, optimize land resource utilization, particularly land and enhance the income generating potential of agro-forestry investments. These approaches together with the policy thrusts will provide the enabling environment to sustain and enhance the growth of the agricultural sector and become more globally competitive.

1.9 SUMMARY

Antigua and Barbuda, as a SID, is extremely vulnerable to the impacts of climate change given its topography, climate and existing state of environmental resources. This vulnerability is further enhanced by the island's challenges faced in its pursuit of economic and social development. However, the country has made great strides in policy and institutional arrangements for the protection of its natural resources and in its social programs. But these have come at a significant price and the country has had to enter into an IMF program to restructure its finances. Consequently, international support is heavily relied upon to meet the island's adaptation and mitigation targets, which will be highlighted later.

During the consultations for this report many of the participants see the way forward for the country as being via a low carbon approach. It's well known however that the necessary finances and political will to get there will require tremendous efforts from the international community. Therefore, the country is looking to the international community to honour commitments made under the UNFCCC particularly those made under the Copenhagen Accord, the recent INDC's and other MEAs to assist Antigua and Barbuda (and other non-Annex I parties) in obtaining the necessary resources through financial mechanisms and technology transfers to achieve a resilient low-carbon economy and sustainable development.

At the national level the Government continues to work at ensuring that the relevant institutional support required are in place to facilitate the necessary legislative and policy initiatives. Activities undertaken to facilitate the country's efforts in meeting its obligations under the convention are discussed later in the report.

2 GHG INVENTORY

Part of the requirements of the UNFCCC for Non-Annex 1 countries, is to prepare regular Greenhouse Gas Inventories. The first and second GHG inventories were carried out for the years 1990 and 2000 respectively. The present Greenhouse Gas (GHG) Inventory report has been prepared for the year 2006. This GHG Inventory was prepared using the 2006 IPCC Guidelines. The sectors reflected in this chapter are the energy sector, industrial sector, agriculture sector, forestry and other land use sector, and the waste sector.

Within the report, each sector was considered separately with a brief description of the sector, along with the methodology clearly delineating the methods of data collection and the related quantities of specific GHG emissions. The gases reported on were CO_2, CH_4, N_2O, NMVOC and HFCs.

The following section of this report includes Key Category Analysis. The purpose of the Key Category Analysis is to identify those areas that contribute greatly to the total GHG emissions. IPCC Guidelines suggest that it is good practice to conduct Key Category Analysis so as to focus resources on those areas that produce most GHG emissions. Uncertainties were then considered within each sector. Mainly qualitative uncertainty analysis was carried out on activity data and quantitative uncertainty analysis on default emission factors used.

Recommendations were made for each sector to improve the quality of data collection for future GHG inventories.

Finally, the policies that have been put in place to reduce GHG emissions by 2020 were noted.

2.1 ENERGY SECTOR

As previously captured, Antigua and Barbuda imports 100% of its petroleum requirements.
Its only supplier of petroleum based fuel to the populous is West Indies Oil Company (WIOC), which is a company owned by 75% private interests and 25% by the government of Antigua & Barbuda. The majority of the fuel imported is used primarily for electricity generation and transportation (vehicular and aviation) with a very small percentage allocated for domestic and commercial consumption.

For the Energy Sector, GHG emissions are estimated using both the Reference Approach (based on import data) and the Sectoral approach (based on consumption). Energy sector activities in Antigua and Barbuda are exclusively due to fuel combustion.
Fugitive emissions (e.g., from primary and secondary fossil fuel production) are null and void due to no refining activity.

2.1.1 METHODOLOGY –ENERGY SECTOR

Country-specific energy sector activity data were provided by the following agencies and businesses:

- West Indies Oil Company (WIOC) provided information on the quantities of liquefied petroleum gas (LPG), motor gasoline, diesel, jet fuel and fuel imported.
- Antigua Public Utilities Authority (APUA) provided fuel consumption data for electricity generation including that from Antigua Power Company (APC).
- The National Statistics Division, Government of Antigua and Barbuda provided import data for lubricants and products. This Division used to provide data on fuel imported but have ceased to collect this data.
- West Indies Oil Company provides fuel to all the Marinas, all Gas Stations and the Airport but has indicated that they do not have data that is clearly defined for them. Interviewing, some Gas Station managers and Marina managers have shown that data of quantities of fuel sold by fuel type annually is not readily available.
- Data on charcoal consumption was obtained from interviews with all known charcoal producers.
- Default values for emission and conversion factors were taken from the 2006 IPCC Guidelines.

2.1.2 EMISSIONS

The carbon dioxide emissions by the reference and sectoral approach may be seen in Table X.

Table 3: CO_2 Emissions in Antigua and Barbuda from the Energy Sector – Inventory Year 2006

Sectoral Approach (Gg CO_2)	Reference Approach (Gg CO_2)
875.780	856.798

The non-CO2 emissions from the Energy Sector may be seen in Table 2-2.

Table 4: Non-CO_2 Emissions from Antigua and Barbuda – Inventory Year 2006

Sectoral Approach (Gg CH_4)	Reference Approach (Gg CH_4)
0.036	0.007

2.2 INDUSTRIAL SECTOR

Antigua & Barbuda is a mass importer with limited production of chemicals, as a result the industrial sector is small and fragmented. There is no mineral or mining activity, save for building materials from several quarries. The refrigeration and air conditioning business are currently the most significant GHG contributors of this sector. It was found that there was limited recorded data on sale activity and use by many providers in this area of the business. Consequently, line, supervisory and management staff in maintenance departments or subject matter experts from service providers supplied much of the information.

2.2.1 METHODOLOGY

Data specific to Antigua and Barbuda was taken from the following sources:

- Estimated lime use from the Central Board of Health (CBH) because Antigua Gases Ltd that actually produces lime as a byproduct were unable to provide data as to the production quantity.
- Consumption of carbonates (limestone and dolomite) from ceramic and pottery makers
- Quantity of lubricants (oil and grease) and paraffin wax imported from the National Statistics Division
- Quantity of refrigerants imported was taken from the National Statistics Division.
- Quantity of refrigerants used commercially, schools, hospitals etc.
- Quantity of Nitrous Oxide used from Medical Practices.
- Bread and cake production from flour importers and local bakeries.
- Alcoholic beverage production from local alcohol manufacturers.

Detailed methodology may be found in the appendices. Default values were used from the 2006 IPCC Guidelines and in the majority of cases the Tier 1 method was used to estimate emissions.

2.2.2 EMISSIONS

The emissions are detailed in Table 5 and summarised in Table 6.

Table 5: Detailed Emissions in Antigua and Barbuda from the Industrial Sector – Inventory Year 2006

Subsector & Content	Type and Quantity of Emission Gas (Gg)
Mineral Industry	
Hydraulic Lime	CO_2 – 0.0142
Ceramics Limestone	CO_2 – 0.0017
Ceramics Dolmite	CO_2 – 0.0003
Total	**0.0162**
Non-Energy Products	
Lubricant (Oil)	CO_2 – 0.5503
Lubricant (Grease)	CO_2 – 0.0028
Paraffin Wax	CO_2 – 0.0050
Total	**0.55811**
Substitutes for Ozone Depleting substances - Solvents	
Aerosols	HFCs – 114.0337
Other Product Use	
Medical Applications	N_2O – 0.0027
Alcoholic Beverages	NMVOC's – 0.0311
Bread Production	NMVOC's – 0.0035

Table 6: Summary Emissions in Antigua and Barbuda from the Industrial Sector - Inventory Year 2006

Type of Emission Gas	Quantity of Emission Gas (Gg)
CO_2	0.5743
HFC's	114.0337
N_2O	0.0027
NMVOC's	0.0346

2.3 AGRICULTURE SECTOR

Within Antigua and Barbuda, the Agricultural Sector consists of mainly livestock production along with fruit and vegetable production. The Greenhouse Gases of concern are mainly methane, direct and indirect nitrous oxide, and carbon dioxide.

Methane is the main greenhouse gas emission that is emitted from livestock. Ruminants, especially cattle have high methane emissions due to their high enteric fermentation rates. Carbon dioxide emissions from livestock are considered negligible and were therefore not included in the inventory.

Livestock manure is the source of two greenhouse gases, mainly methane, direct and indirect nitrous oxide. However, methane emissions are considerably smaller than that from enteric fermentation and will vary depending on the type of livestock and manure management systems used. In most cases as with the ruminants (cattle, sheep, goats, deer) and large livestock (horses and donkeys) manure is left in the open fields to decompose. However, in the case of poultry and swine, these animals are intensively reared and the manure management is different. In general for poultry, the manure (both liquid and solid) is placed in deep pits and left open to dry and in some cases quicklime (calcium oxide and calcium hydroxide) is sprinkled over the manure. In general for swine, the manure is washed out of the pens and left to dry in the back of the structure in the sun.

Carbon dioxide, methane, direct and indirect nitrous oxide emissions are expected from agricultural soils. But because soils in this country are not limed, the expected carbon dioxide emissions were nil. However, urea fertilizers are used, therefore the carbon dioxide emissions were considered in this area. Rice cultivation is not practiced due to insufficient natural resources; therefore this expected source of methane does not exist. Unfortunately, insufficient data was available to determine direct and indirect nitrous oxide emissions from managed soils.

2.3.1 METHODOLOGY

The data used to determine GHG emissions came from the following sources:

- The Veterinary & Livestock Division – Ministry of Agriculture provided all data regarding Livestock and Manure Management.
- The Agricultural Extension Division, Ministry of Agriculture provided all data regarding agricultural soils, and;
- The National Statistics Division provided data on fertilizers imported. Specific methodologies may be found in the Appendix. Default and emission factors were taken from the 2006 IPCC Guidelines.

Specific methodologies may be found in the Appendix. Default and emission factors were taken from the 2006 IPCC Guidelines.

2.3.2 EMISSIONS

The carbon dioxide, methane, direct and indirect nitrous oxide emissions from the agricultural sector may be found in Table 7. The summarized emissions may be found in Table 8.

Table 7: Detailed emissions in Antigua and Barbuda from the Agriculture Sector – Inventory Year 2006

Subsectors	Type and Quantity of Emission Gas (Gg)
Enteric Fermentation	CH_4 – 0.5069
Manure Management	CH_4 – 0.0263
Manure Management (Direct)	N_2O – 0.0191
Manure Management (Indirect)	N_20 – $5.75x10^{-6}$
Agricultural Soils with applied Urea Fertilizer	1.67×10^{-4}

Table 8: Summary Emissions in Antigua and Barbuda from the Agriculture Sector - Inventory Year 2006

Type of Gas Emission	Quantity of Gas Emission (Gg)
CH_4	0.5332
Direct N_2O	0.0191
Indirect N_2O	5.75×10^{-6}
CO_2	1.67×10^{-4}

2.4 FORESTRY AND OTHER LAND USES

As previously mentioned, most of the original forest was cleared to establish sugar plantations during the early colonial settlement.

In 1990, the reporting year for the Initial National Communications, it was reported that there was 13.45 kilohectares (kha) of forest cover. This consisted of Moist Tropical Forest (2.2 kha), Dry Tropical Forest (10.75 kha), Mangroves (0.50 kha). It was also reported that there was 0.01 kha of Open Savannah and 12,000 non-forest trees.

In 2003, the Forestry Division, Ministry of Agriculture was able to provide some data for Antigua but not Barbuda. This data indicated that Antigua has a forest cover of 5.60 kha consisting of:

- 0.52 kha of Cactus Scrub,
- 1.09 kha of Deciduous Seasonal Forests,
- 0.57 kha of Evergreen Seasonal Forests,
- 0.044 kha of Littoral Woodland,
- 0.44 kha of Mangroves,
- 1.52 kha of Semi Evergreen,
- 1.09 kha of Thorn and;
- 0.33 kha of Citronella

The 2010 EIMAS data indicated that Antigua has a forest cover of 8,593.20 ha. Data derived from expert judgment from the National Forestry Division shows that of this approximately 20% is Tropical Moist deciduous Forest (1,718.64 ha), 15% Tropical Forest dry scrubland (1,288.98 ha) and the remainder 65% is Tropical Dry Forest (5,585.58 ha).

2.4.1 METHODOLOGY (FORESTRY & OTHER LAND USES)

The data used in this inventory comes from 2004 and 2010. In 2009, the 2004 aerial photo imagery of Antigua and Barbuda was digitized into EIMAS which is a GIS platform. EIMAS was later updated using the 2010 aerial photo imagery of Antigua and Barbuda taken by the Survey Department. Updates to this specific data within the EIMAS involved the collection of additional metadata and ground truthing. The data derived from comparing 2004 with 2010 was used in this GHG Inventory which only included the mainland of Antigua. This data comparison could not have been done for Barbuda as no data was available for 2010.

Specific methodology may be found in the Appendix. Default and emission factors were taken from the 2006 IPCC Guidelines.

2.4.2 EMISSIONS

The carbon dioxide emissions and removals within the forestry sector may be found in ***Table 9***. This information was determined by converting the carbon stocks (tonnes) to CO2 emissions using the ratio of molecular weights (44/12).

However, Carbon loss from buring or wood removal could not be determined as that data is not available.

Table 9: Detailed Forestry and Other Landuse CO2 Emissions and Removals

	Carbon Stocks (Tonnes)	CO2 Emissions (Gg)	CO2 Removals (Gg)
Annual Change in Biomass Carbon Stocks (Forest Land remaining Forest Land) (3B1a)	10,734.8902		-39.3613
Annual Change in Carbon stocks in dead wood/litter (Land converted to Forest Land) (3B1b)	57.7780		-0.2119
Annual Change in carbon stocks in biomass (Cropland remaining cropland) (3B2a)	-19,667.6640	72.1148	
Annual Change in Carbon stocks in Mineral soils (Cropland remaining cropland) (3B2a)	- 43.4037	0.1591	
Annual Change in Carbon stocks in mineral soils (Grassland remining Grassland) (3B3a)	-9,341.9938	34.2540	
Change in carbon stocks in biomass (Lands converted to Settlements) (3B5b)	-408.7360	1.4987	
Change in carbon stocks in dead wood/litter (Lands converted to Settlements) (3B5b)	142.9470		-0.5241
Change in carbon stocks in biomass (Lands converted to Other Lands) (3B6b)	-20.6120	0.0756	
Total		108.1022	-40.0973
Net Emissions		68.0049	

2.5 WASTE SECTOR

For many years, commingled wastes were dumped the Cooks Disposal Site. This is an area adjacent to an old sugar plantation approximately two miles from the west bus station, on the western side of the island. It was monitored by the CBH. Solid wastes disposed onto the site were burnt periodically, but this, understandably presented numerous hazards to the communities and activities downwind.

Improvements to this method of waste handling and management eventually saw the commissioning of the National Solid Waste Management Authority in 2005, with a mandate for handling all forms of wastes generated in Antigua and Barbuda, as specified by the Revised Solid Waste Act 2005, using sound waste management practices. The Cooks Landfill was then transformed and re-branded as the Cooks Sanitary Landfill and Civic Amenities Site

As waste volumes increased and waste types became more complex, the management of solid wastes had also become more challenging, thereby requiring more scientific approaches in order to adequately keep pace. Waste receipts had been reflecting an increase in waste quantities and also increase in waste characteristics. Consequently, a waste characterization study was undertaken in 2003 with Euro-Columbus and again in 2006 with assistance from the Caribbean Environmental Health Institute CEHI. This was instrumental in detailing and recording data on waste information. Since then, much effort, energies and expenditure had been made to accommodate all the incoming material, and an account was set up to monitor the masses of all materials moving in and out of the site.

2.5.1 METHODOLOGY

Information available for waste volumes produced in 2006 to 2012 were provided by the National Solid Waste Management Authority (NSWMA). However, 2010 data was used instead of 2006 data because the national expert indicated that the data in the previous other years were not as reliable as in 2010 when there were greater efforts to monitor the different waste categories.

Detailed methodology may be found in the appendices. Census data was taken from the National Statistic Division. Default and emission factors were taken from the 2006 IPCC Guidelines.

2.5.2 EMISSIONS

The emissions are detailed in ***Table 10 and Table 11***

Table 10: Detailed emissions in Antigua and Barbuda from Waste sector – Inventory Year 2006

Subsectors	Type and Quantity of Emission Gas (Gg)
Biological treatment of solid wastes	CH_4 - 0.0701
Biological treatment of solid wastes	N_2O – 0.0497
Open Burning of Waste	CO_2 - 1.1848
Open Burning of Waste	CH_4 - $1.375x10^{-11}$
Open Burning Waste	N_2O – $1.65x10^{-6}$

Table 11: Summary emissions in Antigua and Barbuda for the Waste Sector - Inventory year 2006

Type of Emission Gas	Quantity of Emission Gas (Gg)
CO_2	1.1848
N_2O	0.0497
CH_4	0.0701

2.6 KEY CATEGORY ANALYSIS

According to the 2006 IPCC Guidelines (pg 4.12, Vol 1, Chap 4), "it is good practice to identify key 's emissions and removals and total national emissions and removals". The purpose of Key Category Analysis is that it emphasizes those areas that contribute most significantly to the GHG emissions. A Key Category Analysis was performed for the last GHG inventory of 2000 (Table 12) for the present situation and performed on the present GHG inventory 2006 (Table 13) for future inventories.

categories by performing a quantitative analysis of the relationships between level and the trend of each category.

"Level Assessment" was carried out as seen in Table 12 for the 2000 GHG Inventory and in Table 13 for the 2006 GHG Inventory.

Table 12: Approach 1 Level Assessment for GHG Inventory for 2000 (previous inventory) in Key Category Analysis – The Key Categories are in bold*

A	B	C	D	E	F	G
IPCC Category Code	**IPCC Category**	**Green-house Gas**	**Latest Year Estimate**	**Absolute Value of Latest Year Estimate**	**Level Assessment F= E/SUM(E)**	**Cumulative Total of Column F**
1-1	**Energy Sources (reference approach)**	**CO_2**	**412.14**	**412.14**	**0.314**	**0.314**
1-2	**International Bunkers – Source Categories**	**CO_2**	**199.44**	**199.44**	**0.152**	**0.466**
1-1	**Energy Sources (reference approach) – Emissions from International Bunkers**	**CO_2**	**199.44**	**199.14**	**0.152**	**0.618**
1-2	**Transport – Source Categories**	**CO_2**	**181.98**	**181.98**	**0.139**	**0.757**
1-2	**Energy Industries – Source Categories**	**CO_2**	**176.57**	**176.57**	**0.135**	**0.891**
5-2	**Forest and Grassland conversion of C to CO2 from Biomass**	**CO_2**	**57.05**	**57.05**	**0.043**	**0.935**
5-1	**Change in Forest and other woody biomass stocks**	**CO_2**	**-45.82**	**45.82**	**0.035**	**0.970**
1-3	Fuel combustion – Source Category	CO	11.85	11.85	0.009	0.979
1-2	Residential Sector – Source Category	CO_2	7.36	7.36	0.006	0.984
1-2	Process Heat – Source	CO_2	5.52	5.52	0.004	0.988

Approach 1 was used in Key Category Analysis, as it was most suitable to the present national conditions. As estimates are available only for a single year and not several consecutive years the

6-1	Solid Waste Disposal Site	CH_4	5.43	5.43	0.004	0.993
1-4	Energy Industries – Source Categories	SO_2	2.45	2.45	0.002	0.994
1-3	Fuel combustion – Source Category	NOx	2.27	2.27	0.002	0.996
1-3	Fuel combustion – Source Category	NMVOC	2.24	2.24	0.002	0.998
4-1	Domestic Livestock Enteric Fermentation and Manure Management	CH_4	1.13	1.13	0.001	0.999
1-3	Fuel combustion – Source Category- International Aviation Bunkers	NOx	0.7	0.7	0.001	0.999
2-13	Bread and Other Food Production	NMVOC	0.39	0.39	0.000	1.000
1-4	Transport – Source Categories	SO_2	0.29	0.29	0.000	1.000
4-5	Atmospheric Deposition of NH3 and NOx	Indirect N_2O	0.15	0.15	0.000	1.000
1-3	Fuel combustion – Source Category	CH_4	0.04	0.04	0.000	1.000
2-13	Alcoholic Beverage Production	NMVOC	0.028	0.028	0.000	1.000
6-4	Emissions from Human Sewage	N_2O	0.004	0.004	0.000	1.000
2-15	Consumption of Halocarbons	HFCs	0.00368	0.00368	0.000	1.000
1-3	Fuel combustion – Source Category	N_2O	0.003	0.003	0.000	1.000
2-5	Road Paving with Asphalt	NMVOC	0.00056	0.00056	0.000	1.000

Table 13: Approach 1 Level Assessment for GHG Inventory for 2006 in Key Category Analysis – The key categories are in bold*

A	B	C	D	E	F	G	
IPCC Category Code	**IPCC Category**	**GHG**	**Latest Year Estimates**	**Absolute Value of Latest Year Estimates**	**Level Assessment F= E/SUM(E)**	**Cumulative Total of Column F**	
1A Fuel Comb 4 of 4	Fuel Combustion Activities	CO_2	875.78	875.78	1.50 0.44	1.50 0.44	0.00 1.00
4C	Open Burning of Waste	CO2		1.18	1.18	0.00	1.00
1A Ref App. 3 of 3	Fuel Combustion Activities	CO_2	856.80	856.80	0.70 0.43	0.70 0.87	0.00 1.00
2D1	Non-Energy Products from Fuels and Solvent Use	CO2		0.55	0.55	0.00	1.00
2F	Product Uses as Substitutes for Ozone Depleting Substances - Aerosols	HFC	114.03	114.03	0.06	0.92	
3B5b	Land Converted to Settlements: Annual change in carbon stocks in dead wood/litter	CO2		-0.52	0.52	0.00	1.00
3A1	Enteric Fermentation	CH4		0.51	0.51	0.00	1.00
3C3	Urea fertilization	CO2		0.17	0.17	0.00	1.00
3B2a	Cropland Remaining Cropland: Annual change in carbon stocks in biomass	CO_2	72.11	72.11	0.04	0.96	
3B6b	Land Converted to Other Land: Annual change in carbon stocks in biomass	CO2		0.08	0.08	0.00	1.00
4B	Waste - Biological Treatment of Solid Waste	CH4		0.07	0.07	0.00	1.00
4B	Waste - Biological Treatment of Solid Waste	N2O		0.05	0.05	0.00	1.00
Fuel Comb 4 of 4	Fuel Combustion Activities	CH4		0.04	0.04	0.00	1.00
3B1a	Forest Land Remaining Forest Land: Annual increase in carbon stocks in biomass (includes above-ground and below-ground biomass)	CO_2	-33.64	33.64	0.01	0.98	
2-13s1	Industrial -Alcoholic Beverages	NMVOC		0.03	0.03	0.00	1.00
3A2	Manure Management	CH4		0.03	0.03	0.00	1.00
3A21	Manure Management	N2O		0.02	0.02	0.00	1.00
3B5b	Land Converted to Settlements: Annual carbon loss from cultivated soils	CO_2	-29.95	29.95	0.01	0.99	
2A2	Mineral Industry -Lime Production	CO2		0.01	0.01	0.00	1.00
Fuel Comb 4 of 4	Fuel Combustion Activities	N2O		0.01	0.01	0.00	1.00
3B1b	Land Converted to Forest Land: Annual carbon loss from soils	CO_2	-7.47	7.47	0.00	0.99	
2D2	Non-Energy Products from Fuels and Solvent Use - Paraffin Wax Use	CO2		0.01	0.01	0.00	1.00
3C6	Manure Management	N_2O		5.75	0.00	1.00	
2-31s-2	Industrial Bread Production	NMVOC		0.00	0.00	0.00	1.00
2 G	Other Product Manufacture and Use - N_2O from product uses	N_2O					
3B1b	Land converted to forest land: Annual change in carbon stocks in dead organic matter due to land conversion	CO_2	-1.92	1.92	0.00	1.00	
2A4	Mineral Industry – Other Process uses of Carbonates	CO_2		0.00	0.00	0.00	1.00

Table 13 continued

Table 13 continued

2.7 UNCERTAINTIES

2-13s2	**Industrial - Bread Prodn**	**NMVOC**	**0.00**	**0.00**	**0.00**	**1.00**
2G	**Other Product Manufacture and Use - N2O from Product Uses**	**N20**	**0.00**	**0.00**	**0.00**	**1.00**
2A4	**Mineral Industry - Other Process Uses of Carbonates**	**CO2**	**0.00**	**0.00**	**0.00**	**1.00**
4C2	**Open Burning of Waste**	**N2O**	**0.00**	**0.00**	**0.00**	**1.00**
4C1	**Open Burning of Waste**	**CH4**	**0.00**	**0.00**	**0.00**	**1.00**
Total				**2871.654552**	**1**	

***Key categories are those that, when summed together in descending order of magnitude, add up to 95 percent of the total in Column G (2006 IPCC Guidelines pg 4.15, Vol. 4, Chap 4).**

Good Key Category Analysis is usually preformed on a time series of data. It was expected that this could have been done for the period of 2006 – 2010. But this was not the case as for the 2007 – 2010 period very few sectors had good quality data available. The only category that had good quality data for the period 2006 – 2010 was the Energy Industry (reference approach only).

The uncertainties in this inventory were from two main areas; the emission factors and the activity data itself. Antigua and Barbuda is not financially resourceful enough at this time to develop its own national emission factors hence, its heavy reliance on the default emission factors provided by the 2006 IPCC Guidelines. With regards to the activity data, uncertainties arose mainly where data was not available due to responsible agencies not having the resources to collect and manage the data. The specific sector related uncertainties in activity data is discussed below under each sector.

Uncertainty analysis is essential as it can serve as a means to direct meager national resources in reducing the degree of uncertainty in future GHG inventories and also can guide future decisions in methodology. The Approach 1 method of Uncertainty Analysis was used to estimate uncertainties. 2006 IPCC Guidelines suggest that in inventories where the Tier 1 methodology is

predominant Approach 1 is the most suitable fit when estimating uncertainties.

2.8 ENERGY SECTOR – UNCERTAINTIES

Areas of uncertainty within the Energy Sector are as follows:

- Reference Approach: Import data of all types of fuels is provided by one agency, W I O C. There is no way to verify this data as the National Statistics Division has ceased to collect fuel import data.

- Sectorial Approach: The only agency that could provide accurate data was the National Power Company (APUA) for Electricity Generation.

    - Gas Stations and Marinas were not able to provide consistent data for the specified period of 2006 – 2010.
    - The Airport was also not able to provide data.
    - Regarding lubricant and paraffin wax use, it was assumed that all the lubricants and paraffin was imported each year were used in that year.

    - Charcoal use was determined by interviewing as many charcoal producers as could be found. The amount of charcoal produced annually was estimated, as these producers do not keep records. It was assumed that all the charcoal produced in a year was used in that year and it was assumed that quantity of charcoal produced remains the same from year to year.

2.9 INDUSTRIAL SECTOR - UNCERTAINTIES

Areas of uncertainty within the Industrial Sector are listed below:

- There was no available data on lime production from the source provider of lime, as it is produced as a by-product of the lone gas producer on-island. Currently the by-product is currently dumped in a pit with no recorded data on collection. Information was collected from the largest consumer of this waste product the Central Board of Health, which uses this lime to clean drain and streets in the city. They estimated a use of 2 tonnes per month.

- The ceramic and pottery makers do not keep accurate data on quantity of base carbonate materials used hence this information was estimated from monthly use.

- There was no available end usage data on the quantities of lubricants and paraffin waxes consumed hence it was assumed that all lubricants and paraffin waxes imported were used.

- Regarding HFCs:
    - Foam Usage Data provided by the National Fire Department could not be used as the exact HFC composition blend could not be determined. However, this data was expected to be negligible.

    - Data for sub-applications apart from mobile air conditioning units was not available.

    - An estimation of the Emission stock (M) in the 'lifetime' emission equation was calculated by adding available import figures for 2006 from the National Statistics Division of refrigerant unit types to the calculated countrywide stock. The assumption made was that all imported units in 2005 and 2006 were cycled into use.

    - There was an assumption of a 50% usage between the two gases, R410a and R407a, identified by the refrigerant

service providers association as they indicated these were the two most prevalently used in the commercial and stationary sub-application categories.

- Regarding domestic refrigeration; figures were estimated using the national census (2001) figures on housing and assuming at least 95% of homes with refrigeration capacity, with one refrigerator, taking into account the National Poverty and Vulnerability Assessment of 2007 which indicated approximately 18 % of persons were in poverty or indigent and the fact that the country has 100% electricity coverage.

- Data on quantity of HFC annual sales was obtained from automotive service suppliers from their maintenance departments. No comprehensive detailed records were kept by service providers on the usage by most so an estimation of use on a weekly and monthly basis was used to extrapolate the usage per annum. Providers indicated that the sale numbers have been fairly consistent for the past few years, thus the calculated quantity was used for target year 2006.

- Data on amount and type of several refrigerant gas types was collected from several local supermarkets of varying sizes to verify assumptions.

- Regarding Stationary refrigerants; an estimation was done for banks, government buildings, Hospitals and all other large building complexes.

- Regarding Bread production; an assumption was made that the weight of flour was used as an estimate for the weight of bread produced with negligible difference, as producers did not keep the weight of final product. The ratio of flour utilised for bread and cake production was obtained from the bakers' estimation on their production.

2.10 AGRICULTURE SECTOR - UNCERTAINTIES

Areas of Uncertainty within the Agricultural Sector are listed below:

- The accurate number of some species of livestock is not known in Antigua and especially in Barbuda. Therefore estimations were made based on expert judgment and existing data.

- In estimating the methane emissions from enteric fermentation, the default emission factors that were used assumed that the average live weight for sheep and goats are 45 Kg and 40 Kg respectively. However, the actual average live weights nationally are 30 kg and 26kg respectively, this may lead to an incorrect estimation of methane emissions from enteric fermentation.

- In calculating the direct N_2O emissions from Manure Management, default Nitrogen excretion rate values were used for poultry that assumed that 90% of the swine population is market swine and 10% is breeding swine. However, nationally in general 50% of the swine population is market swine and the remaining 50% is breeding swine. It is possible that this will affect the accuracy of the N_2O emissions calculated.

- The Typical Animal Mass (TAM) was needed for the calculation of direct N_2O emissions. Because this data was available readily, national figures were used. Since, the calculations are based on default factors the use of national figures may affect the accuracy of the N_2O emissions calculated.

- As part of the calculation of direct N_2O emissions, the Fraction of total annual nitrogen excretion managed in MMS for each species/livestock was determined using default factors from countries that had similar conditions. Additionally, no default factors were provided for poultry, therefore an estimate was made. All this may affect the accuracy of N_2O emissions calculated.

- With regards to direct and indirect N_2O emissions from managed soil, because sufficient data is not available, this information could not be calculated. This may lead to an overall inaccuracy of the actual emissions.

2.11 FORESTRY AND OTHER LAND USES - UNCERTAINTY

Areas of Uncertainty within the Forestry and Other Land Use Sector are listed below:

- The EIMAS data derived from comparing 2004 with 2010 was used in this GHG Inventory only included the mainland of Antigua. This data comparison could not have been done for Barbuda as no data was available for 2010.

- Additionally, more ground truthing is necessary to identify land uses in both Antigua and Barbuda. This data has uses other than in GHG inventories but for planning and other essential services.

- In calculating the changes in Carbon stocks, data such as the acreage of forest types was required. The expert judgment of the Forestry Staff was used in this case.

- Emissions from Biomass burning in forest could not be determined as the numbers of acres burnt per year is not kept. The Fire department up until now had only kept data on number of fires. This lack of data would reduce the accuracy of calculated GHG emissions due to fires.

2.12 WASTE SECTOR - UNCERTAINTIES

Areas of Uncertainty within the Waste Use Sector are listed below:

- The majority of waste is taken to the Cooks Landfill, however, the private establishments that dispose of their own waste were unable to give complete data as to the categories, quantities etc, therefore, it was assumed that all wastes are taken to the Cooks Landfill.

- As regards to composting; there is uncertainty about the moisture content, ph and actual types of gases generated, as these factors are also influenced by the ambient conditions.

- Regarding compacting and anaerobic digestion of food waste; significant uncertainty exists where quantities of packaging accompany the wastes; this makes it difficult to give the exact weight of the wastes only.

- Regarding open burning; this is not allowed without permission, but information such as quantities burnt and category of waste involved are not generally collected, hence affecting reliable GHG emission data. The fraction of waste openly burnt, was taken as ten percent of the amount disposed at landfill (2010 data) [approx. mass of waste burnt/ total mass of waste collected]. This assumption is based the discrete practices of some rural areas that may be located off the scheduled collection services route.

- Methane Emission Factor is assumed to be 5, the same as for bulk waste, due to the presence of miscellaneous material and an assumed moisture content of approximately 50%.

- Nitrous oxide emission factor assumed the same value as that for bulk waste decomposing under ambient conditions, and on a dry weight basis. The main waste-type burnt are Confidential

Documents in their packaged material, mainly cardboard boxes. This supervised activity is done only as requested.

J Regarding the medical waste, the lowest range was used in the worksheets; it is likely that any moisture from buried waste would percolate deeply to the liquid collection drains while gases that rise would evolve via methane vents – chances are as the gases are buffeted the volume would be significantly reduced.

2.13 QUANTIFIED UNCERTAINTY

Uncertainty is defined by the 2006 IPCC Guidelines as:
"...lack of knowledge of the true value of a variable that can be described as a probability density function (PDF) characterising the range and likelihood of possible values. Uncertainty depends on the analyst's state of knowledge, which in turn depends on the quality and quantity of applicable data as well as knowledge of underlying processes and inference methods. " (pg 3.8, Section 3.1.3, Vol 1, 2006 IPCC Guidelines)

Approach 1 was used in quantifying uncertainty and may be seen in Table 8-1. Explicit uncertainty calculations may be found in the Appendix. Approach 1 requires use of base year emissions. In this case those of 2000 were used as best as possible. The concern here is that, areas considered in the 2006 inventory were not necessarily considered in the 2000 inventory. Additionally, in some areas the data is more detailed. Therefore, it is difficult to compare both inventories. One must remember that the 2000 inventory was prepared using the Revised 1996 Guidelines in which there are some differences compared to the 2006 Guidelines used to prepare the 2006 inventory.

Table 14 indicates that the Percentage Uncertainty in the total inventory is 26%. It must be borne in mind that not all of the uncertainties clearly laid out previously can be quantified, therefore, 26% is not an absolute value but it is the best statistical way of quantifying uncertainties.

Although, Table 14 also shows Trend Uncertainty, the usefulness of this data may not be applicable in this case. This is because as stated previously the base data used are emissions from the 2000 inventory which are sufficiently different from the 2006 inventory for comparisons to be difficult. Therefore, the Trend Uncertainty will not be taken into account and will be considered as a byproduct of this process.

Table 14: Approach 1 –Calculation of Uncertainties

A	B	C	D	E	F	G	H	I	J	K	L	M
IPCC Category	**Gas**	**Base Yr emissions and removals**	**Year t emissions or removals**	**Activity data Uncer-tainty**	**Emission factor / estimation parameter uncertainty**	**Combined uncertainty**	**Contribu-tion to Variance by Category in Year t**	**Type A sensi-tivity**	**Type B sensi-tivity**	**Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty**	**Uncertainty in trend in national emissions introduced by activity data uncertainty**	**Uncertaint introduced into the trend in total national emissions**
		Input data	**Input data**	**Input data Note A**	**Input data Note A**	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	**Note B**	$\left\lvert \frac{D}{\sum C} \right\rvert$	$I \bullet F$ Note C	$J \bullet E \bullet \sqrt{2}$ Note D	K^2+L^2
		Gg CO2 equiva-lent	**Gg CO2 equivalent**	**%**	**%**	**%**		**%**	**%**	**%**	**%**	**%**
Energy Sector Reference Approach1	CO2	412.14	856.8	10	17	19.72308292	36.61920424		1.061916631	0	15.01776901	225.533386
Fuel Combustion Activities	CO2	371	875.78	50	4	50.15974482	247.457755		1.085440414	0	76.75222774	5890.90446
Fuel Combustion Activities	CH4	0.00	0.036	50	100	111.8033989	2.07738E-06		4.46183E-05	0	0.003154993	9.95398E-06
Energy Sector- Fuel Combustion - Sectoral Approach	N2O	0.003	0.007	50	275	279.5084972	4.90893E-07		8.67579E-06	0	0.000613471	3.76347E-07

Table 14

Industrial Sector - Mineral Industry - Other Process use of carbonates	CO2		0.553	3	3	4.242640687	7.05867E-07		0.000685387	0	0.002907852	8.45561E-06
Industrial Sector - Lubricant Use	CO2		0.005	20	50	53.85164807	9.2969E-09		6.19699E-06	0	0.000175277	3.07222E-08
Industrial Sector - Paraffin Wax Use	CO2		114.034	20	100	101.9803903	17.34213017		0.141333568	0	3.997516973	15.98014195
Enteric Fermentation	CH4	22.7	0.51	20	40	44.72135955	6.58984E-05		0.000628251	0	0.017769624	0.00031576
Manure Management	CH4	1	0.03	20	30	36.05551275	1.15658E-07		3.26458E-05	0	0.000923361	8.52596E-07
Manure Management	N2O		0.02	38	100	106.976633	5.33119E-07		2.36229E-05	0	0.001269499	1.61163E-06
Forest Land Remaining Forest Land: Annual increase in carbon stocks in biomass (includes above-ground and below-ground biomass)	CO2		-33.64	10	40	41.23105626	0.246683797		0.041692374	0	0.589619206	0.347650808
Land Converted to Forest Land: Annual carbon loss from soils	CO2		7.47	10	40	41.23105626	0.012163744		0.009258059	0	0.130928724	0.017142331

Land Converted to Forest Land: Annual change in carbon stocks in dead organic matter due to land conversion	CO2		-1.92	10	40	41.23105626	0.000805632		0.00238262	0	0.03369533	0.001135375
Cropland Remaining Cropland: Annual carbon loss from cultivated soils	CO2		203.46	10	90	90.55385138	43.52947385		0.25217124	0	3.56623988	12.71806688
Grassland Remaining Grassland: Annual carbon loss from cultivated soils	CO2		129.40	10	90	90.55385138	17.60754878		0.16038114	0	2.268131831	5.144422002
Land Converted to Grassland: Annual carbon loss from cultivated soils	CO2		1.87	10	90	90.55385138	0.003669957		0.002315444	0	0.032745327	0.001072256
Settlements Remaining Settlements: Annual carbon loss from cultivated soils	CO2		532.85	10	90	90.55385138	298.559253		0.660418322	0	9.339725475	87.23047195
Land Converted to Settlements: Annual carbon loss from cultivated soils	CO2		29.95	10	90	90.55385138	0.943259292		0.037120976	0	0.524969883	0.275593378
Land Converted to Other Land: Annual carbon loss from cultivated soils	CO2		0.70	10	90	90.55385138	0.000518928		0.000870677	0	0.012313238	0.000151616

Table 14 continued

Land Converted to Other Land: Annual change in carbon stocks in biomass	CO2		0.08	10	75	75.66372975	4.19585E-06		9.36985E-05	0	0.001325097	1.75588E-06
Waste - Biological Treatment of Solid Waste	CH4		0.07	10	700	700.0714249	0.000308831		8.68818E-05	0	0.001228695	1.50969E-06
Waste - Biological Treatment of Solid Waste	N2O		0.05	10	100	100.4987562	3.19915E-06		6.15981E-05	0	0.000871129	7.58865E-07
Open Burning of Waste	CO2		1.18	50	40	64.03124237	0.000738031		0.001468439	0	0.103834341	0.01078157
Open Burning of Waste	CH4		0.000000000014	50	100	111.8033989	3.03051E-25		1.70417E-14	0	1.20503E-12	1.4521E-24
Open Burning of Waste	N2O		0.000001650000	50	100	111.8033989	4.36394E-15		2.04501E-09	0	1.44604E-07	2.09103E-14
Total		**806.843**	**2792.542602**				**666.2622608**					**6239.813079**
					Percentage Uncertainty in the total Inventory		**25.8120565**				**Trend Uncertainty**	**78.99248749**

Note A: If only total uncertainty is known for a category (not for emission factor and activity data separately), then:

- If uncertainty is correlated across years, enter the uncertainty into Column F, and enter 0 in Column E;
- If uncertainty is not correlated across years, enter the uncertainty into Column E, and enter 0 in Column F

Note B: Absolute value of: $$\frac{0.01 \bullet D_x + \sum D_i - (0.01 \bullet C_x + \sum C_i)}{(0.01 \bullet C_x + \sum C_i)} \bullet 100 - \frac{\sum D_i - \sum C_i}{\sum C_i} \bullet 100$$

Where:

C_x, D_x = entry from row x of the table from the corresponding column, representing a specific category

$\sum C_i$, $\sum D_i$ = Sum over all categories (rows) of the inventory of the corresponding column

Note C: In the case where no correlation between emission factors is assumed, sensitivity B should be used and the result multiplied by √2:

$$K_x = J_x \bullet F_x \bullet \sqrt{2}$$

Note D: In the case where correlation between activity data is assumed, sensitivity A should be used and the √2 is not required:

$$L_x = I_x \bullet E_x$$

NB: In all cases presented the uncertainties where known for each the emission factor and activity data separately, hence there is no correlation between them. Therefore, Sensitivity A was not used.

2.14 RECOMMENDATIONS

The purpose of providing recommendations is to improve the quality of data collected for future inventories. If recommendations are actually considered and executed areas of existing uncertainties may be reduced as far as possible. This would allow for complete data sets to be collected annually and therefore making trend analysis possible.

Due to the significant lack of good data from the end users it is recommended that the following data be collected annually within the sectors by relevant agencies and housed at the National Statistics Division, as a central repository. Table X recommends the data type and relevant data collection agencies

Sector	Data type & Additional Agencies
Energy	Annual consumption of fuel according to fuel type by Gas Stations, Marinas and Airports Annual consumption of fuel by the National Power Company (APUA and APC) This would improve record keeping by end users of petroleum products. Agencies such as the Bureau of Standards should be targeted to verify accuracy of measuring instruments being used to determine consumption of fuel, lubricants and charcoal. It is recommended that indigenous energy resources should be developed, which in this case would be primarily from wind and photovoltaic systems (PV) to reduce use of fossil fuels and of course GHG emissions.
Industrial	It is recommended that data collected by the National Statistic Division on importations of HFC emitting products be categorized by type of HFC produced and not by weight as is done presently. This would allow for the data to be more useful. It was found that there was limited recorded data on sale activity and use of HFC emitting products by many providers in this area of the business. It is recommended that consumption data of these HFC emitting products be recorded by distributors and collected by the National Statistics Division.
Agriculture	The accurate number of some species of livestock is not known in Antigua and especially in Barbuda. Therefore, it is recommended that the Ministry of Agriculture institute measures to collect this data on an annual basis. With regards to the situation in Antigua there is some draft legislation that considers the annual registration of Livestock, this would provide somewhat accurate numbers of livestock apart from the stray livestock population. The Veterinary &

	Livestock Division is also working towards Good Agricultural Practice Certification; in this case the farmers are required to keep proper records of population numbers among other parameters. Therefore, once the legislation is complete and passed, then this problem may be on its way to be rectified. With regards to the situation in Barbuda, getting accurate numbers of deer and wild pigs may prove difficult without serious human resource input because of the timid nature of these animals especially the deer. However, advice may be obtained from agencies such as WSPA (World Society of Protection of Animals) among others, who may have extensive experience in accurately estimating wild livestock populations. In estimating emissions, in many cases the local situation is far different from the norm, hence use of default emission factors may lead to incorrect estimations. The solution to this according to the IPCC would be to develop national emission factors. The resources may not exist nationally but it may be recommended that regional emission factors be developed within the OECS. Data is not sufficiently available in emissions from managed soils. It is therefore, recommended that more resources be put into the Forestry Unit and the Agricultural Extension Division to allow for scientific monitoring of managed soils.
Forestry and Other Land Use	It is recommended that aerial photos of Barbuda be taken so that data comparison may be done for Barbuda, but this of course depends on the availability of funding. It is essential that ground truthing be done annually to improve the quality of data provided by the EIMAS. It is recommended that the Forestry Unit carry out this task. Additionally, it is also recommended that the Forestry Unit be provided with the necessary expert human resources necessary to carry out such an important activity. Emissions from Biomass burning in forest could not be determined as the numbers of acres burnt per year is not kept. The Fire Department up until now had only kept data on number of fires. However, the Fire Department plans to start collecting number of acres burnt on an annual basis. Therefore, it is recommended that the Fire Department commence with their plans to collect data on number of acres burnt according to land use category on an annual basis.
Waste	It is recommended that private agencies that dispose of their own waste should keep detailed records on quantities of wastes that are disposed by defined categories on an annual basis. This recording and collection of data should be encouraged by the NSWMA and the NSWMA should store this data. The Fire Department issues licenses to the general public to carry out open burning activities. It is recommended that records be kept of waste quantities burnt by defined categories. This data should be stored by the NSWMA.

2.15 POLICIES

The Government of Antigua and Barbuda has agreed to undertake nationally appropriate, measureable and verifiable actions aimed at reducing greenhouse gas emissions by 25% below 1990 levels by 2020, which will be presented in the next chapter.

Presently, there is a National Energy Policy and Strategic Action Plan that attempts to do this via the following methods:

- Energy cost reduction
- Diversification and efficient use of energy sources
- Electricity Reliability
- Environmental Protection
- Stimulate New Economic/Business Opportunities

Additionally, there is an APUA (National Power Company) Interconnection Policy that allows up to 15% grid penetration of renewable energy sources.

Specifically, for refrigerant gas usage, nationally there is the prescribed usage of refrigerants HFC 134a in automotive systems. There is currently a phasing in of 407a and 410a in building AC units to replace R-22 although a number of institutions still utilise some wall unit systems with R-22 like the National Hospital. These new refrigerant gases are more efficient, hence less GHG emissions.

Regulations and policies for the disposal of used oil in most OECD countries often restrict land-filling and dumping, and encourage the separate collection of used oil. However, within Antigua & Barbuda there is limited recycling of waste oil as there is currently only one small operation that has recently begun.

2.16 SUMMARY

A summary of the national GHG emissions (Table 0-1) are as follows:

- Carbon Dioxide (CO2): 945.544 Gg,
- Methane (CH4): 0.639 Gg,
- Nitrous Oxide (N2O): 0.079 Gg,
- Non-methane volatile organic compounds (NMVOC): 0.035 Gg,
- Hydrofluorocarbons (HFC): 114.034 Gg.

The overall uncertainty of the inventory is 26%. The Carbon Dioxide emissions have significantly increased compared to the 2000 GHG Inventory. In 2000, it was reported that there were 383Gg of CO_2 emitted; 3% from Land Use Change and Forestry and the remaining 97% from Fuel Combustion in the Energy Sector. In 2006, 945.544 Gg of CO_2 were reported; 7% from Land Use Change and Forestry and 92% from Fuel Combustion in the Energy Sector. In2000, there was very little data available for the Land Use Change and Forestry Sector but in 2006 there was substantially more data available hence the increase in emissions from that sector.

Methane, Nitrous Oxide and Non-methane Volatile Organic Carbon (NMVOC) emissions decreased when comparing 2000 and 2006 GHG Inventories. In 2000, the methane emissions reported were 6.6 Gg; Nitrous Oxide emissions were 0.159 Gg; and NMVOC emissions were 2.7 Gg.

However, Hydrofluorocarbon (HFC) emissions increased when the 2000 and 2006 GHG inventories were compared. In 2000, the HFC emissions reported were 0.0037 Gg compared with 114.034 Gg in the 2006 GHG Inventory. In the latter case, greater efforts were made in collecting data from that sector than in the previous GHG inventory, hence the significant increase.

It is important to note that there are efforts in place to significantly reduce the GHG emissions

by 2020. This can be seen in the previous section of policies that are now in place to assist with this target.

Additionally, data from this Inventory may be used to provide evidence of the present day situation so that solutions can be encouraged to reduce emissions and point the way forward towards Renewable Energy Sources and Energy Efficiency.

3 MITIGATION: POLICY & MEASURES

As a Non-Annex I Party to the UNFCCC and its Kyoto Protocol, Antigua and Barbuda has no obligation to reduce its greenhouse gas emissions. This is because, it is universally understood that the principle cause of dangerous levels of anthropogenic climate change has been attributed to the historical and modern actions taken to achieve development by the industrialised countries, which are all listed as Annex-I Parties to the UNFCCC. However, the Government and people of Antigua and Barbuda have come to realize that although our GHG emissions have always been regarded as "negligible", the dangers of climate change are so present and serious that it will take the combined actions of all countries to achieve the necessary mitigation targets to ensure the safety of all peoples on the planet. It also safeguards the stability of the environment while ensuring the sustainability of the entire planet and its inhabitants for present and future generations.

Recognizing the ultimate need for global action by all parties, Antigua and Barbuda has continuously pledged and undertaken efforts to mitigate green house gas emissions despite its negligible contribution. Along with 56[19] other developing countries (non-annex I parties), the country has accepted voluntary emissions targets in hopes of sufficiently changing the trajectory of the rate of global climate emissions. This voluntary declaration of emissions targets is referred to as the Nationally Appropriate Mitigation Actions (NAMA). Antigua and Barbuda made this commitment as part of the Copenhagen Accord (*see Figure 7*).

Further, in preparation for COP21 Paris agreements, the country has recently launched its Intended Nationally Determined Contributions (INDCs). The INDCs consists of both conditional and unconditional targets as well as a greater focus on climate change adaptation that will be highlighted later in this chapter.

[19] **As of April 25th 2014, the UNFCCC website reported 57 countries to have made voluntary NAMA commitments. (http://unfccc.int/focus/mitigation/items/7172.php)**

In accordance with decision 1/CP.15 and 1/CMP.5, the Government of Antigua and Barbuda communicated its decision to:

(a) associate with the Copenhagen Accord, noted in Decision 2/CP.15 of the Conference of the Parties at its fifteenth session in Copenhagen, Denmark;

(b) pursue a low carbon, green growth development strategy during the period 2010-2015, and in this regard is requesting so-called "fast track" financing envisaged under paragraph 8 of the aforementioned Accord to implement this strategy;

(c) on the basis of financial and technical support from the international community, including through those envisaged in paragraphs 8, 10 and 11 of the aforementioned Accord, voluntarily undertake nationally appropriate, measurable and verifiable actions aimed at reducing further its already minuscule greenhouse gas emissions by twenty-five percent (- 25%) below 1990 levels by 2020;

(d) develop and implement nationally appropriate adaptation plans, programmes and projects and associated capacity-building, on the basis of financial and technical support that is to be made available in accordance with the relevant provisions of paragraphs 8, 10 and 11 of the aforementioned Accord; and

(e) consistent with Article 12.1(b) of the Convention, communicate through its national communications, on the actions delineated in paragraphs (b), (c) and (d) above, on the basis of guidelines to be adopted by the Conference of the Parties.

Figure 7: Excerpt of Copenhagen Pledge

3.1 TOWARDS COPENHAGEN

The Government of Antigua and Barbuda has agreed to undertake nationally appropriate, measureable and verifiable actions aimed at reducing greenhouse gas emissions by 25% below 1990 levels by 2020.

Presently, there is a National Energy Policy and Strategic Action Plan that attempts to do this via the following methods:

- Energy cost reduction
- Diversification and efficient use of energy sources
- Electricity Reliability
- Environmental Protection
- Stimulate New Economic/Business Opportunities

Additionally, there is an APUA (National Power Company) Interconnection Policy that allows up to 15% grid penetration of renewable energy sources.

Specifically, for refrigerant gas usage, nationally there is the prescribed usage of refrigerants HFC 134a in automotive systems. There is currently a phasing in of 407a and 410a in building AC units to replace R-22 although a number of institutions still utilise some wall unit systems with R-22 like the National Hospital. These new refrigerant gases are more efficient, hence less GHG emissions.

Regulations and policies for the disposal of used oil in most OECD countries often restrict land-filling and dumping, and encourage the separate collection of used oil. However, within Antigua & Barbuda there is limited recycling of waste oil as there is currently only one small operation that has recently begun.

With regards to the National Energy Policy and Sustainable Energy Action Plan, it remains unconfirmed as to what extent these two policy documents will establish an enabling environment to achieve the key metric of Antigua and Barbuda's NAMA.

Notwithstanding the voluntary commitment to achieve national reductions, the Government of Antigua and Barbuda has maintained the position

that the solution to climate change is global action. To this end it has joined with SIDS and LDCs in noting with concern that the "upper safety limit for atmospheric CO_2 is 350 parts per million (ppm)"[20] and that this limit has already been passed thus demanding an urgent need to arrest emissions as closely as possible to maintain concentration of CO_2 at 400ppm with further actions to bring concentrations back to 350ppm. Further, it supports the AOSIS position that "Research clearly shows that unless we act immediately, the opportunity to keep global warming below the crucial 1.5 degree Celsius threshold could be irrevocably lost."[21]

Table 15: National Emission Reporting Source Categories in Gigagrams (Gg)

Year	1990 [22]	1994 [23]	2000 [24]	2006 [25]
Carbon Dioxide (CO_2)	288.22	334.13	383	945.544
Methane (CH_4)	4.67		6.6	0.639
Nitrous Oxide (N_2O)	0.0051		0.159	0.079
Nitrogen Oxides (NOx)			2.3	
Carbon Monoxide (CO)			11.9	
Non-methane volatile organic compounds (NMVOC)	0.65		2.7	0.035
Sulphur Dioxide (SO_2)	2.83	3.25	2.8	
Hydrofluorocarbons (HFC)			0.0037	114.034

The most recent GHG inventory of Antigua and Barbuda closely evaluated emissions from 2006 as the reporting year. There were significant changes in all emissions as compared to the 2000 assessment. CO_2 almost tripled; and HFCs went from <1 to over 110Gg. On the decreasing side CH_4 reduced by around 90%, N_2O by1/2; and NMVOCs went from 2.7Gg to 0.035Gg ***(see Table 15***).

As can be seen in the table, CO_2 emissions in 2006 are 328% greater than the 1990 baseline. While the increases mainly represent slight improvements in data collection, it also highlights the challenge that Antigua and Barbuda will face in maintaining its economic development trajectory while ensuring the safe keeping and sustainability of the environment. It should also be noted that if only the CO_2 emissions were to be considered then for Antigua and Barbuda to achieve its NAMA commitment it would have to balance all of its economic performance and future development on activities that would limited to a net of 254.887Gg of CO2 or approximately ¼ of current GHG emissions.

Antigua and Barbuda does not possess any reservoirs of fossil fuels and as such relies almost entirely on the importation of fuel for electricity generation, transportation and cooking. Due to its relative flatness and ease of access of almost all areas, Antigua and Barbuda has electricity penetration to 95.4% of the country. In fact, only 1.2%[26] of the households were identified as not having access to any form of lighting. Considering also that Domestic consumption accounts from some 40% of all national consumption then percentage of the population not consuming energy would be the equivalent of 0.48%. to further underscore the reliance of Antigua and Barbuda on fossil fuels one need only consider the sources of lighting and cooking fuel used by

[20] Hansen et al (2008)"Target Atmospheric CO2: Where Should Humanity Aim?" http://arxiv.org/ftp/arxiv/papers/0804/0804.1126.pdf

[21] http://aosis.org/press-release-aosis-and-ldcs-urge-focus-on-implementing-short-term-emissions-reductions/ **(2013) Press Release: AOSIS and LDCs Urge Focus on Implementing Short Term Reductions, June 3, 2013**

[22] Data taken from Antigua and Barbuda's Initial Communication to the UNFCCC

[23] Data taken from Antigua and Barbuda's INC

[24] Data taken from Antigua and Barbuda's Second National Communication to the UNFCCC

[25] Data taken from Antigua and Barbuda GHG Emissions and Removals 2006

[26] 2011 Population and Housing Census of Antigua and Barbuda

household which can be regarded at 95.3% and 97.8% respectively.

3.1.1 ELECTRICITY PROFILE

The Utilities Act of 1973 gives the Antigua Public Utilities Authority (APUA) the sole authority to generate, distribute and sell electricity in Antigua and Barbuda. The Act further gives the APUA the authority to permit entities other than itself to produce electricity for their own usage or provide commercially which APUA will purchase and then distribute on its grid. As of 2012 there was some 118 MW installed capacity with 93 MW of actual production capacity on Antigua and Barbuda. A recent study determined that Antigua and Barbuda has maintained a relatively constant energy demand of 232 GWh since 2010. Furthermore peak demand recorded in 2013 was 49.2MW[27].Electricity is almost entirely generated from fossil fuel although there is currently a small photovoltaic grid-connected facility of 3 kW, installed in 2009 in Antigua, which supplies 4.8 MWh of electricity. Additionally, the 2011 census reports some 27 household units being completely reliant on solar energy.

At present, the main island of Antigua makes up approximately 99% of the total electricity consumption. The distribution among the sectors is roughly commercial with 46%, domestic 40%, government 11% and industrial 3%. On Barbuda, consumption is shared only among three sectors, namely domestic 71%, commercial 20% and government 9%.

The NEP estimates that peak electricity demand will increase to approximately 75MW by 2024 another study projected 2028 peak demand to increase to around 100 MW, with net generation increasing to around 650 GWh (increase rate of 3.9 % per year).

In the Second National Communications of Antigua and Barbuda has identified four basic scenarios for the inclusion of different energy sources to meet the projected energy demand. In scenario 1 there are no source alternatives. In Scenario 2 renewable energy is introduced to the grid in 2015, through 10MW of wind and 2.5MW of waste generation. Additionally, this scenario also identified 10MW of distributed photovoltaic being introduced between 2012 and 2030. For the purpose of table XXXX the PV was estimated to be in place by 2020. Scenario 3 observed interventions at the same time as those of Scenario 2 but was more aggressive. Specifically, a 3.5MW waste to energy plant in 2015 and a 15MW distributed PV system in 2020 would be pursued. Additionally, the 10MW of wind in 2015 and a further 5MW in 2025. A 15MW interconnection was also identified in the SNC but there was no political support for this idea so it was not reflected in the table. As an alternative, because the global price of oil has made coal to be considered as a viable alternative, consideration has also been given to installing 10MW coal plants in 2020, 2023 and 2026.

3.2 TOWARDS COP21 PARIS AGREEMENTS

In preparation for COP21 Paris Agreements (2015), and in accordance with the relevant paragraphs of Decision 1/CP.19 and 1/CP.20, Antigua and Barbuda recently launched its INDCs. The country's INDCs focuses on both climate change adaptation and mitigation, and while it features conditional targets which depend on support from the international community, it maintains an unconditional thrust for enabling environments conducive to its targets.

The targets include:

Unconditional Targets

- Enhance the established enabling legal, policy and institutional environment for a low carbon emission development pathway to achieve poverty reduction and sustainable development.

[27] **United Nations (2013) An assessment of fiscal and regulatory barriers to deployment of energy efficiency and renewable energy technologies in Antigua and Barbuda by Sanguinetti, G. and Gomes, C. Ref. LC/CAR/W.5**

10) By 2020, update the Building Code to meet projected impacts of climate change.

Conditional Adaptation Targets

- By 2030, all buildings improved and prepared for extreme climate events, including drought, flooding and hurricanes.
- By 2025, increase seawater desalination capacity by 50% above 2015 levels.
- By 2030, 100% of electricity demand in the water sector[28] and other essential services (including health, food storage and emergency services) will be met through off-grid renewable sources.
- By 2030, all waterways protected to reduce the risks of flooding and health impacts.
- By 2030, an affordable insurance scheme is available for farmers, fishers, and residential and business owners to cope with losses resulting from climate variability.

Conditional Mitigation targets

- By 2020, finalize the technical studies with the intention to construct and operationalize a waste to energy (WTE) plant by 2025.[29]
- By 2020, establish efficiency standards for the importation of all vehicles and appliances.
- By 2030, achieve an energy matrix with 50 MW of electricity from renewable sources both on and off-grid in the public and private sectors.[30]

© By 2030, all remaining wetlands and watershed areas with sequestration potential protected as carbon sinks.

Pivotal to achieving its targets, the recently enacted EPMA 2015 establishes the legal platform within which national adaptation and mitigation actions may be undertaken. For instance, the Act seeks the protection of watershed and wetlands, not only as possible carbon sinks but also to reduce the impacts of flooding within residential communities. It also address ghg emissions in which, once the relevant regulations have been implemented and enforced, businesses will be required to apply for pollution permits if emissions are beyond soon to be prescribed emission levels. The full INDC disclosure has been annexed to this report.

3.3 MAINSTREAMING CLIMATE CHANGE

The thrust for mainstreaming climate change in Antigua and Barbuda will be based on the nation's ability to develop a well institutionalized Climate Change Policy, included in which would be mechanisms and targets to promote low carbon usage and to green the economy. In the past, addressing climate change has been limited

[28] **The water sector includes water generation (seawater desalination), distribution and usage, to ensure water delivery when grid electricity may be interrupted. Based on an informal assessment, water distribution and usage is equal to approximately 15% of GHG emissions in the electricity sector.**

[29] **Waste-to-energy is not considered part of the 50 MW renewable energy target.**

[30] **This target includes distributive renewable energy capacity to be used as backup energy by the commercial sector and some residences. The assumption is that the commercial sector has full backup capacity at approx. 20 MW to continue operations when grid electricity may be interrupted. Backup electricity generation is currently fossil fuel based.**

primarily to the ability of the government to access multilateral financing allocations geared specifically to 'climate only' issues. This has caused the general public to mentally compartmentalize climate change as a standalone environmental occurrence as opposed to being an overarching concept and driver of (or impediment to) sustainable development. In a 2008 Knowledge, Attitude and Practices study of Antigua and Barbuda, this was evidenced by a marked lack of awareness of the non-hydro-meteorological impacts of climate change. It will only be through the institutionalized development of a vibrant green economy that stakeholders and other nationals will begin to make the mental linkages between climate change, other sectors, the economy and society.

The Green Economy is defined by UNEP as "an economy in which income and employment are driven by public and private sector investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent loss of biodiversity and ecosystem services. A green economy, therefore, requires a different way of thinking of economic growth – it requires replacing the focus on exploitation of natural capital with a focus on efficient and sustainable use, employment creation, and minimizing or reversing negative environmental impacts, albeit underscoring the economic dimensions of sustainability."

In Antigua and Barbuda, transitioning to a green economy is seen as an effective mechanism toward climate change mainstreaming because:

- The majority of energy generation in Antigua and Barbuda is fossil fuel based, all of which is imported;
- Its location and climate is deemed to be well suited to the use of a number of renewable energy options;
- The savings accrued from allowing RE and EE technologies to comprise an increasing portion of the national energy and transportation sectors will significantly reduce the national deficit as all fossil fuel is imported and also provide increased capital for investment;
- Present, water produced from desalination ranges from 62% - 95% of demand. Establishing a green economy will increase the capacity and usage of surface water storage, which is significantly cheaper than desalination (US $3.00/$m^3$ from surface water versus $4.70/$m^3$ from desalination);
- The type of employment associated with a green economy will support sustainable livelihoods and should increase the size of the job market and encourage levels of local entrepreneurship;
- The environmental benefits associated with a green economy will enhance and ensure the sustainability of the tourism sector, to which Antigua and Barbuda is heavily dependent.

As a means of allowing the citizenry to gain a first-hand awareness of addressing climate change issues and the green economy, the Government through the APUA has eased restrictions and developed an interconnection policy which allows residents to generate up to 50 KW from renewable energy sources. However, this mechanism in mainly utilized by the affluent and some sections of the corporate sector but lacks the level of infiltration (in rural communities) to significantly reduce GHG emissions. What is needed is for government to source the capital investment to establish large-scale projects that will benefit the wider population.

4 VULNERABILITY, ASSESSMENTS, CLIMATE CHANGE IMPACTS AND ADAPTATION MEASURES

Vulnerability to climate change is identified as "the degree to which a system is susceptible to or unable to cope with, adverse effects of climate change, including climate variability and extremes". It is the propensity or predisposition to be adversely affected by climate impacts. Vulnerability encompasses a variety of concepts including sensitivity or susceptibility to harm and lack of capacity to cope and adapt[31]. Accordingly, many factors are involved in its assessment and as a result, particular areas or communities may demonstrate differing degrees of vulnerability.

Determining the degree to which a country or community is vulnerable to climate related events and the extent of their capacity to adapt and/or cope is important in order to ensure that investments in adaptation measures achieve desired outcomes. The results of a Vulnerability Assessment should be used to guide the decision making process in prioritizing appropriate steps that ought be taken to adapt to climate change. If the country/community is already highly vulnerable and does not have the financial, technical or human resource capacity to implement and sustain adaptation practices, it is less likely to adapt to the impacts of climate change.

In 2013, the Department of Environment (DoE), formerly the Environment Division (ED,) in collaboration with the Antigua Public Utilities Authority (APUA) organized a national consultation where key stakeholders were given the opportunity to discuss and assess the actual and projected vulnerabilities of Antigua and Barbuda as it relates to climate change[32]. It was unanimously agreed during the consultation that the water sector should be given the highest priority with respect to its vulnerability to climate change and direct impacts. Notwithstanding, this assessment also assesses the effects of climate change on the agriculture and health sectors.

As a small island developing state, Antigua and Barbuda is on the front lines of vulnerability to climate change. Higher sea surface and atmospheric temperatures, a rise in sea level, inland flooding, drought and increased hurricane intensity and storm surge have threatened the lives, property, and livelihoods of the Antigua and Barbuda's population. Without appropriate adaptation measures, climate change will have an extremely harmful impact on people, property and ecosystems in Antigua and Barbuda. With the increasing level of extreme weather events, and increasing water demand, adaptation strategies for the water sector will be of long-term importance. In this Chapter, the following are considered: governance structures (institutional framework and policy); security of the quality and quantity of water sources; protection of

[31] **IPCC, 2014. Working Group II Fifth Assessment Report Glossary. England: Cambridge Univeristy Press.**

[32] **ED, 2013. Report on the Climate Change & Policy and Model Water Act Project Consultation.**

distribution networks; and management of demand and supply. Climate change scenarios will help to inform the potential vulnerability and predicted adverse impacts on Antigua and Barbuda.

This chapter also presents the available knowledge on the incidence of this phenomenon in the identified areas: water availability, agriculture, and human health. It draws on valuable information from emerging aspects of regional climate change and proceeds to report on existing adaptation measures, as well as known planned or potentially useful measures.

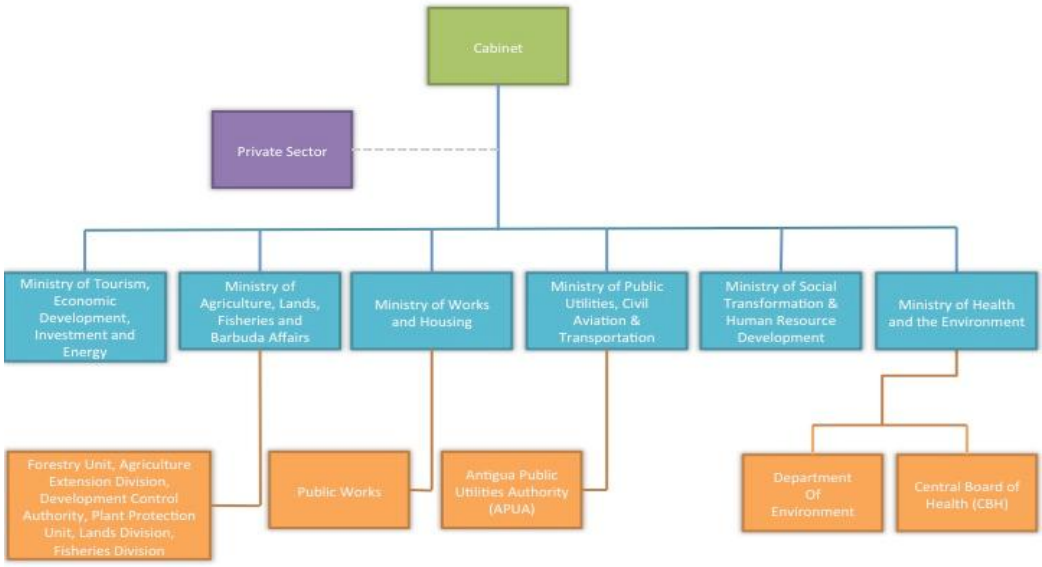


Figure 8: Institutional Map

4.1 ASSESSMENTS OF IMPACTS AND ADAPTATION MEASURES

In an attempt to address the situation in Antigua and Barbuda as it relates to the water sector, it is important to understand the current institutional

and legislative framework. Based on projected climate variability, the institutions will have to position themselves to adapt new stressors and needs that will result from projected impacts. Gaps are addressed here through the revision of the existing relevant policies, plans and legislation that guide these institutions.

The institutional map depicted in ***Figure 8*** shows agencies with a mandate related to water supply and management. Notably, no single authority has an explicit mandate for watershed management, however several institutions have a degree of responsibility for coastal zone management (*Table 16).* The Extension Division in the Ministry of Agriculture, Lands, Fisheries and Barbuda Affairs allocates state lands for agriculture. The Lands Division in the same Ministry handles parcels of more than 2 hectares. The lack of coordination among agencies frequently leads to disputes arising as to who has been allocated which land.

Antigua and Barbuda, in 2012, passed the SIRMZP, however its effective implementation has been affected due to inadequate resources within the Government system, previously captured in Section *1.1.3.* This plan would help guide the proper uses of land in a rational way.

A large number of agencies are involved in activities associated with watersheds, water harvesting and treatment, management of the marine and coastal zone. These institutions include government ministries, statutory bodies, NGO's and community groups. The recent enactment of the EPMA 2015 provides an improved legal status for watersheds, including the establishment of a multi-stakeholder Watershed and Wetland Management Committee, and the designation of critical wetlands and watersheds. The national public utility company (APUA) has legal rights over all water resources but has no legal obligations regarding watershed protection or maintenance.

Table 16: Summary of Agencies/ Responsibilities

AGENCY	RESPONSIBILITY
Non-Government Organisations (NGOs) and Community Based Organisations (CBOs)	
There are a number of NGOs and CBOs that play a major role in environmental awareness, training, advocacy, poverty alleviation and community development. They collaborate on many occasions amongst themselves and with government agencies to pool resources and address key issues affecting communities and the environment, including water resources.	
Ministry of Tourism, Economic Development, Investment and Energy	
The Ministry of Tourism, Economic Development, Investment and Energy has portfolio responsibility for beach protection, heritage sites, the Botanical Gardens, the National Parks Authority, the National Economic & Social Council, Tourism Corporation, St. John's Development Corporation, A&B Hospitality, Investment Authority, and the National Energy Council.	
Ministry of Agriculture, Lands, Fisheries and Barbuda Affairs	
Forestry Unit	Management of the country's forest and woodland areas and theoretically for reforestation. In recent years, the Forestry Unit has taken on activities more related to biodiversity conservation and eco-tourism development. The Unit is also the authority regarding the issuance of permits to import or export any form of wildlife.
Development Control Authority	The Authority regulates built development through the Physical Planning Act of 2003, which provides for the granting or refusing of permission to develop land. Implementing a Physical Development Plan with clear directives on further development of natural resources.
Fisheries Division	Has some responsibility for coastal zone management, including mangroves/wetlands that are included in the marine protected areas. The Division is given powers under the Marine Areas Act (1972), to restrict fishing in certain areas and to preserve habitats, flora and fauna, natural beauty or shipwrecks in marine areas. The Division also undertakes regular monitoring of major beaches for erosion.
Land Division	Responsible for the management and control of Government lands, including land reclamation, land use and the sub-division of land.
Agricultural Extension Division	Major responsibility for training and assisting farmers and the allocation of state lands to farmers for agricultural purposes. Plots of up to 2 hectares (5 acres) can be leased out under the authority of the Chief Extension Officer. Theoretically it is also responsible for control of stray animals however, it is the Livestock Division that has responsibility, under new legislation for the operation of the animal pound.
Plant Protection Unit	Responsibility for plant protection and recommendations as well as playing an important role in the Pesticide Control Board. This Board governs the pesticides that are approved for importation for use in Antigua and Barbuda. It is also responsible for plant quarantine at Ports of Entry

AGENCY	RESPONSIBILITY
Ministry of Works and Housing	
Public Works	Responsible for roads and drainage structures throughout the country. It has considerable influence on sedimentation management as part of road construction and maintenance as well as the management of floodwaters. The Director of Public Works is also responsible for the enforcement of the Beach Protection Act, which is supposed to prevent the unauthorized removal of material from beaches or foreshores and for granting permits, where permission is approved.
Ministry of Public Utilities, Civil Aviation and Transportation	
Water Division of APUA	Legal control over all water resources in the country and is mandated to provide supplies of water to meet the municipal needs of the country. It is also responsible for water quality testing, hydrological surveys, planning & digging of wells and construction of dams
Ministry of Social Transformation and Human Resource Development	
The Ministry of Social Transformation and Human Resource Development has portfolio responsibility for social welfare, community development, social improvement, poverty eradication, disaster preparedness, gender affairs, the civil service, establishment department, training division, human resource development & management services, youth empowerment and local government.	
Ministry of Health and the Environment	
Central Board of Health	Responsible, among other things, for enforcement of the environmental sanitation regulations, preventing the spread of infectious diseases, operating a mosquito control program and for the handling of liquid and solid waste
National Solid Waste Management Authority	Responsible for the practical aspects of solid waste management and was set up as part of a sub-regional program to improve management of solid waste in the OECS and to provide facilities for the onshore disposal of the growing amount of cruise ship generated waste as required under the MARPOL Agreement
Department of Environment (DoE)	Established with the primary role of coordinating the national environmental program. Since its formation as a Division in 1996, its role has expanded in response to environmental issues related to the Development Control Authority (DCA) and the processing of Environmental Impact Assessments (EIA's). The DoE is responsible for the implementation of Environmental Protection Orders, development and implementation of national and international projects related to rehabilitation and protection of environment; coordinates commitments to the MEAs; develops environmental legislation and any other duties assigned by the Ministry or the Cabinet of Antigua and Barbuda, as defined in the Environmental Protection and Management Act of 2015. It also collaborates with Forestry Unit to address issues of land degradation through the national urban reforestation programme.

AGENCY	RESPONSIBILITY
Cabinet of Antigua and Barbuda	
This is the executive branch of the Government of Antigua and Barbuda and includes the representative Ministers and Ministers of State from the various Ministries	

4.2 CLIMATE VARIABILITY AND CHANGE

The combination of Antigua and Barbuda's size, location and low-lying topography results in:

- The island's climate being influenced by the ocean,
- High temperatures,
- Low diurnal and seasonal variation in temperature, and
- Vulnerability to tropical storms and hurricanes.

Throughout the year, the country's climate is strongly modulated by the migration of the north Atlantic subtropical high, the eastward spreading of the tropical Atlantic warm pool, the fairly steady easterly trade winds and the passage of tropical waves, depressions, storms and hurricanes. As a result, the climate regime is characterized by a dry winter-wet summer pattern together with high and fairly uniform temperatures year-round. Inter-annual climate variability is strongly influenced by the El Niño Southern Oscillation. El Niño events bring warmer and drier conditions during the late, wet season and La Niña events bring colder and wetter conditions at this time.

A study was commissioned in 2014 under the Regional Gateway for Technology Transfer and Climate Change Action in Latin America and the Caribbean (REGATTA), implemented by the United Nations Environment Programme: Regional Office for Latin America and the Caribbean (UNEP-ROLAC) to conduct climate change vulnerability, impact and adaptation (VIA) analysis in Antigua and Barbuda. That VIA analysis complemented and reinforced ongoing research and planning processes in the country. It also contributed to this document by providing the following analyses:

a. Standardized Precipitation Index (SPI) calculated from monthly precipitation time series;
b. Remotely sensed Normalized Difference Vegetation Index (NDVI) time series from January 2001 to late December 2014;
c. Monthly precipitation time series from January 1979 to October 2014, and;
d. National and regional wet and dry season analysis.

In summary, detailed climate modeling projections for Antigua and Barbuda indicate an increase in average atmospheric temperature and reduced average annual rainfall, and an increase in rainfall variability leading to exposure to both flooding and drought conditions[33]. In that VIA, the authors present findings of an analysis by Simpson et. al. (2012) [34] whereby observed and general circulation models (GCM) projected changes in temperature and precipitation for the country are summarized. This information is presented below (*tables 17 and 18*).

[33]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) - Antigua and Barbuda. DFID, AusAID and The CARIBSAVE Partnership, Barbados, West Indies.

[34]Ibid.

Table 17: Observed and GCM Projected Changes in Temperature for Antigua and Barbuda

Antigua and Barbuda: Country Scale Changes in Temperature												
	Observed Mean 1970-99	Observed Trend 1960-2006		Projected changed by the 2020s			Projected changes by the 2050s			Projected changes by the 2080s		
				Min	Median	Max	Min	Median	Max	Min	Median	Max
	(°C)	*(change in °C per decade)*		*Change in °C*			*Change in °C*			*Change in °C*		
			A2	**0.2**	0.7	**0.8**	**0.9**	1.4	**1.8**	**1.7**	2.3	**3**
Annual	**26.3**	**0.13***	**A1B**	**0.2**	0.7	**1**	**0.9**	1.5	**1.7**	**1.1**	2.1	**2.8**
			B1	**0.3**	0.7	**0.8**	**0.5**	1.1	**1.3**	**0.8**	1.4	**2**
			A2	**0.3**	0.7	**0.9**	**1**	1.4	**1.8**	**1.7**	2.4	**3**
DJF	**25.2**	**0.10***	**A1B**	**0.2**	0.7	**1**	**0.9**	1.5	**1.7**	**1.2**	2.1	**3**
			B1	**0.3**	0.7	**0.8**	**0.5**	1.1	**1.4**	**0.8**	1.4	**2.1**
			A2	**0.2**	0.6	**0.8**	**0.7**	1.2	**1.7**	**1.5**	2.2	**2.8**
MAM	**25.7**	**0.11***	**A1B**	**0.1**	0.6	**1**	**0.9**	1.4	**1.7**	**0.9**	2	**2.6**
			B1	**0.1**	0.6	**1**	**0.4**	1	**1.3**	**0.6**	1.3	**1.9**
			A2	**0.1**	0.7	**0.8**	**0.8**	1.3	**1.7**	**1.6**	2.2	**2.9**
JJA	**27.3**	**0.16***	**A1B**	**0.2**	0.7	**0.9**	**0.9**	1.4	**1.7**	**1**	1.9	**2.7**
			B1	**0.2**	0.6	**0.8**	**0.4**	1	**1.2**	**0.8**	1.3	**2**
			A2	**0.3**	0.8	**1**	**1**	1.4	**1.9**	**1.8**	2.4	**3.2**
SON	**27.1**	**0.17***	**A1B**	**0.3**	0.7	**1.2**	**1**	1.5	**2**	**1.3**	2	**3.1**
			B1	**0.3**	0.7	**1.1**	**0.6**	1.1	**1.4**	**0.9**	1.4	**2.1**

(Source: Replicated from the CARIBSAVE Climate Change Risk Atlas (CCCRA) - Antigua and Barbuda. DFID, AusAID and The CARIBSAVE Partnership, Barbados, West Indies; Simpson, et. al., 2012)

Table 18: Observed and GCM Projected changes in Precipitation for Antigua and Barbuda

Antigua and Barbuda: Country Scale Changes in Precipitation												
	Observed Mean 1970-99	Observed Trend 1960-2006		Projected changed by the 2020s			Projected changes by the 2050s			Projected changes by the 2080s		
				Min	Median	Max	Min	Median	Max	Min	Median	Max
	(mm per month)	*(change in mm per decade)*		*Change in mm per month*			*Change in mm per month*			*Change in mm per month*		
			A2	**-8**	-2	**3**	**-17**	-3	**10**	**-31**	-6	**8**
Annual	**172**	**-2.8**	**A1B**	**-5**	-1	**7**	**-9**	-3	**8**	**-21**	-5	**13**
			B1	**-8**	-2	**9**	**-10**	-2	**5**	**-12**	-4	**8**
			A2	**-8**	0	**8**	**-10**	-2	**3**	**-8**	-1	**6**
DJF	**138.9**	**2.9**	**A1B**	**-6**	0	**4**	**-5**	0	**6**	**-22**	0	**3**
			B1	**-8**	0	**5**	**-7**	-1	**4**	**-15**	0	**7**
			A2	**-8**	-1	**9**	**-17**	-1	**10**	**-25**	-2	**3**
MAM	**133.4**	**-5.9**	**A1B**	**-4**	0	**6**	**-11**	0	**7**	**-17**	-1	**6**
			B1	**-2**	0	**11**	**-10**	0	**3**	**-8**	0	**5**
			A2	**-18**	-3	**8**	**-27**	-9	**11**	**-64**	-16	**4**
JJA	**176.9**	**-4.2**	**A1B**	**-12**	-2	**11**	**-21**	-10	**14**	**-44**	-9	**12**
			B1	**-18**	-3	**20**	**-26**	-6	**0**	**-22**	-10	**10**
			A2	**-17**	-3	**10**	**-20**	-4	**24**	**-48**	-11	**26**
SON	**235.3**	**-3.6**	**A1B**	**-13**	0	**13**	**-22**	-3	**21**	**-32**	-2	**41**
			B1	**-24**	-1	**14**	**-28**	-1	**20**	**-22**	-3	**23**

(Source: Replicated from the CARIBSAVE Climate Change Risk Atlas (CCCRA) - Antigua and Barbuda. DFID, AusAID and The CARIBSAVE Partnership, Barbados, West Indies; Simpson, et. al., 2012)

4.3 INCREASED CLIMATE VARIABILITY

The risks of higher temperatures, sea level rise, flooding, drought, and increased hurricane intensity and storm surge are examined this section.

4.4 CHANGES IN MEAN CLIMATE: RAINFALL

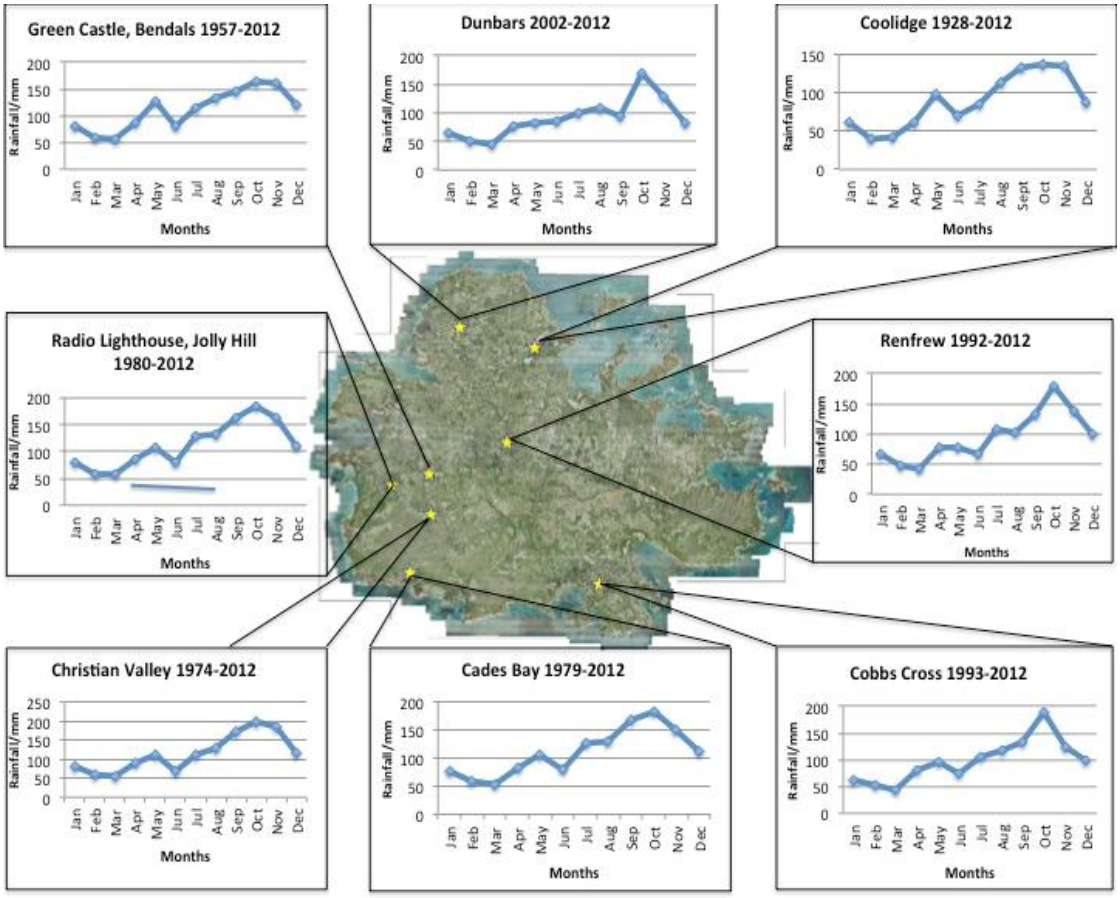


Image 4: Monthly rainfall Climatology stations in Antigua

Most rainfall stations in Antigua reflect a bi-modal pattern. This has been characterized by maxima in May and October, with the latter exhibiting the higher records (*Image 4*). Rainfall observations from the V.C. Bird Airport reveal however, that the bi-modal pattern is less well defined. Further examination of the rainfall periods by decades (1970-2011) from this particular station suggest a shift in seasonality with two peaks occurring between August and November, though still exhibiting a bi-modal distribution (*Figure 9*).

The V.C Bird Airport station also records an average of 12.0 - 12.7 rain days per month for July-December, which correlates to the active part of the hurricane season. The Codrington station in Barbuda (*image 5*) shows a single primary peak in average monthly rainfall around October where an average of 200 mm is recorded.

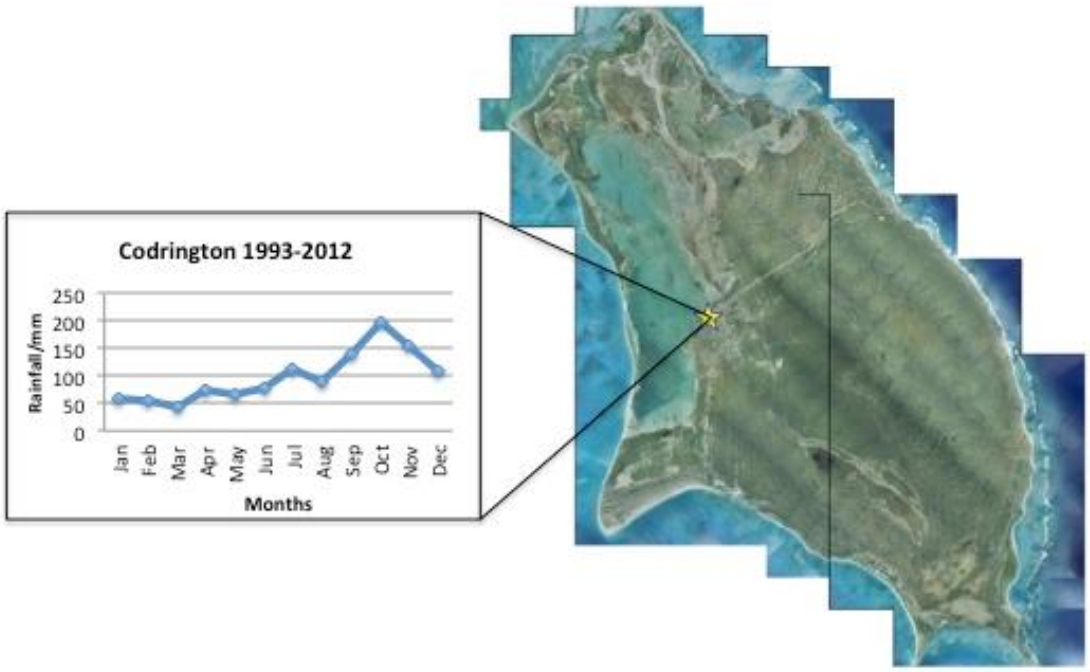


Image 5: Monthly Rainfall Climatology for Barbuda

that the seasons over Antigua may be described as early dry (January-March), early wet (April-June) and late wet (July-December). Most of the stations in Antigua generally exhibit similar seasonal patterns. The rainfall pattern over Antigua is largely conditioned by the North Atlantic High (NAH) pressure system, this is a large, subtropical, semi-permanent centre of high atmospheric pressure typically found south of the Azores in the Atlantic Ocean between 30° N and 35° N. Codrington in Barbuda exhibits a single rainfall season July to December.

The percentage contribution of monthly totals to annual rainfall amounts suggests

is the Tropical Upper-level Tropospheric Trough (TUTT); a trough situated in the upper level (200 hPa) tropics.

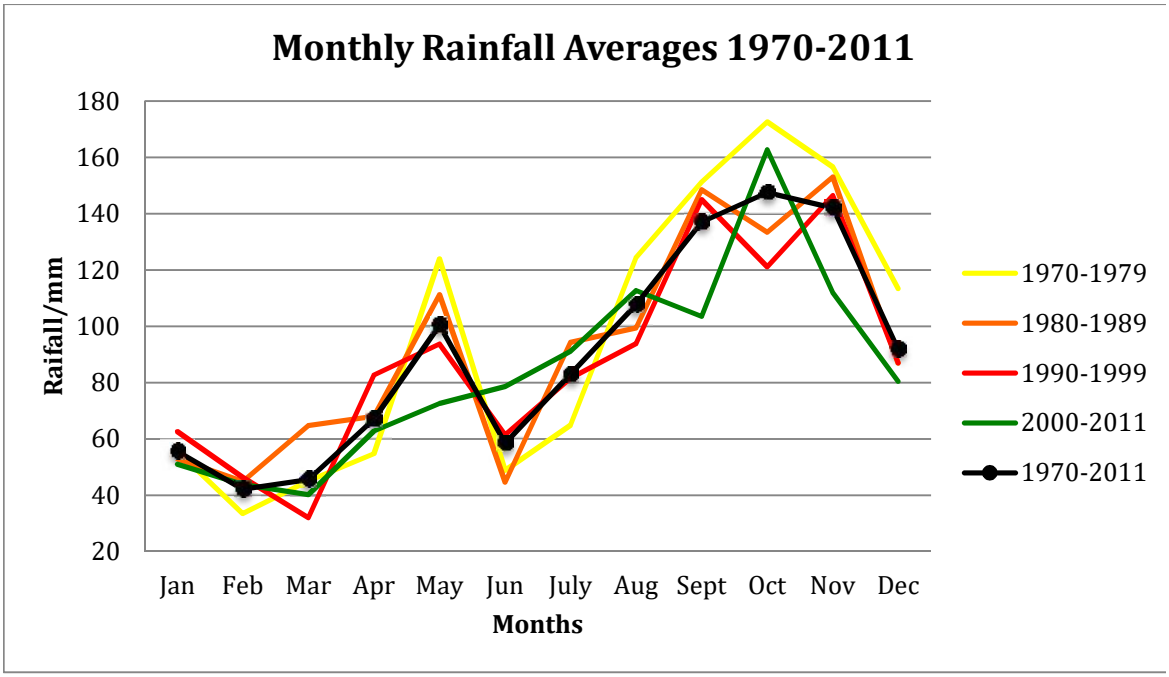


Figure 9: Average monthly rainfall by decades. Data recorded from VC Bird International Airport

The primary source of rainfall from June to November is the passage of easterly waves that traverse the Atlantic Ocean from the west coast of Africa to the Caribbean. The waves are themselves a source of convection and can develop into depressions, storms and tropical cyclones under conducive conditions. Near July, a temporary southward movement of the NAH is associated with diminished rainfall and the occurrence of a mid summer drying. Enhanced rainfall occurs with the return of the NAH to the north and the passage of the Inter Tropical Convergence Zone (ITCZ) northward. When the NAH treks south again at the end of the year, it marks the onset of the dry season. Another atmospheric feature important to rainfall variations during the rainfall season(s)

4.5 CHANGES IN MEAN CLIMATE: TEMPERATURE

Due to the small size of Antigua and Barbuda and limited downscaling of climatic models, it is not easy to provide projections for the country's climate with any detailed certainty; however, the trend towards a warmer climate in Antigua is however well established.

It is anticipated that air temperature within the insular Caribbean will increase by 1.8 – 4.0°C by 2099, while air temperatures specifically in Antigua and Barbuda are expected to increase by as much as 1.3°C by 2050 and by up to 3.5 °C by the end of the century[35]. In recent years, both maximum

[35] **Gomes J., 2008. Antigua and Barbuda Red Cross Background Document: Impacts of Climate Change and Disaster Risk Reduction in Antigua and Barbuda. Antigua and Barbuda: Antigua and Barbuda Red Cross.**

and minimum temperatures in Antigua and Barbuda have increased, providing observational evidence that the temperature in Antigua and Barbuda is increasing. It is also anticipated that the warming trend will continue, which will increase the frequency of hot days and reduce the frequency of cool nights[36].

The average monthly maximum and minimum temperature range is 5°C and 4°C respectively with temperatures peaking during summer months. Maximum temperatures may reach 31.2°C in August and September, while minimum temperature values dropped to 22°C in January/February (*Figure 10*). The 1990's was the hottest decade on record with the year 1998 being the hottest year, likely linked to El Nino Southern Oscillation events and the positive phase of the Atlantic Multi-decadal Oscillation (AMO). This is illustrated in *Figure 11.*

4.6 CHANGES TO MEAN CLIMATE: EXTREME WEATHER

A significant number of extreme events of different categories and strikes have impacted Antigua and Barbuda between 1971 and 2012. These events tend to be accompanied with heavy rainfall. For example, May 1979 showed heavy rainfall and this is closely linked with Hurricane Claudette. Similarly, September 1995 had anomalously high rainfall, due to Hurricane Luis. November 1999 showed anomalously high rainfall and this correlates with Hurricane Jose.

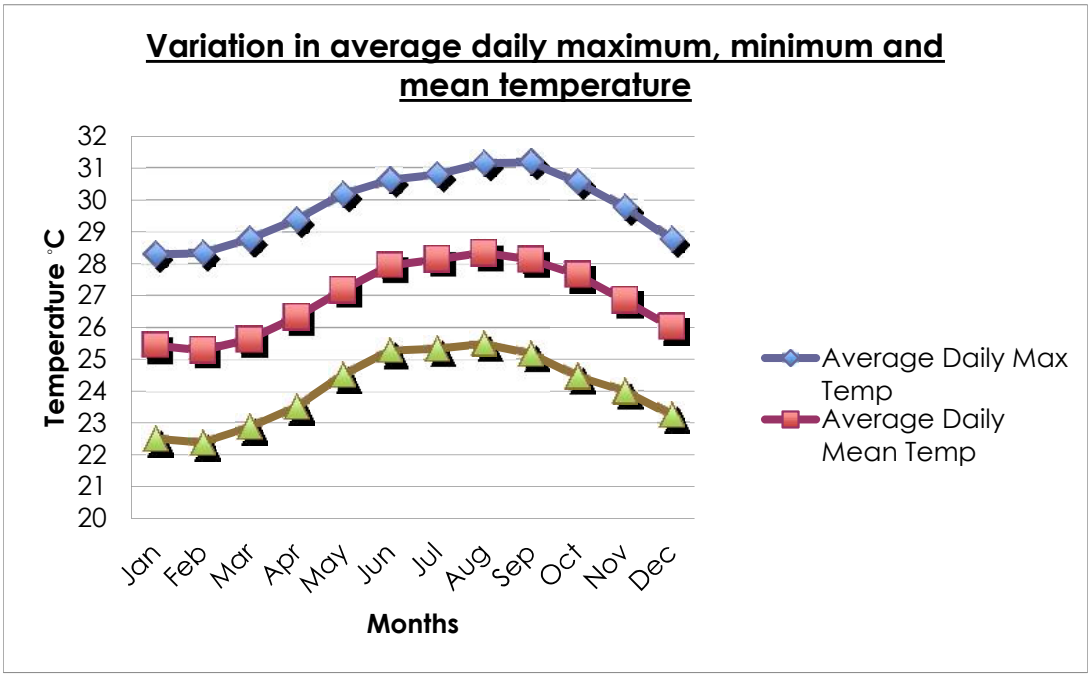


Figure 10: Monthly variation in average daily maximum, minimum, and mean temperature 1995 -2014

[36] **Gomes J., 2008. Antigua and Barbuda Red Cross Background Document: Impacts of Climate Change and Disaster Risk Reduction in Antigua and Barbuda. Antigua and Barbuda: Antigua and Barbuda Red Cross.**

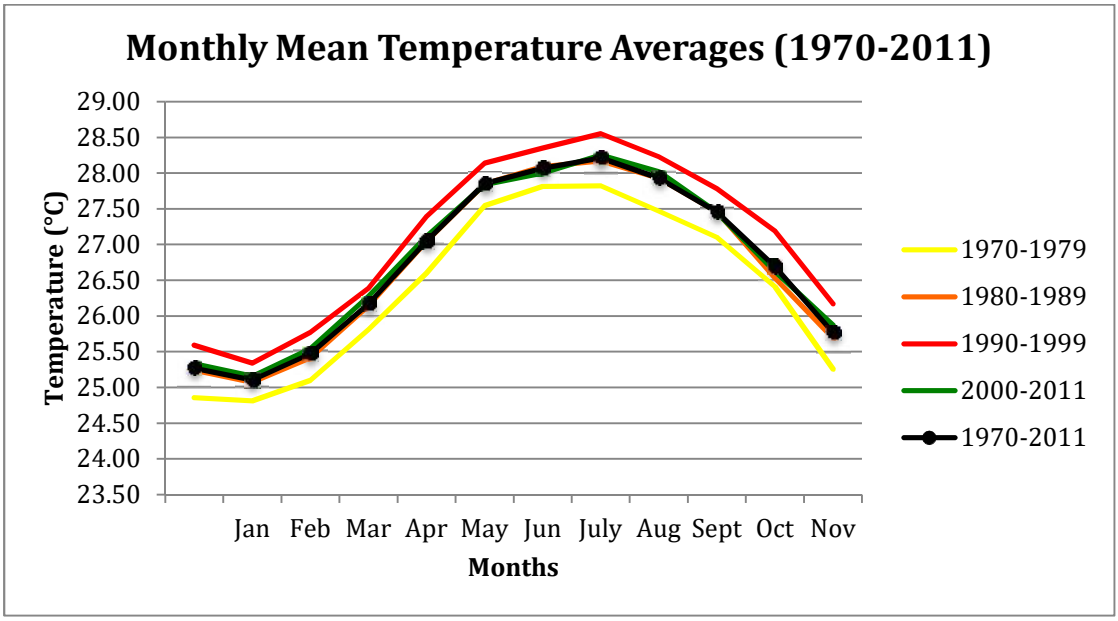


Figure 11: Average monthly mean daily temperature by decades. Data recorded from VC Bird International Airport

The period assessed from 1970 to 2011 is largely during the low phase of the AMO with the exception of the late 1990's. Anomalously high rainfall events were recorded during the positive phase of the AMO. During this period a total of 10 tropical depression, 16 tropical storms, 6 category I hurricanes, 2 category II hurricanes, 3 category III hurricanes and 4 category IV hurricanes affected Antigua and Barbuda in varying degrees. These range from directly hitting the country to passing up to 105 nautical miles [minds] off shore. In all cases storm conditions were felt with the most devastating being from impacts and/or direct hits to the country.

The most devastating system to affect Antigua and Barbuda was Hurricane Luis (1995) resulting in 17% decrease in tourist arrivals that year, 7000 being unemployed, 90% of buildings damaged or destroyed and damages amounting to 30.49% of the GDP. Other significant storms were Hurricane Georges (1998), Hurricane Jose (1999) and Lenny (1999) and Hurricane Earl (2010), (*see Table 19*).

Table 19: Economic Loss/Damage of events between 1995 - 2010

Year	Event	Economic Loss/Damages ($XCD)
1995	Hurricane Luis	346.55 million
1998	Hurricane Georges	200 million
1999	Hurricanes Jose & Lenny	247.43 million
2008	Hurricane Omar	48.6 million
2010	Hurricane Earl	slightly > 52 million

During the passage of Hurricane Earl in 2010, 7.78 inches of rain was recorded within 24 hours and this resulted in significant damages to the Agriculture sector including Fisheries,

road networks, utilities and infrastructural damage to hotels[37].

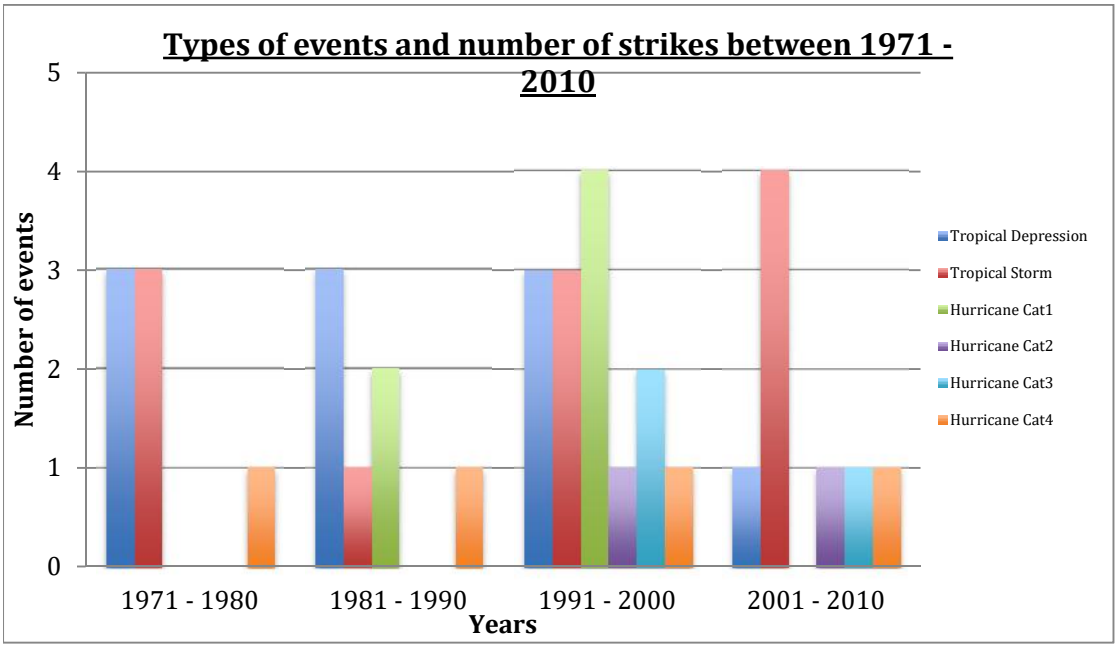


Figure 12: Category of cyclones and their number of strike types for Antigua and Barbuda (1971 - 2012)

It was observed that after a near thirty-year lull (1961-1989) in direct hits, the country experienced the effects of eight hurricanes (direct hits or near brushes) between 1995 and 2000 (*Figure 12*). In general, North Atlantic hurricane frequency is influenced by the AMO, which yields active and inactive phases lasting 10 or more years[38]. Since 1995, the North Atlantic has swung into an active hurricane phase. Since 2000 there has again been a lull in hurricane impact on the country. This is in spite of the fact that the current active hurricane phase continues in the north tropical Atlantic.

4.7 CHANGES IN MEAN CLIMATE: SEA LEVEL RISE AND STORM SURGE

Using proxy and instrumental data, it is virtually certain (i.e. with 99-100% probability) that the rate of global mean sea level rise has accelerated during the last two centuries, marking the transition from relatively low rates of change during late Holocene (order tenths of mm/year^{-1}) to modern rates (order mm/year^{-1}). Rates and absolute changes in global mean sea level pressure obtained from the IPCC (2013)[39] are included in the *table 20*.

[37] Gore-Francis, J. (2013). Antigua and Barbuda SIDS 2014 Preparatory Progress Report. Antigua and Barbuda: Ministry of Agriculture, Housing, Lands and the Environment.

[38]Goldenberg, S., C. Landsea, A. Mestas-Nuñez, W. Gray (2001) The Recent Increase in Atlantic Hurricane Activity: Causes and Implications Science 20 July 2001:Vol. 293. no. 5529, pp. 474 – 479.

[39]IPCC, 2013: Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Table 20: Rates and absolute changes in mean sea level pressure

PERIOD	RATE (MM YR^{-1})	TOTAL SEA LEVEL RISE (MM YR^{-1})	IPCC LIKELIHOOD
1901 – 2010	1.7 ± 0.2	0.19 ± 0.02	Very likely
1971 – 2010	2.0 ± 0.2	-	Very likely
1993 – 2010	3.2 ± 0.4	-	Very likely

Instrumental monitoring (tide-gauge and satellite altimeter) reflected the rate represented in the 1993-2010 period. It is highly probable that rates similar to this period also occurred between 1930 and 1950. It is also very likely that global mean sea level has accelerated since the early 1900's, with estimates ranging from 0.000 to 0.013 [-0.002 to 0.019] mm yr^{-2} [40].

country has already exhibited evidence of sea level rise and based on surveys conducted, areas at greatest risk in Antigua are Dickenson Bay, Fort Bay and Runaway Bay and in Barbuda, Cocoa Point, Low Bay and Palmetto Point, with Low Bay at greatest risk in Barbuda. These areas include notable resorts, ports and an airport that lies less than 6 m above sea level[41].

Simpson et al (2012)[42] projected sea level rise scenarios of 1 m and 2 m for Antigua and Barbuda (*Table 21*). The table shows the percentage of the infrastructure that is at risk from these scales of sea level rise. Additionally, it gives the percentage of the major tourism establishments and sea turtle nesting sites that would be impacted by erosion due to 1 m sea level rise.

Table 21: Impacts associated with sea-level rise (1and 2 m) and beach erosion (50 and 100m in Antigua & Barbuda

Impacts	Scale	Major Tourism	Sea Turtle Nesting Sites	Airport Lands	Major Road Networks	Seaport Lands
Sea Level Rise	1 m	10%	12%	0%	2%	100%
	2 m	18%	18%	100%	6%	100%
Coastal Erosion	50m	34%	50%	-	-	-
	100m	44%	65%	-	-	-

It is expected that the sea level rise in the region near Antigua and Barbuda approximate to the global average. This

[40]IPCC, 2013: Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

[41]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) - Antigua and Barbuda. DFID, AusAID and The CARIBSAVE Partnership, Barbados, West Indies.

[42]Ibid.

In addition to sea leave rise, another major impact to the coastal zone is storm surges. These have resulted in severe sand loss affecting many of the beaches in the country. For example, between 1996 and 2001, Palm Beach in Barbuda experienced erosion at an alarming rate of 0.8 m/year and can expect increased rates of erosion in the future[43].

The high density of tourism development on the coast increases vulnerability to climate change and sea level rise as well as the risk of degradation of coastal and marine biodiversity. A reduction in the width of the beach buffer zone due to sea level rise and storm surge will increase the vulnerability of coastal infrastructure to erosive wave action and can contribute to the loss of critical fish landing sites in Antigua and Barbuda. In addition, impacts of sea level rise and storm surge on beaches increases the vulnerability of species of marine turtles, shore birds and other species that depend on the coastal zone for survival.

4.7.1.1 Drought

A drought can be classified as an extended period of deficiency in precipitation (relative to what is considered normal), which is then insufficient to meet economic, social and environmental demands. According to the U.S National Drought Mitigation Center, there are three main types/definitions of drought: 1)meteorological, 2) agricultural and 3) hydrological drought. Given the relatively small size of Antigua and Barbuda drought effects are felt island-wide and are a recurrent feature of the climate.

Owing to the country's geographic position and topographic features, the islands of Antigua and Barbuda are two of the driest islands in the Caribbean region. The low levels of rainfall combined with porous limestone geology make the islands vulnerable to hydrological drought[44]. Antigua and Barbuda has a long history of droughts. Overall rainfall has decreased significantly from historical records, evaporation rates are high and therefore the impact of drought has become more severe recently in the country[45].

Previously, meteorological drought for Antigua/Barbuda was defined using a precipitation level of 80% or less of yearly average rainfall (or <30.74 inches in Antigua and < 27.79 inches in Barbuda) for a drought year. However, given the variability in rainfall distribution, the Antigua Barbuda Meteorological Department started using an adjusted version of the decile (DI) method developed by Gibbs and Maher (1967). Rainfall periods of three months or more are assessed to determine whether they fall below the 30th percentile of historical records. Drought levels are based on the maximum consecutive three-month deficit of historical records and are defined in *Table 22:*

[43] Simpson, M., Scott, D., Harrison, M., Silver, N., O'Keeffe, E., Harrison, S., et al., 2010. Quantification and Magnitude of Losses and Damages Resulting from the Impacts of Climate Change: Modelling the Transformational Impacts and Costs of Sea Level Rise in the Caribbean. Barbados: United Nations Development Programme (UNDP)..

[44] CARIBSAVE, 2014. Vulnerability, Impact and Adaptation Analysis in the Caribbean (VIAAC). National Vulnerability Analysis for Antigua and Barbuda. Prepared with funding from the United Nations Environment Programme: Regional Office for Latin America and the Caribbean (UNEP:ROLAC).

[45] 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) - Antigua and Barbuda. DFID, AusAID and The CARIBSAVE Partnership, Barbados, West Indies.

Table 22: National Drought Index

Category Drought	Definition
Slight	Rainfall ranges from less than 30th percentile to the 20th percentile. Approximate range of 7.2 months
Moderate	Rainfall ranges from less than the 20th percentile to the 10th percentile. Average range is 7.8 months
Serious	Rainfall ranges from less than the 10th percentile to the 5th percentile with an average range of 5 to 29 months (average 17.2 months). Such droughts tend to commence during the first half of the year.
Severe	Rainfall is less than the 5th percentile and ranges from 5 to 26months; average range is 11.9 months.

Between the years 1966 and 1968 there were three consecutive years of rainfall below 30 inches[46]. In 1983-1984 Antigua and Barbuda experienced a period of severe drought between January to March, with extreme low rainfall temperatures of 22.2 inches and forced Government to resort to importing water from neighbouring islands. For the remaining months of the year drought conditions persisted but were reduced to moderate/severe conditions.

During these years, all surface reservoirs were depleted and the ground water supply only produced one sixth of the constrained national demand[47].

Furthermore, prevailing drought conditions between 1984-2001 contributed to the rapid loss of vegetative cover and exacerbated land degradation[48]. This has also had an impact on the domestic and hotel sectors. Fortunately, these sectors have been somewhat shielded from a significant impact due to the installation of desalination plants on the island, however desalination is 5 to 6 times more expensive for water provision. The agriculture sector, unable to pay high rates, is not so fortunate.

The ongoing drought conditions have significantly impacted the country's economy, particularly with reference to water supply, and the agricultural sector. The Government owned national utility, APUA, has increased its reliance on desalination as the main source of potable water supply. Ideally, desalination would contribute 57% of potable water production, with 28% from surface catchments and 15% from the ground[49]. However, given the ongoing drought, desalinized contribution was up to 95%.

This reliance on desalination is extremely costly. Estimated costs to APUA is EC$27 million in energy costs and the current capacity of desalination plants are still inadequate to meet total demands[50]. This further increases the cost of water to households, and farmers.

[46] Hodgkinson-Chin, E. 2001. Drought Hazard Assessment and Mapping for Antigua and Barbuda :Post-Georges Disaster Mitigation Project in Antigua & Barbuda and St. Kitts & Nevis. Organization of American States, Unit for Sustainable Development and Environment for USAID-Jamaica/Caribbean Regional Program.

[47] Simpson, M., Scott, D., Harrison, M., Silver, N., O'Keeffe, E., Harrison, S., et al. (2010). Quantification and Magnitude of Losses and Damages Resulting from the Impacts of Climate Change: Modelling the Transformational Impacts and Costs of Sea Level Rise in the Caribbean. Barbados: United Nations Development Programme (UNDP).

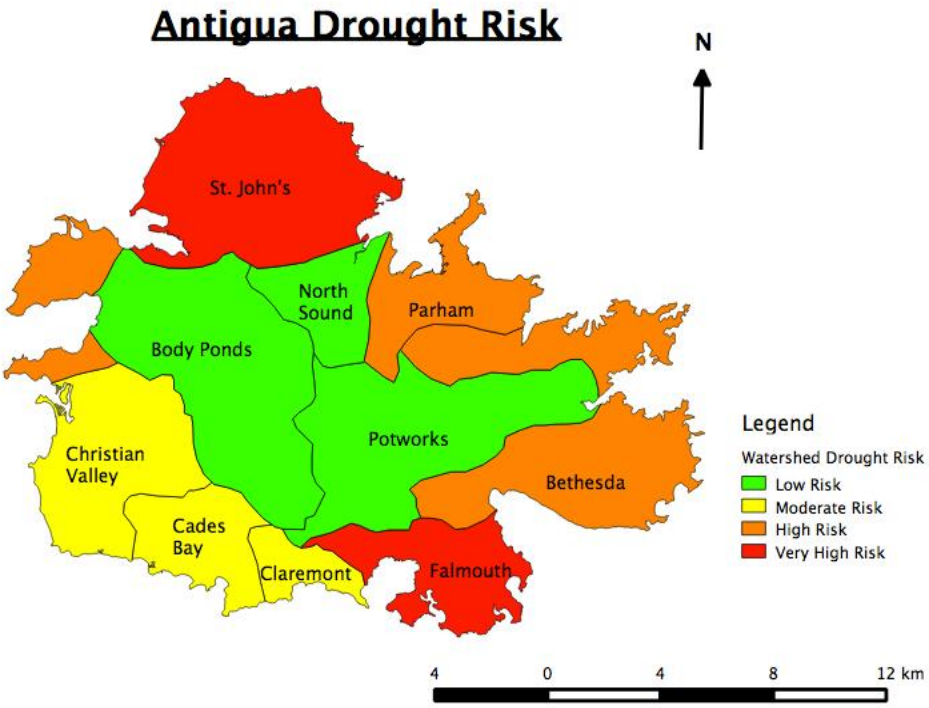
[48] Government of Antigua and Barbuda (GoAB), 2001. Antigua and Barbuda Initial National Communication on Climate Change. St. John's, Antigua and Barbuda. GoAB

[49] https://anumetservice.wordpress.com/2015/08/17/antigua-is-out-of-surface-water-again/

[50] http://antiguaobserver.com/apua-desalination-plant-will-be-installed-at-pigeon-point/

The agriculture sector is highly vulnerable to climate related events and due to drought conditions it has suffered extensive crop losses. For example, in 2010 onion and tomato crops in Antigua and Barbuda decreased by 25 and 30% respectively due to water stressed conditions[51].

Using the criteria of the drought map, with the presence of wells, it clearly shows that the watersheds of Cades Bay, Claremont, Christian Valley and Body Ponds are not affected by drought as the watersheds in the north and east. The agricultural zone for crops and grazing to some extent coincides with the location of groundwater wells, with areas of high rainfall and low drought risk The



Map 6: Drought Risk map based on watershed groupings

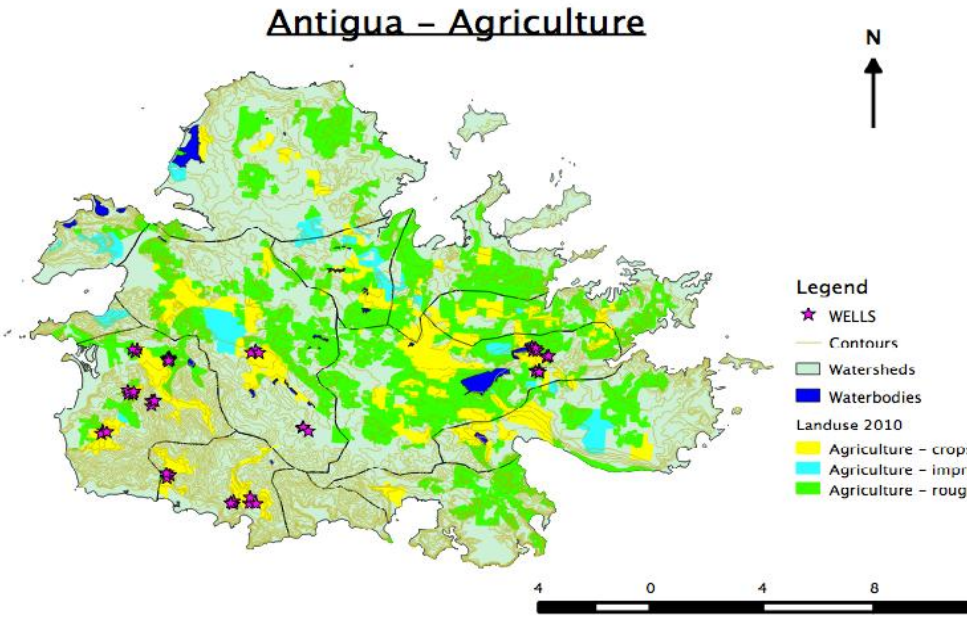
A drought risk map created in the Drought Impact Assessment Report[52] identifies the northeast and southeast watersheds as the most vulnerable areas to drought in Antigua. The drought vulnerability zones were determined based on environmental, meteorological, hydrological, infrastructure and land use parameters (Map 6 *and 7*).

GoAB (2001)[53] cited that, based on the drought vulnerability zones, the northeast and southwest of Antigua are the most vulnerable to drought. It went on to state that the most vulnerable area to drought on the island was the southeast of Antigua between English Harbour and St. James.

[51] Roberts, D., 2013. Status of Disaster Risk Management: Plans for Floods, Hurricanes and Drought in the Agriculture Sector: A Caribbean Perspective. Bridgetown, Barbados: Food and Agriculture Organisation (FAO) Sub Regional Office.

[52] Hodgkinson-Chin. 2001. Drought Hazard Assessment and Mapping for Antigua and Barbuda

[53] Government of Antigua and Barbuda (GoAB), 2001. Antigua and Barbuda Initial National Communication on Climate Change. St. John's, Antigua and Barbuda. GoAB



Map 7: Agricultural zones by watershed groups

In Barbuda, most of the development occurred within the zone of high drought vulnerability to include the town of Codrington and the entire south coast from River Port to Cocoa Point. However, agriculture and tourism development within Palmento in Barbuda were located within the zone of low drought vulnerability. The average annual rainfall between 1965 and 2000 was 34.74 inches (Met Office, 2001) in Barbuda. During this period, if < 27.79 inches/year of rain is used to define meteorological drought, then drought years were experienced in 1966, 1967, 1968, 1971, 1977, 1983, 1990, 1991, 1994 and 2000.

4.7.1.2 Flooding

Flooding in most SIDS is due to the effect of short duration, high intensity rainfall associated primarily with hurricanes and tropical storms. Although Antigua and Barbuda is prone to severe droughts, flooding is a growing and critical concern for the country. In Antigua and, to a lesser extent, Barbuda, flooding has been responsible for significant social and economic loss, and even drowning fatalities. Some of the major hurricanes that have affected the island and caused major damage from flooding are: Hurricane Lenny (November, 1999), Hurricane Omar (October, 2008) and Hurricane Earl (August, 2010).

Hurricane Lenny is noted for the level of flooding which directly affected Antigua and Barbuda when an estimated 20 to 33 inches of rain fell over a 48-hour period. The northwest and southern tips of Antigua were affected the most with severe landslides and major flooding was recorded. An estimated

65% of Barbuda went under water. The eye of Hurricane Omar passed some 126 miles south west of Antigua and Barbuda; however, during its passage 6 inches of rainfall was recorded at the V.C Bird Station. The country received a tropical storm effect that caused massive flooding and landslides[54]. Hurricane Earl hit the island recording 7.78 inches in a period of 24 hours. The impact of the hurricane resulted in flooding of some communities, damages to roads, bridges, drains, culverts and the general infrastructure. The road networks in the rural areas and crops were also damaged[55].

In addition to the passage of the tropical cyclones, other reasons for the increase in flood risk include poor development practices, blockage of natural and man-made watercourses and poor maintenance of vegetation growth and increased soil deposits in and around waterways.

Cooper (2001)[56] identified areas in Antigua and Barbuda prone to flooding as those having mild slopes (0.2% to 0.5%). This 2001 study indicated that most of the flood prone areas are located in areas of low slope <5% and elevations <135m. Lithologically, the flood zones range from volcanic, volcanoclastics in the Southwest watershed (SWW) to the alluvium and limestone in the north. There is insufficient data on the type of flooding but from the rainfall data available, the types of drainage and lithology suggest that the island gets both surface and groundwater flooding.

According to the National Office of Disaster Services, the flood prone areas in Antigua and Barbuda include:

Table 23: Flood Prone villages in Antigua and Barbuda

Airport Road	All Saints (Mack Pond)
Lightfoot	McKinnons
Bolans	Bath Lodge
Bendals Road	Bethesda
Old Parham Road	Swetes
Cassada Gardens	Cedar Grove
Cobbs Cross	Freetown
Pigotts (Burma Road)	Jennings
Grays Farm	Paynters (east & west)
John Hughes (Folly Gut)	Liberta
Picadilly	Yorks village
Villa & Point	
Lagoon & Marl Hole area in Barbuda	

In Antigua, surface water flooding could be the type seen in the southwest area where high run-off from storms and hurricanes causes water settling on the downstream end of the watersheds. Groundwater flooding would be more common in the east and north due to the presence of limestone allowing for higher subsurface infiltration. In Barbuda, run-off tends to be rapid as a result of very thin soil depths that provide very little infiltration and relatively low flow retardation. The run-off tends to accumulate in depressions or flow through Codrington on its way to be discharged in the salt ponds and the sea.

The flood zones have been categorized as very high, high, moderate and very low. However, this categorization does not attempt to provide water levels at various

[54] National Office of Disaster Services, 2008. Hurricane Omar Preliminary Summary Report. Government of Antigua and Barbuda.

[55] National Office of Disaster Services, 2010. Hurricane Earl Preliminary Report. Government of Antigua and Barbuda.

[56] Cooper, B. and Brown, V. 2001. Integrating Management of Watersheds & Coastal Areas in Small Island Developing States of the Caribbean. National Report for Antigua and Barbuda.

places within the flood plain, but is rather based on the maximum volume of water expected to be ponded within the plain from the 24 hour, 100 year return period. During such a rainstorm the extent of the hazard zone may be larger than the actual area inundated and water depths are likely to be greater in areas close to waterways and in depressions.

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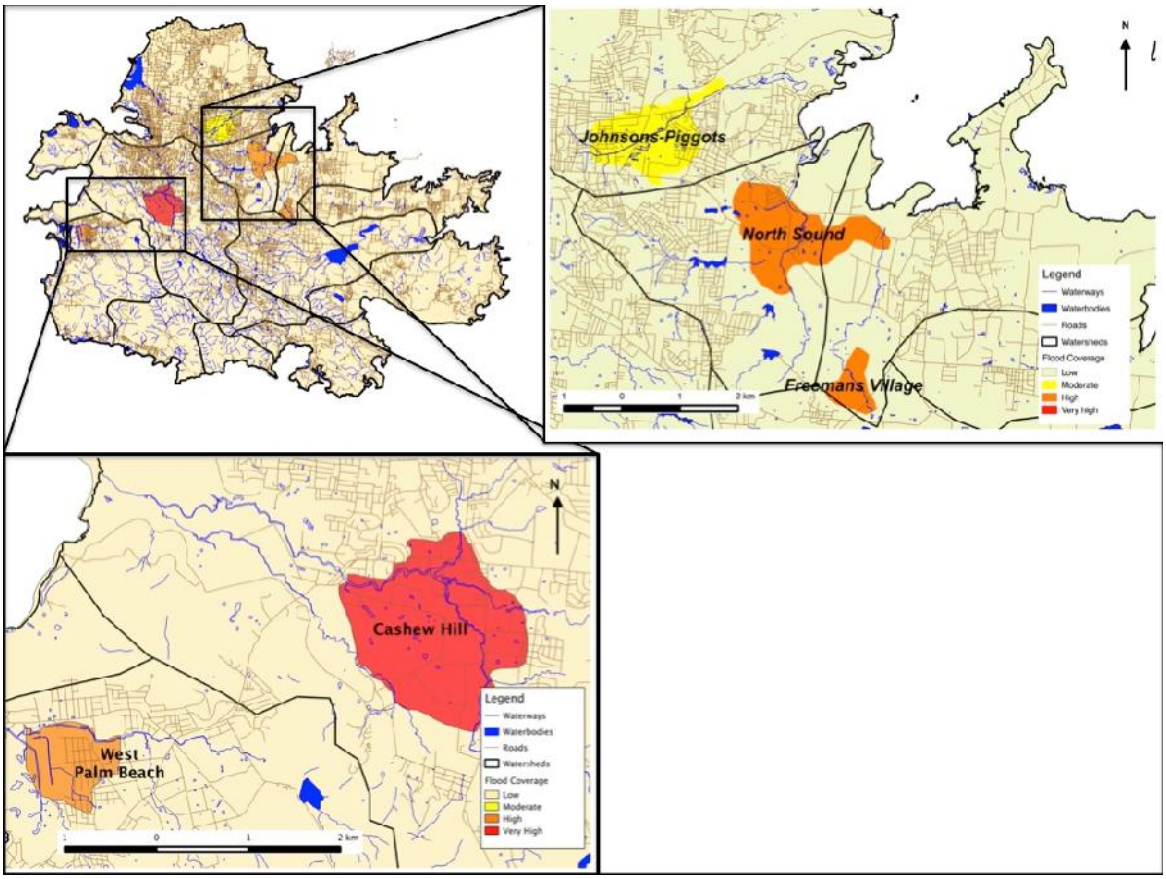

Figure 13: Major Flood prone areas

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4.8 VULNERABLE SECTORS

Stakeholder consultations and various studies identified key vulnerability sectors requiring urgent intervention as:

- biodiversita
- water resources
- agriculture and
- health

The following subsections will provide a more in-depth discussion of issues currectly faced within those sectors.

4.8.1 BIODIVERSITY

The threats to biodiversity within the country are well documented in the country's National Biodiversity Strategy and Action Plan (NBSAP)[57]. These are similar to many other Caribbean SIDS and include unsustainable management of the natural resources exacerbated by the effects of extreme weather patterns that are being experienced more frequently than in the past. The degraded integrity and functionality of the island's ecosystem has reduced its capacity to cope with the variable weather patterns.

In Antigua and Barbuda, the agriculture sector has suffered due to continued practices of indiscriminate cutting, setting of fires and uncontrolled grazing. This has contributed to severe degradation, accelerated erosion and reduced productivity of the land[58]. In addition to these, poor farming practices have negatively affected biodiversity and have contributed to the overall decline in ecosystem health across the islands[59].

Specifically, certain species of flora and fauna experience different levels of threats to their survival. For example, the sea turtle populations (***Chelonia mydas, Eretmochelys imbricata and Dermochelys coriacea)*** have been affected by the destruction of critical nesting and foraging habitats because of coastal construction, sand mining, pollution and over fishing[60]. Similarly, the flora biodiversity of the important forest reserve area of Wallings is threatened by the introduction of invasive species such as the lemon grass. As mentioned earlier in the section on National Circumstances, the lemon grass was noted as one of the most critical invasive species in 2010 because it covered over 345 acres of land creating a serious problem for farmers. Other species that threaten the biodiversity of the Wallings area include the Indian Mongoose, the Black Rat (***Rattus rattus***) and roaming goats.

Barbuda has experienced less development pressure, however, coastal erosion and salt water intrusion threaten the biodiversity on that island as well.

The barriers to Biodiversity protection are many; the most important however is the transition of lands from natural uses to housing which results in permanent loss. The Systems Plan for Protected Areas[61] is the first step in the identification of the systematic approach to reduce the loss of biodiversity. The plan, while highlighting the financial challenges for its implementation, does not however identify any ways to meet the costs associated.

[57] ED, 2014. Antigua and Barbuda National Biodiversity Strategy and Action Plan (NBSAP).

[58] Government of Antigua and Barbuda (GoAB), 2009. Antigua and Barbuda Second National Communication on Climate Change. St. John's, Antigua and Barbuda. GoAB).

[59] Mitchell, 2009. Wallings Forest Conservation Area Management Plan. Volume II Annex. St. John's Antigua and Barbuda. Prepared for the OECS Secretariat.

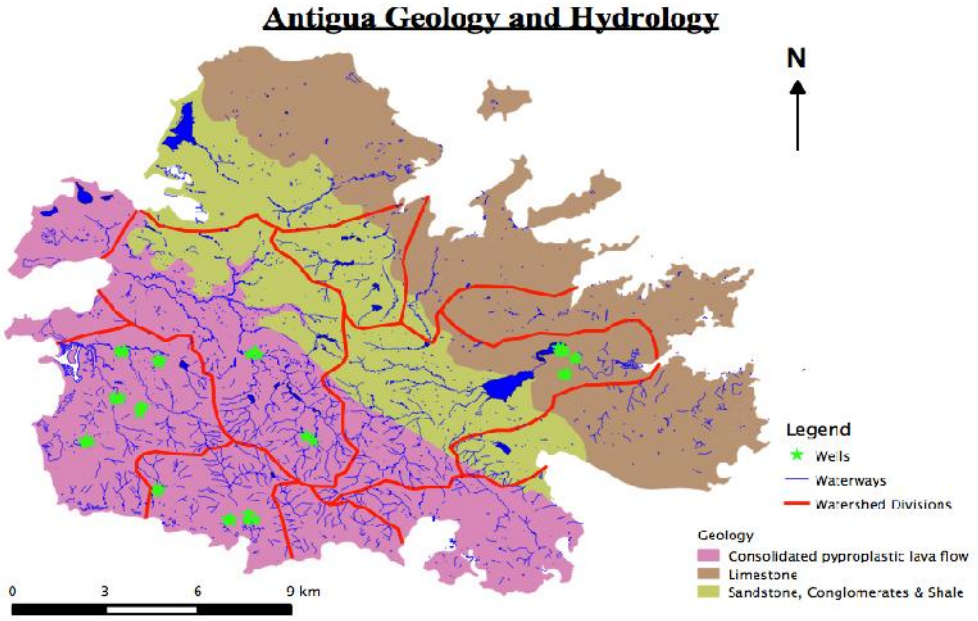
[60] Government of Antigua and Barbuda (GoAB), 2009. Antigua and Barbuda Second National Communication on Climate Change. St. John's, Antigua and Barbuda. GoAB).

[61] Environmental Advisors Inc., 2010. A Systems Plan for Protected Areas in Antigua and Barbuda. Funded by the OECS Protected Areas and Associated Livelihoods (OPAAL) Project.

4.8.2 WATER

Antigua has 86 small watersheds that, for the purpose of land use and water resource planning, can be categorized into 13 larger watershed management units (*Map 8).* Of these 13 watersheds, 6 of them (Body Ponds, Potworks, Fitches Creek, Parham, Bethesda and Christian Valley) have been identified as major catchments based on socio-economic and agro-ecological conditions. These 6 watersheds occupy 43% of the land area and contain 80% of the groundwater supplies and 90% of the surface water storage[62].

With respect to the geology of the country, Antigua is divided into three main geological regions running roughly parallel, from the north-west to south-east. The southwest region is categorized as a volcanic region comprising of consolidated pyroclastics, lava flows and hard igneous rocks in the uplands and sedimentary material in the associated valley. The central plain is also considered as volcanic origin, however in this case it consists of a mixture of agglomerates, tuffs and conglomerates, together with some cherts and limestone. The northeastern part of the country on the other hand is composed of a mixture of hard limestone and softer marl deposits of the Antigua formation. The slopes in the southwest region range from 100-20^0, in the central plain regions are generally are <10^0, while the northeast has mainly flat lands.



Map 8: Antigua's Geology and Hydrology

The two largest watershed units Body Ponds (44.74km^2) and Potworks (38.1km^2) drain the northern slopes of the south west volcanic region and the main parts of the Central Plain to the east and west respectively[63].

[62]Cooper, B., & V. Bowen, 2001. Integrating Management of Watersheds and Coastal Areas in Small Island Developing States of the Caribbean: National Report for Antigua and Barbuda. St. John, Antigua and Barbuda: Environment Division, Ministry of Tourism and Environment, Government of Antigua and Barbuda.

[63]ED, 2005. Draft National Action Plan for Antigua and Barbuda for the United Nations Convention to Combat Desertification.

In Antigua, Hill (1966) [64] produced a detailed description identifying 33 soil series that can be conveniently grouped into 5 broad categories according to depth and texture[65]. In the southwest volcanic region deep alluvial/colluvial soils can be found in the valley systems while shallow soils are present in the mountainous part. The central plain is dominated by deep kaolinitic clay soils. Shallow calcareous clay soils are distributed in the north of the limestone area while in the eastern part there is a complex of shallow and deep calcareous soils.

The combined effect of rainfall, geology and soils accounts for the concentration of resources. The majority of the wells and ponds in Antigua are found within the six major watersheds that were described above. Due to the nature of the groundwater supply in water being described as a lens of fresh water floating above salt water only to be replenished by rainfall, the country has had to rely heavily on desalination to provide the country with a constant supply of potable water.

Currently, there are three (3) desalination plants being operated in Antigua, two government-owned and one privately owned. The largest desalination plant is privately owned by SembCorp/Eneserve and provides approximately 3.1MIG/Dp (60-75% of Antigua's drinking water). The other two government operated reverse osmosis desalination plants located at APUA's Camp Blizzard site, and Ffryes Beach each produce 600,000 Imperial Gallons per day. The cost of producing water by desalination (US$4.70 per m^3) is significantly more expensive than that for groundwater (US$2.50 per m^3) and surface water (US$3.00 per m^3)[66]. Between 70% and 100% of Antigua's daily water supply during the wet years and the very dry periods respectively is obtained from desalination water, with the remainder supplied by ground and surface water[67].

Less information is available on Barbuda with respect to mapped watersheds units and drainage lines. However, Barbuda does have 10 watersheds[68] and categorised as an arid island with the absence of permanent streams and a few seasonal lakes and inland depressions. Similarly to Antigua, it is also divided into three geological regions. These include the Highlands limestone area, the Codrington limestone area and the Palmetto Point Series composed of beach sands and ridges with shelly horizons. In Barbuda, three main soil series correspond to the three geological regions: (i) reddish kaolinitic clay loam in the highland limestone area, (ii) brown clay loam found at lower elevations over hard limestone and (iii) dark coloured montmorillonitic clay found on more recent terraces of hard limestone. There are also extensive areas of very young soils developing on stabilized beach sands and dunes where water holding capacity is very low and drainage is excessive.

Barbuda also has two ponds that are located in the southern section of the island along the coastline. Drainage from all other watersheds

[64]Hill, I., 1966. Soil and Land Use Surveys No. 19A & 19B: Antigua and Barbuda, Regional Research Centre, UWI, St. Augustine, Trinidad.

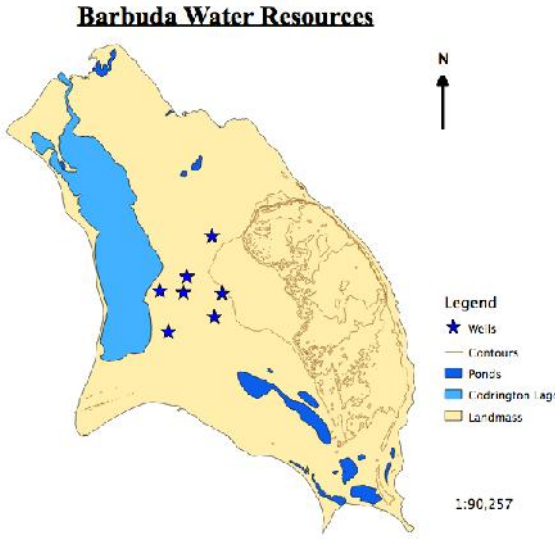
[65]CEP., 1991. Country Environmental Profile: Antigua and Barbuda. Caribbean Conservation Association; 212 pp.

[66] Fernandes, 2011 in Environment Solutions Ltd. (ESL), 2014. Vulnerability and Capacity Assessment in the South West Coast and Watershed Area of Antigua. EU-GCCA Caribbean Support Project.

[67]Global Water Partnership Caribbean. (2013). Antigua and Barbuda: National Stakeholder Consultation on Water Supporting the Post-2015 Developing Agenda: Priorities on Water Resources and Issues on WRM Monitoring and Reporting. Port of Spain, Trinidad and Tobago: Global Water Partnership Caribbean.

[68]Cooper, B., & V. Bowen, 2001. Integrating Management of Watersheds and Coastal Areas in Small Island Developing States of the Caribbean: National Report for Antigua and Barbuda. St. John, Antigua and Barbuda: Environment Division, Ministry of Tourism and Environment, Government of Antigua and Barbuda.

originates in the highlands[69]. In Barbuda, the nature of the soil and topography makes surface run off minimal[70]. Therefore, its main water supply is based on ground water, which was increasingly threatened by saline intrusions[71]. Available data on Barbuda's water resources identifies 7 wells located in the lowlands in the western end of the island. It has been suggested that the fresh groundwater reserves are extensive in Barbuda but poorly managed[72] ***Map 9.*** There are no records on the number of private household wells and pumping is unregulated.



Map 9: Barbuda Water Resources

As stated on numerous occasions previously, the health of the watersheds is directly related to the quality and quantity of the water being supply. Unfortunately, the watersheds in Antigua and Barbuda have been subjected to various stresses stemming primarily from increased agriculture and settlements in critical areas. This creates further degradation of the watersheds, which in turn affects the water supply and recharge rates of the aquifers. The indiscriminate activities that occur within the upper watershed areas are the primary causes of the increased siltation that is seen in the reservoirs today. Furthermore, the effects of these stresses on the water sector are exacerbated by other factors to include challenges faced by the water utility such as insufficient storage capacity, deterioration/damages to dams and limited number and conditions of distribution pipes and treatment plants. Another factor that needs to be considered would be the inefficient use of water by consumers.

The changes that have been seen in the climate during the past few decades also impact the viability of the water sector. Effects include a reduction in water availability due to decreased rainfall, saline intrusions in the fresh water aquifers in coastal areas, increased evaporation from surface water storage and increased vulnerability due to increasing drought conditions.

Providing a safe and adequate supply of water for agriculture has increasingly been a significant challenge for Antigua and Barbuda. With an increase in population growth, consumption patterns and food

[69]Hodgkinson-Chin, E. 2001. Drought Hazard Assessment and Mapping for Antigua and Barbuda: Post-Georges Disaster Mitigation Project in Antigua & Barbuda and St. Kitts & Nevis. Organization of American States, Unit for Sustainable Development and Environment for USAID-Jamaica/Caribbean Regional Program.

[70]Cooper, B., & V. Bowen, 2001. Integrating Management of Watersheds and Coastal Areas in Small Island Developing States of the Caribbean: National Report for Antigua and Barbuda. St. John, Antigua and Barbuda: Environment Division, Ministry of Tourism and Environment, Government of Antigua and Barbuda.

[71]Gomes, J. (2008). Antigua and Barbuda Red Cross Background Document: Impacts of Climate Change and Disaster Risk Reduction in Antigua and Barbuda. Antigua and Barbuda: Antigua and Barbuda Red Cross.

[72]Hodgkinson-Chin, E. 2001. Drought Hazard Assessment and Mapping for Antigua and Barbuda: Post-Georges Disaster Mitigation Project in Antigua & Barbuda and St. Kitts & Nevis. Organization of American States, Unit for Sustainable Development and Environment for USAID-Jamaica/Caribbean Regional Program.

demands, it is clearly predicted that the future water demands of the country will also increase. The combined inputs of ground, surface and desalinated water will need to meet this supply.

In terms of reporting on GDP contributions, the Agriculture sector is divided into two sub-sectors; one for crops, livestock and forestry while the other reports on fisheries. From 1970 to 2008 there has been a decrease in its share of contributions from 14 to 3%[73] with a further decline to 2% being recorded in 2013. Nonetheless, there has been an increase seen in the agricultural output by an average of 6.4% per annum over the 5-year period 2009 – 2013. Evidently, at one time agriculture was one of the major contributors to the GDP and this was primarily due to an active large-scale sugar production inclusive of its by-products, molasses and rum. However, more recently the agricultural production has become a small contributor to the country's GDP in any one year. In 2011, it accounted for approximately 2.8% of the workforce *(Table 23).*

The challenges that the agriculture sector is faced with are considered both institutional and natural. The main challenges being the dissemination of knowledge and monitoring of sustainable farm practices to avoid indiscriminate land clearing. Additionally, wells become unusable during the dry season because of saltwater intrusion, an impact which will be exacerbated by climate change. It is noteworthy to mention that in the drier seasons fires in watershed areas can be very devastating. It is not unlikely to see the occurrence of three per week on average during this time. In addition to this, major water resources such as Potworks Dam are not maintained and lose their retention capacity. Unfortunately, funding is often not readily available to execute projects within these areas and when they do appear there is no succession plan to ensure its sustainable interventions.

Data analysis suggest that the root of these challenges lies in the health of the watersheds. This is seen as critical to the sustainable development of the sector particularly as it relates to food security. Overgrazing of pastures and upper watershed areas by livestock has led to the over-exposure of topsoil, which results in erosion and downstream sedimentation. Such occurrences have caused dams, streams, and ponds to lose effective storage capacity and therefore increased the likelihood of downstream flooding and pollution.

Furthermore, the water availability has been a contributing factor. Its limited supply has been the cause of stunted plant growth and fruit sizes. Antigua's average evaporation has been significantly higher than the annual average rainfall and as such, has required supplemental irrigation to sustain yields. Even during the wet season, the frequent dry periods have been sufficiently serous to impact crop production. It has been predicted that irrigation will become more critical with the anticipated increase in temperature extremes due to climate change[74]. In addition to all this, the biodiversity has also been impacted which has further contributed to a decline in ecosystem health[75].

[73]Environmental Solutions Antigua Limited (ESAL), 2008. Integrated Watershed Management. St. John's, Antigua: Environment Division, Government of Antigua and Barbuda.
[74]Cooper, B., & V. Bowen, 2001. Integrating Management of Watersheds and Coastal Areas in Small Island Developing States of the Caribbean: National Report for Antigua and Barbuda. St. John, Antigua and Barbuda: Environment Division, Ministry of Tourism and Environment, Government of Antigua and Barbuda.
[75]Mitchell, A. H. (2009). *Wallings Forest Conservation Area Management Plan Volume II Annex.* St, John, Antigua and Barbuda: Government of Antigua and Barbuda; Organisation of Eastern Caribbean States (OECS) Secretariat.

4.8.3 AGRICULTURE

In terms of reporting on GDP contributions, the Agriculture sector is divided into two sub-sectors; one for crops, livestock and forestry while the other reports on fisheries. From 1970 to 2008 there has been a decrease in its share of contributions from 14 to 3%[76] with a further decline to 2% being recorded in 2013. Nonetheless, there has been an increase seen in the agricultural output by an average of 6.4% per annum over the 5-year period 2009 – 2013. Evidently, at one-time agriculture was one of the major contributors to the GDP and this was primarily due to an active large-scale sugar production inclusive of its by-products, molasses and rum.

However, more recently the agricultural production has become a small contributor to the country's GDP in any one year. In 2011, it accounted for approximately 2.8% of the workforce *(Table 24).*

Table 24: Agriculture and Fishing- Relationship to the Water Sector

2011	%GDP	% of Total Water Demand	%of Total Water Customers	Growth Rate over 2010	Contribution to total Employment
Agriculture & Fishing	2.10%	0.803%	0.656%	-12.168%	2.8%

The Fisheries sub-sector makes the greatest contribution of agriculture in GDP. In 2011 it accounted for 51.5% or EC$26.3 million dollars. A release from the Fisheries Division indicates that there is 1500 registered fisher-folk. Fishing is undertaken within the 34,000 sq.km of the Exclusive Economic Zone, one of the largest fisheries within the Organization of the Eastern Caribbean States (OECS).

This sub-sector is vulnerable to hurricanes, high winds and extreme wave action but also indiscriminate actions such as pollution, wetland destruction and unplanned development. Despite the fact that it was thriving economically, there has been threats to the biodiversity of the resource and entire marine environment and ecosystem. These take the form of resource depletion (overfishing, use of destructive fishing methods and invasive alien species), increased coastal development, pollution (land and marine-based sources), changes to habitats (modification and destruction) and financially motivated (changes to global economy and market conditions).

4.8.4 HEALTH

The health sector in the Caribbean is faced with challenges that can be accredited to the region's geography, culture, size and development. Specifically, in the Lesser Antilles, these challenges include the rapid development of chronic non-communicable diseases that plague the world but also, the historical presence and periodic recurrence of the communicable diseases such as malaria. These are made more difficult to avoid because of the increasing movement of persons due to tourism-related activities and a legacy of low income and relatively vulnerable agricultural based economies.

As a result of climate change, changes in precipitation have affected the availability of water for consumption and other domestic

[76] **Environmental Solutions Antigua Limited (ESAL), 2008. *Integrated Watershed Management.* St. John's, Antigua: Environment Division, Government of Antigua and Barbuda.**

and agricultural uses. This in turn has had an impact on the health and nutrition levels of the population. On one hand, drought conditions have contributed to water shortages, which have resulted in increased risk of the transmission of diseases such as cholera, typhoid and bacterial dysentery. In addition to intensifying the prevalence of wind-borne contaminants, drought conditions can also exacerbate the appearance of communicable diseases. On the other hand, increased precipitation that result in flooding contributes to increased pest populations and contamination of surface and groundwater. This contributes to biological contamination of water sources and an expansion of the habitat of vectors such as the ***Aedes aegypti*** mosquito.

The increase in temperature of approximately 1.5 – 2.0°C by 2030 and 2050 due to climate change could also have an impact on the health sector. Heat stress generated by altered average temperatures could serve as a major source of morbidity or mortality for high-risk groups such as the elderly, persons with cardiac and respiratory problems, among others. Higher temperatures create more conducive environment for the growth and development of various bacteriological and epidemiological agents[77]. Specific vectors particularly rodents and mosquitoes are capable of adapting and even thriving in warmer conditions, therefore increasing the possibility of the spread of various communicable and infectious diseases. For example, it is projected that transmission of dengue fever in the Caribbean will increase approximately threefold. Increased temperatures reduced the time for the parasite to incubate in mosquitoes, resulting in more rapid transmission of the disease[78].

In Antigua and Barbuda, the Central Board of Health (CBH) has the mandate to regulate all matters concerning public health. The concerns that the CBH have relating to the water sector can be linked to infrastructure and public health practices. One of the more prevalent challenges stem from the poor conditions of most drains in the country. They are not paved and are not properly sized or cleaned regularly. During periods of heavy rains this leads to serious drainage problems and flooding occasions. There is a notable increase of diarrhea cases during the rainy seasons. Likewise, during the dry season there is an occasional increase in scabies ('water rash' disease). Although these diseases are not water borne they are considered water-related.

Most homes in the flood-prone areas have 'soak-aways' or septic tanks, which become inundated with floodwaters during the rainy season. It is not infrequent for water cisterns to get contaminated and test extraordinarily high for Escherichia coli during these periods. Overall, the actions taken by the CBH can be considered epidemiologically focused in relation to monitoring and prevention. That agency is presently working on drafting a strategic action plan for health and climate change with the assistance of the Pan-American Health Organization (PAHO).

4.9 SUMMARY OF VULNERABILITY ASSESSMENTS

Table 25 summarizes projected impacts and adaptation measures. The importance of each impact is also rated and is reported in terms of vulnerability. Using the definition of

[77] Government of Antigua and Barbuda (GoAB), 2009. Antigua and Barbuda Second National Communication on Climate Change. St. John's, Antigua and Barbuda. GoAB).

[78] ECLAC, 2011. Caribbean Development Report: The economics of Climate Change in the Caribbean. Port of Spain, Trinidad and Tobago. ECLAC.

the IPCC Fifth Assessment Report[79], vulnerability is the degree to which a system is susceptible to or unable to cope with, adverse effects of climate change including climate variability and extremes. Vulnerability is a function of climate variation, the degree to which the system responds to this variation, and its adaptive capacity. This is often relatively difficult to assess as it depends on a range of factors but it is of key importance for policy implications and society's perception of climate change.

It is important to note that three levels of vulnerability can be defined:
– High: means that this impact may have severe consequences and that it is not certain whether affordable adaptation measures can be found;
– Moderate: means that severe impacts are unlikely but significant impacts are likely, even after implementation of simple adaptation measures;
– Limited: means that no severe impact is projected, the issue will probably be unimportant, at least when simple, low-cost adaptation measures are implemented.

When rating vulnerability, we take possible adaptation measures into account, as explained below, because the existence (or not) of such measures is an essential part of the problem. According to IPCC (2014)[80], adaptation is "the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects".

It involves anticipating the adverse effects of climate change and taking appropriate action to prevent or minimize the damage they can cause, or taking advantage of opportunities that may arise. Well-planned, early adaptation action has been shown to save money and lives later. Adaptation measures could include: using scarce water resources more efficiently; adapting building codes to future climate conditions and extreme weather events; building flood defenses and raising the levels of dykes; developing drought-tolerant crops; choosing tree species and forestry practices less vulnerable to storms and fires; and setting aside land corridors to help species migrate.
The timelines for implementing the adaptation measures are noted below according to the following scale:

- Immediate: signifies that the action needs to be implemented at the present moment;
- Short-term: signifies that the action needs to be implemented in the next 1-3 yrs;
- Medium-term: signifies that the action needs to be implemented in the next 3-5 yrs;
- Long-term: signifies that the action can be implemented in a time period of more than 5 yrs.

[79] **IPCC, 2014. Working Group II Fifth Assessment Report Glossary. England: Cambridge Univeristy Press.**

[80] **IPCC, 2014. Working Group II Fifth Assessment Report Glossary. England: Cambridge Univeristy Press.**

Table 25: Summary of Climate Change Impacts, Adaptation, and Vulnerability

Sectors	Stressors	Vulnerability	Adaptation
1. Water	I. Low annual rainfall with high inter-annual variability	Moderate: Projected Stresses from CC -Increasingly drier conditions. -Heavy rainfall events decrease. -Increase in annual temperatures Projected impact of changes without action: More frequent drought events; increased evaporation resulting in greater pathogen density in water leading to a lack of potable water	Needs: **Immediate** - To develop the appropriate regulations and systems as contained within the Environmental Management and Protection Act 2015 (EPMA) for enforcement. - To establish the Watershed and Wetland Management Committee - To develop and implement a water quality monitoring system, targeting educational institutions. -To fund community rainwater harvesting projects - To upgrade existing water supply infrastructure to minimize leakages **Short-term** -To increase desalination capacity - To develop water-budgets for each major watershed - To develop an improved methodology for acquiring meteorological and hydrological data and establish a knowledge and data sharing platform - To develop and enforce a Meteorological Act to enhance the functions and budgetary allocations of the Meteorology Department, particularly in climate monitoring and forecasting - To prepare and implement Local Area Plans including sub-watershed hydrologic modeling, to
	II. Annual exposure to hurricanes and tropical storms (which reduces the national intake ability of desalination plants through electrical outages)	Moderate: Projected Stresses from CC -Hurricane intensity expected to increase (not necessarily frequency) Projected impact of changes without action: Increased flooding in certain areas and high risk of exposure to debris and sediment; damage to water sector infrastructure	
	III. Over extraction of wells resulting in saline intrusion	High: Projected Stresses from CC Increase in sea level Projected impact of changes without action: Water quality problems may arise	

Sectors	Stressors	Vulnerability	Adaptation
	IV. Balancing increased demand for water and reduced rainfall as well as increased costs for desalinations	Moderate: Projected Stresses from CC Reduction in annual average rainfall- more droughts Projected impact of changes without action: Reduction of water supply from rain fed sources (groundwater and surface water storage areas)	prevent development in areas that compromise water resources. To update the Building Code to enhance climate resilience. **Short-medium term** - Additional and upgraded water storage catchment systems - To develop Watershed Master, and local Plans - To develop and implement a Water Policy that takes into account climate change considerations - To conduct a feasibility study to create a Water Resource Regulatory Agency -To develop climate change adaptation and mitigation policy -To equip the water sector with renewable energy including off-grid back up energy storage. **Long-term** - To utilize renewable energy for desalination plants - To carry out a study to create a centralized sewage system for St. John's City -To implement wastewater reuse and recycling
	V. Desertification and watershed deterioration	Moderate: Projected Stresses from CC Increasing drought conditions Projected impact of changes without action: Increase in risk of forest fires resulting in a reduction of protective tree cover and reduced water infiltration.	
	VI. Inadequate water capture and storage infrastructure	Moderate: Projected Stresses from CC Reduction in annual average rainfall- results in reduction in surface flows and reduced ground water recharge and ground water resources Projected impact of changes without action: Inadequate capture of rainfall with growing population resulting in reduced supply and/or heavier dependence on desalination.	

Sectors	Stressors	Vulnerability	Adaptation
2. Agriculture	I. The sector relies significantly on rainwater	Moderate: Projected Stresses from CC Reduction in annual average rainfall- more droughts Projected impact of changes without action: More frequent drought events resulting reduced crop yield.	Needs: **Immediate** -Pilot climate-smart agriculture technology **Short-term** - To continue the development of training programs in improved farming practices to include water conservation measures, as well as to provide incentives to farmers who incorporate these practices on their farms - To develop expertise in the Ministry of Agriculture in matters related to international and regional trading in agricultural commodities, particularly those that are resilient to climate change - To continue to encourage the use of dryland farming techniques around the island, particularly in the drier sections of Antigua - To increase technological options and solutions for production and post- harvest handling in Agriculture that offer resilience to climate change and make available the resources necessary for these options. **Short-medium term** - To diversify away from low yield/low return agricultural production. - To establish a framework and policy for water access and drainage system - Redesigned and improved drainage system
	II. Poor dryland farming techniques	Moderate: Projected Stresses from CC Increase in annual temperature and drier conditions Projected impact of changes without action: Increased evaporation combined with drier conditions and poor farming practices resulting in reduced yield.	
	III. Damage from heavy rainfall/storm events	Moderate: Projected Stresses from CC Hurricane intensity expected to increase (not necessarily frequency) Projected impact of changes without action: Loss of crops, reduction in crop yield	

Sectors	Stressors	Vulnerability	Adaptation
3. Health	I. Increases in pathogens (e.g., E. coli) present in cisterns & pollution of groundwater. II. Increases in vector borne diseases	Moderate: Projected Stresses from CC Reduction in annual average rainfall- more droughts Increases in atmospheric temperature Projected impact of changes without action: Water Quality Issues	Needs: **Immediate** - To develop plan for water quality monitoring program **Short-term** - To develop climate change adaptation and mitigation policy - To Revise the Public Health Act -To develop vector control programmes - To build capacity for the National Office of Disaster Services in several aspects of disaster management **Long-term** - To carry out a study to create a centralized sewage system, for St. John's City
	III. Heavy rainfall events result in flooding and the overflow of septic systems	Moderate: Projected Stresses from CC Hurricane intensity expected to increase (not necessarily frequency) Projected impact of changes without action: Water quality and health issues	

(Source: Adapted from the "National Adaptation Strategy and Action Plan to address Climate Change in the Water Sector in Antigua and Barbuda[81]" and the "Vulnerability and Capacity Assessment in the South West Coast and Watershed Area of Antigua[82]": Environmental Solutions Ltd., 2014)

[81] Environmental Solutions Ltd., 2014. National Adaptation Strategy and Action Plan to address Climate Change in the Water Sector in Antigua and Barbuda. Prepared for the Caribbean Community Climate Change Centre (CCCCC) and the Government of Antigua and Barbuda under the European Union Global Climate Change Alliance (EU-GCCA) Caribbean Support Project.

[82] Environmental Solutions Ltd., 2014. Vulnerability and Capacity Assessment in the South West Coast and Watershed Area of Antigua. Prepared for the Caribbean Community Climate Change Centre (CCCCC) and the Government of Antigua and Barbuda under the European Union Global Climate Change Alliance (EU-GCCA) Caribbean Support Project.

4.10 COOPERATION ON ADAPTATION

The islands of Antigua and Barbuda are exposed to natural phenomena such as frequent droughts and occasional tropical storms. These have negatively affected the habitats and populations of a wide range of species. It has already been explained above how these events have affected the main islands and also the near shore marine and coastal ecosystems. While there is little that can be done nationally to reduce the occurrences of these events, the country has attempted to address climate change through strategic and systematic planning. Although its contribution to greenhouse gas emissions is not large compared to global emissions, the country is not immune to the consequences that are caused.

The Government of Antigua and Barbuda has implemented a number of environmental projects in the past that are some way or the other linked to identifying vulnerabilities and addressing adaptation to climate change. One of the most recently concluded project is the Global Environment Facility funded – Sustainable Island Resource Management Mechanism (GEF-SIRMM) Project. In addition to implementing small-scale adaptation interventions throughout the country, the SIRMM project also collected baseline information required for the accurate assessment and general idea of costs of elements in the National Environment Management Strategy (NEMS). That project recommended the establishment of the SIRF Fund to provide a consistent and dedicated source of funds for all areas of Multilateral Environmental Agreement (MEA) implementation[83].

Presently the country has a Technical Advisory Committee (TAC) which is a national multi-stakeholder peer review group made up of technical officers from 15 government agencies, 3 community representatives and nongovernment organizations, and 1 private sector coalition representative. The TAC plays a crucial role in quality control, inter-agency coordination, and ensuring project interventions represent multiple interests. Presentations are made to the TAC on all national and regional projects, and input is integrated into project design and implementation.

To facilitate the implementation of MEAs, the country is actively pursuing the preparation of several projects that will be submitted to international donor agencies. One such upcoming project is the GEF Special Climate Change Fund – Building Climate Resilience through Innovative Financing Mechanisms for Climate Change (SCCF) project. The SCCF project is aimed at increasing the climate resilience of vulnerable communities and sectors in Antigua and Barbuda by improving access to innovative financing mechanisms for climate change adaptation, and implementing cost-effective adaptation interventions focused on ecosystems[84]. Another such project is the GEF Sustainable Pathways, Protected Areas and Renewable Energy (SPPARE) Project. While the SPPARE has more a biodiversity and sustainable forestry management focus, it also has a renewable energy component that will address the provision of alternative energy in order to ensure the nation's energy diversification[85].

[83] ED, 2008. Project Document: Sustainable Island Resource Management Mechanism (SIRMM) Project.

[84] ED, 2013. Project Identification Form: Building climate resilience through innovative financing mechanisms for climate change adaptation (SCCF) Project. Submitted to the Global Environment Facility.

[85] ED, 2014. Project Document – Sustainable Pathways, Protected Areas and Renewable Energy (SPPARE) project. Submitted to the Global Environment Facility.

As mentioned earlier in this chapter, a national consultation was held in 2013 where the Department of Environment (DoE) in collaboration with APUA brought key stakeholders together to discuss and assess the actual and projected vulnerabilities of Antigua and Barbuda as it relates to climate change[86]. At that consultation the consensus was to rank the water sector with the highest priority with respect to its vulnerability to climate change and direct impacts. Subsequent to that meeting, the country has participated in regional projects that have provided funding to conduct vulnerability and adaptation analyses. These are elaborated on in the following section.

4.11 REGIONAL COOPERATION

Antigua and Barbuda is participating in the REGATTA project being implemented by the UNEP-ROLAC. REGATTA supports countries in this region to address climate change through the exchange of knowledge, development of pilot projects and provision of advisory services in adaptation and mitigation. This project is currently funding a VIA analysis in Antigua and Barbuda, which is being conducted by the Caribbean Sectoral Approach to Vulnerability and Resilience (CARIBSAVE) Partnership[87]. Some findings of this study have informed this chapter.

Another regional project that the country is participating in is the European Union funded – Global Climate Change Alliance (EU-GCCA) Caribbean Support Project implemented by the Caribbean Community Climate Change Centre (CCCCC). The overall objective of this project is to support the sustainable development of the Caribbean region and preserve the progress of the countries towards the Millennium Development Goals (MDGs) [88]. Two outputs of this project were, (i) Vulnerability and Capacity Assessment in the South West Coast and Watershed Area of Antigua (VCA)[89] and a National Adaptation Strategy and Action Plan to address Climate Change in the Water Sector in Antigua and Barbuda (NASAP)[90]. Both these documents were consulted during the preparation of this chapter.

The NASAP identifies several adaptation strategies for the country based on findings from that study and past studies assessing the existing water sector of Antigua and Barbuda. It requires that, within the Ministry of Health and Environment, the Department of Environment (DoE) be responsible for ensuring that the action items set out are carried out by the respective lead and partner agencies. A recommendation coming forward is to increase awareness raising and capacity building programmes at the national level. Furthermore, integration into existing and proposed cooperation programmes of Antigua and Barbuda's bi-lateral and multi-lateral partners are encouraged. One requirement is that the implementation of the NASAP be monitored and evaluated to ensure that the activities are successfully on track, and to ensure transparency and accountability. This will entail the monitoring

[86] ED, 2013. Report on the Climate Change & Policy and Model Water Act Project Consultation.

[87] CARIBSAVE Partnership, 2014. First Draft: Vulnerability Impact And Adaptation Analysis In The Caribbean (VIAAC) National Vulnerability Analysis For Antigua And Barbuda. Prepared with funding from the UNEP-ROLAC.

[88] CCCCC, 2010. Project Document – European Union funded – Global Climate Change Alliance (EU-GCCA) Caribbean Support Project.

[89] Environmental Solutions Ltd., 2014a. Vulnerability and Capacity Assessment in the South West Coast and Watershed Area of Antigua. Prepared for the Caribbean Community Climate Change Centre (CCCCC) and the Government of Antigua and Barbuda under the European Union Global Climate Change Alliance (EU-GCCA) Caribbean Support Project.

[90] Environmental Solutions Ltd., 2014b. National Adaptation Strategy and Action Plan to address Climate Change in the Water Sector in Antigua and Barbuda. Prepared for the Caribbean Community Climate Change Centre (CCCCC) and the Government of Antigua and Barbuda under the European Union Global Climate Change Alliance (EU-GCCA) Caribbean Support Project.

of the actual implementation of the NASAP, and also evaluating and assessing the cause of any changes, both external and internal to the NASAP, to determine what corrective actions, if any, are needed. More information on this is readily available in the actual document (Environmental Solutions Ltd., 2014a).

More recently, the country has signed on to the European Union funded - Climate Change Adaptation and Sustainable Land Management Project in the Eastern Caribbean under the GCCA launched by the European Commission in 2007. The OECS is implementing the GCCA project and the primary purpose is to improve the region's natural resource base resilience to the impacts of climate change through policy and capacity building, as well as demonstration of physical adaptation interventions. The country is presently collaborating with the OECS to implement a land management adaptation activity in the vulnerable Cashew Hill sub-watershed, in addition to policy and training for adaptation.

4.12 BUILDING AWARENESS

Through events and other sensitization activities (e.g. national workshops and consultations), the Antiguan Government will contribute to the public's awareness of the problem of climate change. The DoE has made appearances on national media (i.e. radio and television talk shows) and maintains a website and social media accounts where current information is uploaded to inform the public of initiatives that are being implemented. Moreover, the DoE continues to work in close collaboration with NGOs and CBOs to take advantage of their existing networks to raise awareness. This is primarily achieved through its Technical Advisory Committee (TAC) which initiates training workshops, project design and development and subsequent reviews. The committee is comprised of representatives across all ministries as well as representatives of NGOs, CBOs and the GEF SGP.

Another goal is to increase the participation of students and/or researchers in the debate on climate change. One possibility that is being considered is to support their participation in regional and international conferences and events.

5 OTHER INFORMATION

As a Party to the UNFCCC, Antigua and Barbuda is obligated to cooperate in climate change and related research, exchange of information, education, training, public awareness and report such activities to the Convention. In previous Communications to the UNFCCC, this has generally focused on highlighting Antigua and Barbuda is involved in a series of regional projects coordinated by the Caribbean Community Climate Change Centre (CCCCC) and the routine meteorology work conducted by the Department of Meteorological Services located at the V.C. Bird International Airport. In the SNC, some preliminary work on renewable energy research was reported.

The ability of Non-Annex I parties to conduct regular research and monitoring and build their internal capacity to carry out such research is not only vital to the implementation of the convention but also vital to the ability of said countries toward achieving and maintaining sustainable development goals. Antigua and Barbuda, like many SIDS, is recognized without question to be in the category of countries deemed most vulnerable to the negative impacts of climate change; however being labeled as 'most vulnerable' does not provide policy makers, international development partners and other stakeholders with the information and tools necessary to develop effective programmes and projects to address issues of mitigation or adaptation. It is therefore imperative that Antigua and Barbuda take a more practical approach to research, including the development of the capacity to conduct research. Also, capacity in the ability to measure people's GHG emissions, and increase public awareness to understand the varied manifestations and impacts of climate change will ensure that appropriate and significant measures for mitigation and adaptation goals are achieved.

5.1 RESEARCH AND SYSTEMATIC OBSERVATION

In recent years, the Department of Meteorological Services (DMS) has been able to expand the menu of services offered. Previously, the DMS had been limited to providing daily meteorological forecasts, archiving of meteorological data and supporting hydro-meteorological hazard impacts (droughts, storm surges and hurricanes) predictions. Through participation in projects such as the Caribbean Agro-meteorological Initiative (see below); and Enhancing Resilience to Reduce Vulnerability in the Caribbean (ERC) Project the DMS has been able to further enhance its abilities to conduct climate research and predictions and translate it into information usable by key sectors such as agriculture, water and disaster management, they assist in forecasting for potential flash flood conditions and wildfire risk and issuing warnings.

5.1.1 EIMAS

The GEF funded Sustainable Island Resource Management Mechanism (SIRMM) project assisted with the creation of a Geographical Information Systems (GIS) based platform to map not only all environmental resources but also socio-economic amenities. The Environmental Information Management and Advisory System (EIMAS) was legislated under the Environmental Protection and Management Act of 2015 and is currently used by five key government agencies, namely the DoE, Lands Division, Surveys Division, National Office of Disaster Services and the National Parks Authority. With regard to climate change, the EIMAS is a data management platform and provides information related to hydro-meteorological,

health, disaster and tourism data, which can then be used for sustainable development planning and land use management. It is envisioned that the EIMAS will eventually include energy consumption information within its database.

The EIMAS also ensures that environmental information is regularly uploaded to regional and international databases of environmental indicators such as those managed by CARICOM, UN-ECLAC, UNSD and UNEP. EIMAS will continue to develop as a vital tool by the DoE for planning sustainable development within Antigua and Barbuda.

5.1.2 RESEARCH IN RENEWABLE ENERGY

Antigua and Barbuda has made the commitment under the Copenhagen Accord and has accepted the SIDS DOCK Challenge (i.e. to achieve a 25% reduction of 1990 emissions by 2020). This target was complemented more recently by Antigua and Barbuda's communication of Intended Nationally Determined Contributions (INDC) to the UNFCCC. This included several renewable energy related targets, including: 50MW of on-and-off grid renewables, as well as critical services supported by off-grid renewable energy with battery storage[91].

One of the primary means through which such targets can be achieved is through the adoption of renewable energy, to this end it becomes essential that Antigua and Barbuda evaluate its potentials to successfully and efficiently adopt and transition into greater renewable energy usage. Through the combined efforts of the Energy Unit in the Office of the Prime Minister, the Antigua Public Utilities Authority and others, direct research has and is currently being done to determine the potentials for solar, wind and bio-digestion as viable sources of alternative energy. According to a GIZ report for Antigua and Barbuda, the country has been estimated to have potentials equivalent to 27MW for solar and 400MW for wind.

The APUA and the Energy Unit, along with the support of the Caribbean Renewable Energy Development Programme (CREDP) and the agency for German Technical Cooperation (GIZ) recently completed a "Pre-Feasibility Study for a grid-parallel Wind Park at Crabbs Peninsula, Antigua" The study concluded with a strong recommendation that an 18MW wind park be established at the test site, which would meet 15-20% of current electrical demand at an estimated generation cost of US $75-80 per MWh as compared to the US$230 per MWh (based on an oil price of 112 USD/barrel).

Pivotal to the effectiveness of any RE and EE initiatives is the development of standardized baselines to assess and monitor the impacts and benefits of implementing RE and EE initiatives. The DoE serves as the Designated National Authority of the Clean Development Mechanism (CDM). Through the CDM, efforts are ongoing to gather relevant data that will facilitate the development of such baselines most notably the national grid emission factor.

5.1.3 COASTAL MONITORING

The Fisheries Division has expanded their climate related research from sea level rise and beach profile analysis to include reef, sea grass and mangrove monitoring and evaluation. Coral reefs around the world are being stressed by a number of climate change-related factors, namely sea level rise,

[91] **Antigua and Barbuda's INDC: http://www4.unfccc.int/submissions/INDC/Published%20Documents/Antigua%20and%20Barbuda/1/INDC_Antigua_Barbuda.pdf**

rising sea temperatures, ocean acidification, pollution from land-based sources and other habitat-species imbalances. Considering that Antigua and Barbuda has extensive coral reef habitats, it needs to develop the capacity to determine the level of contribution of any and all causal factors to reef damage and then develop and apply the appropriate solutions to allow reefs the best opportunity to withstand and adapt to the stresses of climate change.

Healthy seagrass and mangrove habitats have also been recognized as being able to assist in climate resilience both in their roles as carbon sinks and through their potentials to support adaptation. The Fisheries Division, and by extension Antigua and Barbuda, recognizes the need for robust research, monitoring and where necessary development projects addressing reefs, seagrass beds, mangroves and beaches and their extensive rolls in ensuring the health and vibrancy of Antigua and Barbuda's marine environment inclusive of their abilities to promote climate change adaptation, resilience and mitigation.

5.1.4 DATA COLLECTION

Environmental management and decision making has suffered considerably due to poor data collection as evidenced throughout this report. Through the EPMA 2015, an EIMAS has been legislated for and will be maintained by the Department of Environment to address gaps in data collection and provide for more accurate and up to date information. The EIMAS will also provide for public, private, and NGO access.

Through the Sustainable Financing and management of the Eastern Caribbean Marine Ecosystem Project, the Department will purchase a small Unmanned Aerial Vehicle (UAV) or drone. The drone will be programmed to a select path in order to gather environmental information at a fraction of the cost, and requires less labour. It will also enhance data collection on land use cover and land use change related to GHG emissions in addition to other natural resources, biodiversity monitoring, and climate impact assessments.

Further, as a means of efficient management, standardization and verification, the Department has taken steps to support the development and implementation of a National Spatial Data Infrastructure (NSDI).

5.1.5 MODEL DOWNSCALING

Under the leadership of the CCCCC and in collaboration with partners INSMET and the Climate Studies Group (CSG) of the University of the West Indies, advances have been made in the downscaling of global climate models to provide outputs that have been utilized in the conduct of sector-based vulnerability and impact assessments. The assessments have been used to develop sector adaptation strategies which have since been utilized by national governments to inform their development plans and to mobilize resources for the execution of specific recommendations. Antigua and Barbuda will be participating in regional downscaling through the Global Climate Change Alliance (GCCA) project. It is hoped that the training made available and the results of the downscaling will allow each sector and level to better evaluate and understand how climate change impacts upon them separately and collectively.

5.2 TECHNOLOGY TRANSFER

5.2.1 MET AND CLIMATOLOGY

The DMS has benefitted from the provision of a number of automatic meteorological stations through various projects. The provision of these stations have allowed the DMS to significantly enhance and improve its ability to provide quality and trusted meteorological data regarding the various microclimates around Antigua and Barbuda. These stations have also allowed the DMS to contribute to agriculture, water sector and disaster planning. In addition to new weather stations, the DMS has also begun to utilize the DEWETRA platform, which is a real-time integrated system for hydro-meteorological and wildfire risk forecasting, monitoring and prevention. The platform allows the DMS to effectively combine different types of data so as to develop up-to-date and reliable risk scenarios.

5.2.2 RENEWABLE ENERGY AND ENERGY EFFICIENCY

The Government of Antigua and Barbuda has agreed to undertake nationally appropriate, measureable and verifiable actions aimed at reducing greenhouse gas
emissions by 25% below 1990 levels by 2020. This is further supported by the country's recently submitted INDCs. To date, there is a National Energy Desk and a a National Energy Policy and Strategic Action Plan. The NEP and Strategic Action Plan attempt to reduce energy costs by:

- Diversifying and enabling efficient use of energy sources
- Ensure reliable supply of electricity
- Environmental Protection
- Stimulate new economic/business opportunities.

In conjunction there is an APUA Interconnection Policy that allows up to 15% grid penetration of renewable energy sources.

As Antigua and Barbuda moves closer to a low carbon and green economy there is recognition that key to achieving this goal will be the adoption of renewable energy (RE) and energy efficient (EE) technologies. A number of demonstration projects have already been initiated to show the ease of adoption, success and benefits of RE and EE as well as to raise awareness and public support for such a transition.

The National Energy Policy also recognizes the potential benefits of adopting more energy efficient transport technologies however to do such would require significant investment in national infrastructure so as to give residents the option of accessing such technologies. It should also be noted that a few local businesses have invested in the use of biofuels as alternatives to diesel. However, the capital investments needed to facilitate the transition to RE and EE is cost intensive (or prohibitive) and remains a challenge for national budgetary allocations. This increases the reliance on international funding to mobilize large scale transitions.

To this end, however, national efforts and regional collaboration are underway to enabling are low carbon economy in the country. As previously mentioned, through the regional CDM body, RCC, a national emission factor is being developed and will be included in future communications. The OECS/GIZ Eastern Caribbean Energy Labelling Project (ECELP) with co funding from the European Union, has begun implementation of an energy efficient standards and public education programme to reduce energy costs in the region. Through the National Bureau of Standards, the project identified a variety of household appliances and worked with retailers and importers to establish energy efficiency standards and labels. The

project also deployed a variety of public awareness paraphernalia in active centres as one of many means to public education.

5.3 EDUCATION, TRAINING AND PUBLIC AWARENESS

The Caribbean Institute for Meteorology and Hydrology (CIMH) in partnership with the Caribbean Agricultural Research and Development Institute (CARDI) World Meteorological Organization (WMO) received a grant from the European Union through the African Caribbean and Pacific Group of States (ACP) Science and Technology (S&T) Programme for the Caribbean Agrometeorological Initiative (CAMI). This grant allowed the National Meteorological and Hydrological Services (NMHSs) of ten Caribbean member States to utilize improved dissemination and application of weather and climate information to increase and sustain agricultural productivity at the farm level in the Caribbean region. The CAMI is a three-year project launched in 2010. In Antigua and Barbuda, a notable output of this project has been the production of a Monthly Agrometeorological Bulletin.
The CAMI is described as having the following outputs:

- Improved ability of policy makers and extension agencies in exploiting the rainy season potential fully through strategic decisions and better preparedness strategies in case of a high probability of occurrence of extreme events.
- Better informed farming community regarding the climate situation before and during the crop growing season More efficient irrigation scheduling and quantifying, especially for domestic food crops and important export crops.
- Conservation-effective soil and crop management practices to reduce land degradation and improve long-term crop productivity.
- Greater farm incomes, improved crop quality and enhanced environmental benefits for small farmers through more effective pest and disease management.
- Increased interactions between the meteorological services, agricultural research and extension agencies and the farming community resulting in the provision of better services to farmers.
- Availability of regular feedback to the meteorological services on the nature of services and products needed by the farmers resulting in the preparation of user-friendly products from the meteorological services.
- Enhanced capacity of Meteorological and Agricultural Services, CARDI and CIMH to perform the tasks relevant to the goals of this action.

Information developed through the CAMI and other regular functions of the DMS are made widely available through the internet, social networking and more conventional multi-media formats. Staff at the DMS have also been afforded various levels of training and certification through the support of various projects.

Under the National Energy Policy the Government of Antigua and Barbuda has developed the following points to be achieved to ensure that renewable energy and energy efficient technologies are adopted:

- Institutionalize educational programs to educate students in different energy topics, e.g. better ways to manage energy-usage,
- bringing about attitudinal change towards responsible energy use, energy responsibility, among many others.
- Establishing awareness programs on energy in the school curriculum.
- Promote the use of renewables in schools and universities. This could be done by placing solar energy generating equipment on roofs at schools and universities.
- Establish a National Energy Education Program with the aim of promoting energy awareness by creating effective networks among students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education program's activities.
- Transforming Antigua & Barbuda's energy systems will require a level of expertise, innovation and generational effort. Antigua & Barbuda needs major investments in capacity building. To achieve that, a National Energy Education Act is needed to provide direct investments to retool local and regional academic institutions as centers for research, education and workforce training in energy-related fields, both at professional and technical levels.

There are a number of agencies, public and non-governmental, within Antigua and Barbuda which have developed sophisticated environmental and sustainable development education and public awareness programmes. These agencies have national mandates which far exceed climate change to address varying facets of sustainable development and utilize a variety of mechanisms through which to achieve education, awareness and training. These are:

- ***The Department of Environment*** (DoE) – Through a variety of projects and programmes, the DoE, a focal agency in addressing a number of environment and sustainable conventions and issues has developed a comprehensive system of disseminating climate change information, training and awareness. Specific work in schools was achieved through the Environmental Cadet Programme, EcoZone Summer Camp and interschool events. The Department has also participated in curriculum development from primary through to tertiary levels. It has even provided internships for students from around the Caribbean Region to conduct research and gain practical experience in climate

change and other environmental issues. The Government of Antigua and Barbuda has mandated that all the environment and sustainable development projects undertaken carry public awareness as an essential component and where possible training. A number of projects such as the SIRMM and GCCA have facilitated training in Geographical Information Systems, downscaling climate models, developing climate projection scenarios and climate modeling.

- ***National GEF Small Grants Programme (GEF SGP)***

  Antigua and Barbuda has recently established its own National SGP to facilitate the development of community projects designed to address global environmental challenges through community based actions under the GEF. The GEF has highlighted key focal areas including climate change mitigation and adaptation which not only educates community groups but enables them to explore and implement of climate mitigation and adaptation strategies. Many civic and community groups have participated in tree planting and beach cleanup activities. More recently community groups as well as NGOs have taken on a more substantive role by becoming involved in efforts to improve community management of coastal natural resources, providing training to stakeholders in practices that conserve reefs, off-shore island ecosystems and mangrove wetlands which are all essential to climate resiliency. Additionally, some community groups have also undertaken sustainable agriculture and organic farming projects to assist in enhancing national food security.

- ***The National Office of Disaster Services*** -NODS has been incorporating Climate Change into its CDM education activities and presentations in all of the country's primary schools, community visits and presentation with civil, private and public sectors. Practically all schools have been covered and a wide cross section of the private sector, particularly Hotels/tourism sector. NODS has also been partnering with other public sector agencies (e.g. Government Training Division) and NGOs (such as the Antigua & Barbuda Red Cross) in the development of Community Emergency Response Teams (CERTs) beginning with high priority hazard profile communities such as Pigotts, Yorks and Bendals. The CERTs have also been involved in training initiatives that focus on many of the issues tackled under Climate Change Mitigation and Adaptation.

- ***The Environmental Awareness Group or EAG*** is the oldest non-

profit, non-governmental environmental organisation in Antigua and Barbuda, established in 1989. The EAG's vision is for a world where we are environmentally conscious, coexisting in harmony with a healthy natural environment, through respect for our biodiversity and sustainable development. Some of its achievements include:

- rescuing the Antiguan Racer from the brink of extinction,
- ecosystem restoration on offshore islands (which led to the establishment of the North East Marine Management Area),
- the inclusion of environmental education in the national school curriculum,
- ground breaking work on plant conservation, the publication of the Red List of threatened plant species and also the Wild Plants of Antigua & Barbuda.

Currently, the EAG manages nine main projects, none of which specifically focuses on climate change. However, realising that this is an issue that affects every aspect of environmental conservation, each project's educational component addresses climate change, and its negative impacts on our natural heritage. Educational campaigns such as the Endangered Species Presentations and the Floating Classroom aim to bring residents, especially school students, teachers and parents in direct contact with our local biodiversity and the threats that they currently face. In addition to these initiatives, the EAG also run a school reading programme, publishes books, brochures, educational calendars and hosts monthly environmental fieldtrips.

The monthly field trips often emphasize climate change vulnerabilities when visiting sites around Antigua and Barbuda, whether terrestrial or marine, highlighting ways of mitigating such vulnerabilities where possible. The EAG works with several local partners including the Ministry of Agriculture, and the Gilbert Agricultural and Rural Development Center (GARD). The EAG and GARD have collaborated to execute a successful summer camp, Camp GROW, Gaining a Respect for the Outdoors and our World.

- ***The Gilberts Agricultural and Rural Development (GARD) Centre*** - a non-profit NGO specializing in certified technical, vocational and enterprise development training for vulnerable youth and women. Its original mandate was to encourage youth to select agricultural and its related ventures as worthy occupations and not view it as drudgery and having a slave image.

Over the 23 years of existence the GARD Center has been demonstrating that agriculture is a business and must be competitive with other sectors and meet the global challenges and requirements of safety, sustainability and, traceability through the use of Good Agricultural Practices (GAP). The Center has collaborated with a number of partners to strengthen the response to climate issues affecting the country. The Center has partnered with the Department of Environment, Forestry Division and Agricultural Extension; and the Environmental Awareness Group in projects to protect the nation's watersheds and plant biodiversity.

GARD Center's training programs included introduction to agro-ecological, agro-forestry and organic farming practices for farmers. The Center has been involved in public awareness activities with the production of videos for public media, brochures and flyers for distribution, demonstrations for schools, agricultural producers and the general public highlighting climate change effects on biodiversity, increased risk of droughts, disasters and the preparation. Camp Grow was introduced in collaboration with the Environmental Awareness Group as a summer vacation camp for young children between the ages of 8 to 11 years to sensitize the youth of the importance of preserving their environment and to create an appreciation of the role of agriculture and its interrelationship with the environment.

5.4 SUMMARY

Over the years, Antigua and Barbuda has continued and in some cases improved the quality and variety of research and information aimed at understanding the drivers, vulnerability and exposure to the impacts of climate change. However, with small scalability and limited human, technical and financial resources, there is a wide and increasingly complex range of climate research to which Antigua and Barbuda has limited capacity to access and engage. Key among the areas which still require development if Antigua and Barbuda is to be able to fully assess and address the impacts of climate change are:

- A comprehensive State of the Environment Report, which details all habitats and ecosystems their health and status and opportunities for resilience;
- Ocean acidification;
- Sea level rise monitoring;
- Rates of coastal erosion and accretion;
- In depth assessment of the impacts of climate change on environmental, cultural, social and economic activity;
- Comparative assessment on the costs of climate change adaptation and mitigation actions and targets;
- Regional specific default values for some monitoring and assessment tools such as GHG emission calculations and methodologies for recognizing sea grass beds as carbon sinks should also be included
- A National Climate Change Policy;
- Operationalize the SIRF Fund;

- Technology Road Map for achieving climate adaptation and mitigation targets; and
- Workforce Training for Adaptation and Mitigation.

Additionally, both a comprehensive and a coordinated national climate change research and observation are key. A number of agencies are interested or actively involved in actions to address climate change, however the level of cooperation among agencies could be enhanced and technical expertise on the most cost-effective climate monitoring and data collection methods are needed.

Areas for improving public awareness and general information sharing include:

- the integration of climate change into formal education syllabi. Considering that Antigua and Barbuda participates in a regional education system, Caribbean Examination Council (CXC), integration may be more readily achieved through a regional or sub-regional (OECS) project to better integrate and advance environmental issues, including climate change. Such an exercise can ensure that information is provided at levels appropriate to subject and grade. Additionally, it will allow students to more readily appreciate the different facets of climate change; especially as such a programme would expectantly contain regional examples of climate change impacts, adaptation and mitigation. Additionally, as CXC is beginning to incorporate tablets and mobile applications into the syllabi a regional project such as this could develop multimedia and multiplatform content and applications which can used beyond the classroom.

- Alignment of financial incentives for consumers purchasing energy efficient appliances and renewable energy, and a Public Awareness Programme on energy efficiency and renewable energy, specifically appropriate energy saving practices and technologies and possibly the development of EE testing facilities. Such an action will assist the general public to see the real benefits of energy efficient practices and technologies and as consumers make the necessary behavioural changes which could translate into measurable mitigation.

- Establishing a Farmer's Computer Access Centre at the Extension Division. This would allow farmers who may not have access to computers or may be computer illiterate, to go over the Monthly Agrometeorological Bulletins and other forecasting data produced by the DMS with the support of Extension Division staff. Such a facility can also be supportive of schools agricultural courses.

6 GAPS AND CONSTRAINTS

Throughout this report a number of areas have been highlighted as limitations in the effective reporting, and exercising of sufficient measures to mitigate as well as adapt to climate change. This concluding chapter provides a summary of the gaps and constraints needed to nationally address climate change.

6.1 DATA COLLECTION

As highlighted throughout the various chapters, data availability continues to be a major constraint. This is evidenced not only in the GHG Inventory but also in reference to data collection in Barbuda which is still very negligible. This limitation of data availability impacts environmental monitoring, and decision making needed to effectively steer the country towards sustainability.

6.2 INADEQUATE INFRASTRUCTURE

Like many SIDS, the Government of Antigua and Barbuda is unable to provide adequate infrastructure and institutional support in addition to generating the revenues to fund these needs. Chief among these are the necessary tools and capacity for research, data collection, analysis, and management as highlighted in the chapters on GHG Inventory, and Policy and Measures,

Additionally, although there is an enabling environment for renewable energy (RE), economic and financial barriers limit the distribution of RE. As previously captured, it is mainly the more affluent populations and corporate sector that are able to install RE technology. To gain a larger penetration of RE, particularly in rural and impoverished communities, the Government must secure capital investments, if national emissions are to be reduced.

While the willingness of the country exists through policy development, implementation is slow due to the limited availability of finance. Although there have been many international support initiatives and programmes, many of these are geared towards regional bodies and multiple countries. This minimizes national impact as national projects must conform to stringent methodologies and approaches that may not be applicable based on cultural norms, and other variables.

6.3 FINANCIAL SERVICES SECTOR

While Antigua and Barbuda has a relatively high financial sector ratio to its size (10 to 100,000 inhabitants), the premium generated for reinsurance when compared to disaster claims is relatively negligible. This is also unattractive for the reinsurance market as Antigua and Barbuda falls within one of the most disaster prone regions. The performance and rates of reinsurers throughout the region will undoubtedly increase, threatening the financial viability and availability of local insurances. This increases the risk burden borne by vulnerable populations through higher deductibles and premiums, and in some instances the unavailability of insurance coverage based on coastal locations. This also has implications for banking institutions as studies have shown that extreme weather events affect client behavior namely, default on mortgages. This increase the portfolio of non performing loans

6.4 PRIVATE AND PUBLIC SECTOR ENGAGEMENT

As highlighted previously, there is no national climate change strategy or national adaptation plan. Consequently, climate

change has not been effectively mainstreamed across all sectors, particularly the private sector, which includes the financial services sector. As such, approaches to climate change adaptation and mitigation within the private sector have been sporadic and uncoordinated. Further, while the DoE informally established a Technical Advisory Committee for the supervision of projects and implementation of MEAs, there still exists inadequate cross sectoral collaboration to ensure that climate change related issues are mainstreamed into work programs and budgets.

6.5 TRANSPORTATION SECTOR

Data on the local transportation sector is negligible owing to improper data collection and management protocols. However, the Transport Board Authority has recently embarked on a database management of all motorized vehicles on the island. Once completed, this data will be a primary feature in subsequent communications.

Given the lack of data on motorized vehicles type, and fuel, efficient fuel within the transport sector has not yet been pursued. Additionally, transitioning to more fuel efficiency is currently not financially feasible or practical given the exorbitant costs and skills requirements. This stems from the fact that the Sea island jetty, the sole importation source of fuel, possesses only two offshore pipes that brings fuel to the island. Transitioning to more efficient fuel would require construction and installation of additional submerged pipes, vehicle and service station retrofitting island wide. This would also require enhancing national skills capacity to undertake the retrofitting of all vehicles. However, it must be noted that while the international community implements measures to ensure the use of efficient fuels in motorized vehicles (land or sea), developing states, like Antigua and Barbuda, are marginalized from advances in this sector. For instance, for many years, Antigua has been a docking and fuel station for many international yachts. However, given the unavailability of efficient fuel, there has been a decline in the yachting sector as yachts make their way to other islands, notably St. Maarten, for fuelling.

7 ANNEX: UNCERTAINTY CALCULATIONS

Uncertainty Calculations

Uncertainty: Lack of knowledge of the true value of a variable that can be described as a probability density function (PDF) characterising the range and likelihood of possible values. Uncertainty depends on the analyst's state of knowledge, which in turn depends on the quality and quantity of applicable data as well as knowledge of underlying processes and inference methods.

(pg 3.8, Section 3.1.3, Vol 1, 2006 IPCC Guidelines)

ENERGY SECTOR

Worksheet 1A Reference Approach

Activity Data Uncertainty: Experts believe that uncertainty resulting from errors in the activity data of countries with well-developed statistical systems is probably in the range of ±5% for a given fuel. For countries with less well-developed energy data systems, this could be considerably larger, probably about ±10% for a given fuel (pg. 6.13, Section 6.10.1 Vol 2 Chap 6). It was decided that the uncertainty used in this case would be the higher value of ±10%.

Emission Factor Uncertainty:

The Tables UC-1 and UC-2 show how uncertainty was calculated.

Table UC-1 showing calculations of uncertainty for the Net calorific value needed to determine CO2 emissions

A	B	C	D	E	F	G
Fuel Type		Net calorific value (TJ/Gg) [Table 1.2, Vol2 Chap1]	Lower limit of 95% Confidence Interval	Upper limit of 95% Confidence Interval	Calculation of Uncertainty of lower limit [((C-D)/C)*100]	Calculation of Uncertainty of upper limit [((C-E)/C)*100]
Motor gasoline		44.3	42.5	44.8	4	1
Jet Gasoline		44.3	42.5	44.8	4	1
Other Kerosene		43.8	42.4	45.2	3	3
Gas / Diesel Oil		43	41.4	43.3	4	1
LPG		47.3	44.8	52.2	5	10
Lubricants		40.2	33.5	42.3	17*	5

***Highest Uncertainty is taken as the uncertainty for the Net Calorific Value ±17%**

Table UC-2 showing calculations of uncertainty for the Carbon Content needed to determine CO2 emissions

A	B	C	D	E	F
Fuel Type	Default Carbon Content (kg/GJ) Table 1.3 pg1.21 Vol2 Chap 1	Lower limit of 95% Confidence Interval	Upper limit of 95% Confidence Interval	Calculation of Uncertainty of lower limit [((B-C)/B)*100]	Calculation of Uncertainty of upper limit [((D-B)/D)*100]
Motor Gasoline	18.9	18.4	19.9	3	5
Jet Gasoline	19.1	18.4	19.9	4	4
Other Kerosene	19.6	19.3	20.1	2	3
Gas/Diesel Oil	20.2	19.8	20.4	2	1
Liquefied Petroleum Gases	17.2	16.8	17.9	2	4
Lubricants	20	19.6	20.5	2	3

***Highest uncertainty is ±4%**

Default uncertainty ranges are not available for oxidation factors.

The highest uncertainty was used and that was ±17%

Worksheet 1A Sectoral Approach – CO2, CH4, N2O

Activity Data Uncertainty – CO2, CH4, N2O:

For countries with less well-developed energy data systems, this could be considerably larger, probably about ±10 percent. Informal activities may increase the uncertainty up to as much as 50 percent in some sectors for some countries (pg 2.40 Section 2.4.2. Vol 2, Chap 2). The uncertainty was estimated at 50%.

Emission Factor Uncertainty – CO2

For fossil fuel combustion, uncertainties in CO_2 emission factors are relatively low. These emission factors are determined by the carbon content of the fuel and thus there are physical constraints on the magnitude of their uncertainty (pg 2.8, Section 2.4.1, Vol 2, Chap 2). Therefore the uncertainty is taken from Table UC-2 which would be ±4%

Emission Factor Uncertainty – CH4 & N2O

Emission factors for CH_4 and especially N_2O are highly uncertain (pg 2.8, Section 2.4.1, Vol 2, Chap 2). According to Table 2.12 (pg 2.8, Section 2.4.1, Vol 2, Chap 2, 2006 IPCC Guidelines), CH4 uncertainties may be estimated as between 50 – 150%. In the case of Antigua and Barbuda an average was used which was 100%.

Table UC-3 Calculations of Uncertainty for the N2O Emission Factor

A	B	C	D	E	F
Fuel Type	N2O Emission Factor (kg/TJ) Table 2.2 pg2.16 Vol2 Chap 2	Lower limit of 95% Confidence Interval	Upper limit of 95% Confidence Interval	Calculation of Uncertainty of lower limit [((B-C)/B)*100]	Calculation of Uncertainty of upper limit [((D-B)/D)*100]
Motor Gasoline	0.6	0.2	2	67	233
Jet Gasoline	0.6	0.2	2	67	233
Other Kerosene	0.6	0.2	2	67	233
Gas/Diesel Oil	0.6	0.2	2	67	233
LPG	0.1	0.03	0.3	70	200
Lubricants	0.6	0.2	2	67	233
Paraffin Waxes	0.6	0.2	2	67	233
Charcoal	4	1.5	15	63	275*

***The highest Uncertainty was ±275%**

The uncertainty for N2O emission factor was taken as 275% (Table UC-3).

INDUSTRIAL SECTOR

Worksheet 2A2

The uncertainty in Activity data could not be scientifically determined.

The Uncertainty for the emission factor of lime was found in Table 2.5, pg. 2.25, Section 2.3.2, Vol 3, Chap 2, 2006 IPCC Guidelines and it is 15%.

Worksheet 2A4

Activity Data Uncertainty:

Activity data uncertainties are greater than the uncertainties associated with emission factors. Assuming that carbonate consumption is allocated to the appropriate consuming sectors/industries, the uncertainty associated with weighing or proportioning the carbonates for any given industry is 1-3 percent. The uncertainty of the overall chemical analysis pertaining to carbonate content and identity also is 1-3 percent (pg. 2.39, Section 2.5.2.2, Vol.3, Chap 2, 2006 IPCC Guidelines). It can be assumed then that the uncertainty is 3% but it is most likely to be higher.

Emission Factor Uncertainty:

The Emission factor for carbonates is low and is assumed to be 1 – 5% according to 2006 IPCC Guidelines (pg 2.39, Section 2.5.2.1, Vol 3 Chap 2). An average will be used in this case of 3%.

Worksheet 2D1

Activity Data Uncertainties:

Much of the uncertainty in emission estimates is related to the difficulty in determining the quantity of non- energy products used in individual countries, for which a default of 5 percent may be used in countries with well developed energy statistics and 10-20 percent in other countries, based on expert judgement of the accuracy of energy statistics (pg. 5.10, Section 5.2.3.2, Vol 3, Chap 5).

The highest uncertainty of 20% was used as it is believed that there is much uncertainty in this data.

Emission Factor Uncertainties:

The default ODU factors developed are very uncertain, as they are based on limited knowledge of typical lubricant oxidation rates. Expert judgment suggests using a default uncertainty of 50 percent (pg. 5.10, Section 5.2.3.1, Vol 3, Chap 5).

The carbon content coefficients are based on two studies of the carbon content and heating value of lubricants, from which an uncertainty range of about ±3 percent is estimated (U.S.EPA, 2004) (pg. 5.10, Section 5.2.3.1, Vol 3, Chap 5).

The highest uncertainty of 50% was used.

Worksheet 2D2

Activity Data Uncertainties:

According to 2006 IPCC Guidelines, an uncertainty of 10 – 20 % should be used in countries

without well developed energy statistics (pg 5.13, Section 5.3.3.2, Vol 3. Chap 5). The upper limit of 20% uncertainty is used because of local conditions.

Emission Factor Uncertainties:

According to 2006 IPCC Guidelines if an Oxidized During Use (ODU) Factor, if a value of 0.2 is used it should exhibit an uncertainty of about 100% (pg 5.13, Section 5.3.3.1, Vol 3. Chap 5). Therefore, an uncertainty of 100% was used.

Worksheet 2F4 - Aerosols

According to 2006 IPCC Guidelines, Inventory compilers should seek industrial advice on uncertainties, using the approaches to obtaining expert judgments. Because the industrial sector is so small in this country, experts could not be found to assist with this (pg 7.58, 7.5.3, Vol 3, Chap 7). Therefore the uncertainty was not calculated for this emission.

Worksheet 2G3 N2O Use

Activity Data Uncertainties: According to 2006 IPCC Guidelines uncertainty estimates should be obtained from manufacturers and distributors (pg.5.38, Section 8.4.3.2, Vol 3, Chap 8). This data was not readily available, therefore no uncertainty determination was made for this emission.

Emission Factor Uncertainties: According to 2006 IPCC Guidelines, the uncertainty should be very small (pg.5.37, Section 8.4.3.1, Vol 3, Chap 8).

Worksheet 2-13

No data was available to determine the uncertainties for both alcoholic beverage production and Bread production. Therefore, no uncertainties were determined for this emission.

AGRICULTURAL SECTOR

Worksheet 3A1 – Enteric fermentation

Activity Data Uncertainties: The uncertainty associated with populations will vary widely depending on source, but should be known within +20% (pg. 10.23, Section 10.2.3, Vol 4, Chap 10). Therefore an uncertainty of 20% was used.

Emission Factor Uncertainties: The emission factors have an uncertainty of 30 – 50% according to the 2006 IPCC Guidelines (pg 10.28, Vol 4, Chap 10). An average uncertainty was used in this case of 40%.

Worksheet 3A2 – Manure Management CH4

Activity Data Uncertainties: The uncertainty associated with populations will vary widely depending on source, but should be known within +20% (pg. 10.23, Section 10.2.3, Vol 4, Chap 10). Therefore an uncertainty of 20% was used.

Emission Factor Uncertainties: Default Emission factors are estimated to have an uncertainty of 30% (pg. 10.48, Section 10.4.4, Vol 4, Chap 10).

Worksheet 3A2 – Manure Management N2O

Activity Data Uncertainties:

The uncertainty associated with populations will vary widely depending on source, but should be known within 20% (pg. 10.23, Section 10.2.3, Vol 4, Chap 10).

The uncertainty for countries where there is a wide variety of management systems used with locally different operating practices, the uncertainty in management system usage data can be much higher, in the range of 25% to 50%, depending on the availability of reliable and representative survey data that differentiates animal populations by system usage (pg 10.67, Vol 4, Chap 10). The average uncertainty will be used, which is 38%.

The highest of both uncertainties (20% and 38%) was chosen which was 38%.

Emission Factor Uncertainties:

Uncertainty ranges for the default N excretion rates are estimated at about +50% (Source: Judgement by IPCC Expert Group). There are large uncertainties associated with the default emission factors for direct N2O emissions (–50% to +100%).

The highest of the uncertainties was chosen which was 100%.

Worksheet – Urea Fertilization

Insufficient information available to calculate uncertainties.

FORESTRY AND OTHER LAND USE SECTOR

Worksheet 3B1a - Biomass

Activity Data Uncertainties:All the activity data should have the same uncertainty as it was all derived in the same manner (aerial photos and some ground truthing – Approach 3 – Table 3.7, pg 3.20, Vol 4, Chap 3). This uncertainty is estimated to be 10%.

Emission Factor Uncertainties: FAO (2006) provides uncertainty estimates for forest carbon factors; basic wood density (10 to 40%); annual increment in managed forests of industrialized countries (6 %); growing stock (industrialized countries 8%, non- industrialized countries 30%); combined

natural losses for industrialized countries (15%); wood and fuelwood removals (industrialized countries 20%) (pg 4.19, Section 4.2.1.5, VOl 4 Chap 4).

The highest uncertainty will be used, which would be 40%.

Worksheet 3B1b – Dead Organic Matter (Forest Land)

Activity Data Uncertainties: All the activity data should have the same uncertainty as it was all derived in the same manner (aerial photos and some ground truthing – Approach 3 – Table 3.7, pg 3.20, Vol 4, Chap 3). This uncertainty is estimated to be 10%. Emission Factor Uncertainties: This should be similar as in the worksheet previously. Therefore, the uncertainty used will be 40%.

Worksheet 3B1b – Soil (Forest Land)

Activity Data Uncertainties: All the activity data should have the same uncertainty as it was all derived in the same manner (aerial photos and some ground truthing – Approach 3 – Table 3.7, pg 3.20, Vol 4, Chap 3). This uncertainty is estimated to be 10%. Emission Factor Uncertainties: This should be similar as in the worksheet previously. Therefore, the uncertainty used will be 40%.

Worksheet 3B2a – Biomass (Crop Land)

Activity Data Uncertainties: All the activity data should have the same uncertainty as it was all derived in the same manner (aerial photos and some ground truthing – Approach 3 – Table 3.7, pg 3.20, Vol 4, Chap 3). This uncertainty is estimated to be 10%.

Emission Factor Uncertainties: According to IPCC Guidelines (pg 5.12, Section 5.2.1.5., Vol 4, Chap 5), default uncertainty level of +75% of the parameter value has been assigned based on expert judgment. Therefore, 75% will be used as the uncertainty.

Worksheet 3B2a – Soils (Crop Land)

Activity Data Uncertainties: All the activity data should have the same uncertainty as it was all derived in the same manner (aerial photos and some ground truthing – Approach 3 – Table 3.7, pg 3.20, Vol 4, Chap 3). This uncertainty is estimated to be 10%.

Emission Factor Uncertainties: According to 2006 IPCC Guidelines (Table 5.6, pg 5.19, Vol 4, Chap 5), the uncertainty for the emission factor for cultivated organic soils is 90%. Therefore, an uncertainty of 90% is used.

Worksheet 3B3a – Soils (Grass land)

Activity Data Uncertainties: All the activity data should have the same uncertainty as it was all

derived in the same manner (aerial photos and some ground truthing – Approach 3 – Table 3.7, pg 3.20, Vol 4, Chap 3). This uncertainty is estimated to be 10%.

Emission Factor Uncertainties: According to 2006 IPCC Guidelines (Table 6.3, pg 6.17, Vol 4, Chap 6), the uncertainty for the emission factor for cultivated organic soils is 90%. Therefore, an uncertainty of 90% is used.

Worksheet 3B3b – Soils (Land converted to Grassland)

Activity Data Uncertainties: All the activity data should have the same uncertainty as it was all derived in the same manner (aerial photos and some ground truthing – Approach 3 – Table 3.7, pg 3.20, Vol 4, Chap 3). This uncertainty is estimated to be 10%.

Emission Factor Uncertainties: According to 2006 IPCC Guidelines (Table 6.3, pg 6.17, Vol 4, Chap 6), the uncertainty for the emission factor for cultivated organic soils is 90%. Therefore, an uncertainty of 90% is used.

Worksheet 3B5a – Soils (Settlements)

Activity Data Uncertainties: All the activity data should have the same uncertainty as it was all derived in the same manner (aerial photos and some ground truthing – Approach 3 – Table 3.7, pg 3.20, Vol 4, Chap 3). This uncertainty is estimated to be 10%.

Emission Factor Uncertainties: According to 2006 IPCC Guidelines (Table 5.6, pg 5.19, Vol 4, Chap 5), the uncertainty for the emission factor for cultivated organic soils is 90%. Therefore, an uncertainty of 90% is used.

Worksheet 3B5b – Biomass (Land converted to Settlements)

According to 2006 IPCC Guidelines, assessment of uncertainty is not required, because the change in living biomass is set to zero (pg 8.12, Vol 4 Chap 8).

Worksheet 3B5b – DOM (Land converted to Settlements)

According to 2006 IPCC Guidelines (pg 8.23, Section 8.3.2.4, Vol 4, Chap 8), Dead Organic Matter (DOM) changes are subsequently assumed to be zero, and no associated uncertainty is needed at Tier 1 after the initial transition.

Worksheet 3B5b – Soils (Land converted to Settlements)

Activity Data Uncertainties: All the activity data should have the same uncertainty as it was all derived in the same manner (aerial photos and some ground truthing – Approach 3 – Table 3.7, pg 3.20, Vol 4, Chap 3). This uncertainty is estimated to be 10%.

Emission Factor Uncertainties: According to 2006 IPCC Guidelines (Table 5.6, pg 5.19, Vol 4, Chap 5), the uncertainty for the emission factor for cultivated organic soils is 90%. Therefore, an uncertainty of 90% is used.

Worksheet 3B6b – Biomass (Land converted to Other Lands)

Activity Data Uncertainties: All the activity data should have the same uncertainty as it was all derived in the same manner (aerial photos and some ground truthing – Approach 3 – Table 3.7, pg 3.20, Vol 4, Chap 3). This uncertainty is estimated to be 10%.

Emission Factor Uncertainties: Using Tier 1, a default uncertainty level of +75% of the estimated mean CO_2 emission may be assumed (pg 9.6, Section 9.3.1.4, Vol 4, Chap 9). Therefore the uncertainty used is 75%.

Worksheet 3B6b – Soils (Land converted to Other Lands)

Activity Data Uncertainties: All the activity data should have the same uncertainty as it was all derived in the same manner (aerial photos and some ground truthing – Approach 3 – Table 3.7, pg 3.20, Vol 4, Chap 3). This uncertainty is estimated to be 10%.

Emission Factor Uncertainties: According to 2006 IPCC Guidelines (Table 5.6, pg 5.19, Vol 4, Chap 5), the uncertainty for the emission factor for cultivated organic soils is 90%. Therefore, an uncertainty of 90% is used.

WASTE SECTOR
Worksheet 4B CH4

Determination of Activity Data Uncertainty : According to Table 3.5 pg 3.27 Vol 3 Chap 3 Waste IPCC Guidelines, in cases where wastes are weighed every time the uncertainty may be estimated as 10%.

Determination of Emission Factor Uncertainty according to 2006 IPCC Guideline rules from Vol1 Chap 3

CH4 Emission Factor Range (0.03 – 8) Table 4.1 Pg 4.6 Vol 4 Chap 4

Using Emission Factors chosen by field expert the following calculations were carried out and the highest Uncertainty chosen:

(4-0.03/4 *100), (4-8/4 *100) = 99%, 100%
(6-0.03/6*100), (6-8/6*100) = 99.5%, 25%
(1-0.03/1*100), (1-8/1*100) = 97%, 700%
(5-0.03/5*100), (5-8/5*100) = 99%, 60%
(2-0.03/2*100), (2-8/2*100) = 98.5%, 300%

The Highest Uncertainty is 700% for the Emission factor for CH4

Worksheet 4b N2O

Determination of Activity Data Uncertainty : According to Table 3.5 pg 3.27 Vol 3 Chap 3 Waste IPCC Guidelines, in cases where wastes are weighed every time the uncertainty may be estimated as 10%.

Determination of Emission Factor Uncertainty according to 2006 IPCC Guideline rules from Vol1 Chap 3

N2O Emission Factor Range (0.03 – 8) Table 4.1 Pg 4.6 Vol 4 Chap 4

Using Emission Factors chosen by field expert the following calculations were carried out and the highest Uncertainty chosen:

(0.3-0.06/0.3 *100), (0.3-0.6/0.3*100) = 6%, 100%
(0.6-0.06/0.6*100), (0.6-0.6/0.6*100) = 90%, 0%

The highest Uncertainty factor for N2O is 100%

Worksheet 4C2– CO2

Activity Data Uncertainties: The conversion of waste amounts from wet weight to dry weight adds additional uncertainty. Depending on the frequency and the accuracy of the dry weight determination, this uncertainty varies substantially. The uncertainty of the dry matter content may therefore range between ± 10 percent up to ± 50 percent and even more (pg 5.24, Section 5.7.1. Chap 5). The higher range of 50% was chosen for activity data uncertainty.

Emission Factor Uncertainties: A default value of ± 40 percent is proposed for countries relying on default data on the composition in their calculations (pg 5.23, Section 5.7.1. Chap 5).

Worksheet 4C2 – CH4
Activity Data Uncertainties: The conversion of waste amounts from wet weight to dry weight adds additional uncertainty. Depending on the frequency and the accuracy of the dry weight

determination, this uncertainty varies substantially. The uncertainty of the dry matter content may therefore range between ± 10 percent up to ± 50 percent and even more (pg 5.24, Section 5.7.1. Chap 5). The higher range of 50% was chosen for activity data uncertainty.

Emission Factor Uncertainties: Since default values for N_2O and CH_4 emission factors are used, uncertainty ranges have been estimated to be ± 100 percent or more (pg 5.23, Section 5.7.1. Chap 5).

Worksheet 4C2 – N2O

Activity Data Uncertainties: The conversion of waste amounts from wet weight to dry weight adds additional uncertainty. Depending on the frequency and the accuracy of the dry weight determination, this uncertainty varies substantially. The uncertainty of the dry matter content may therefore range between ± 10 percent up to ± 50 percent and even more (pg 5.24, Section 5.7.1. Chap 5). The higher range of 50% was chosen for activity data uncertainty.

Emission Factor Uncertainties: Since default values for N_2O and CH_4 emission factors are used, uncertainty ranges have been estimated to be ± 100 percent or more (pg 5.23, Section 5.7.1. Chap 5).

8 STATEMENT OF INDC

ANTIGUA AND BARBUDA
INTENDED NATIONALLY DETERMINED CONTRIBUTION (INDC)

Communicated to the UNFCCC on 7 October, 2015

Introduction

The Government of Antigua and Barbuda is committed to the successful conclusion of negotiations under the Ad-Hoc Working Group on the Durban Platform for Enhanced Action (ADP) in order to adopt, at COP21 in Paris, a new legally-binding agreement under the United Nations Framework Convention on Climate Change (UNFCCC) appropriate to all Parties, which will come into effect and be implemented from 2020 onwards.

Antigua and Barbuda hereby communicates its Intended Nationally Determined Contribution (INDC), in accordance with the relevant paragraphs of Decisions 1/CP.19 and 1/CP.20, towards achieving the objective of the Convention to stabilize greenhouse gas (GHG) concentrations to "prevent dangerous anthropogenic interference with the climate system" (Article 2), and towards the Convention's commitment for all Parties to take "measures to facilitate adequate adaptation to climate change" (Article 4).

As agreed in Decision 1 CP/20 para 11, "Small island developing states may communicate information on strategies, plans and actions for low greenhouse gas emission development reflecting their special circumstances in the context of intended nationally determined contributions." Mitigation and adaptation targets in this INDC are presented in an up-front format to facilitate clarity and transparency, and are a mix of conditional and unconditional contributions, contingent upon receiving international support for technology transfer, capacity-building and financial resources.

Antigua and Barbuda reserves the right to revise this INDC prior to finalization and/or ratification under a new global climate agreement.

Intended Nationally Determined Contribution (INDC)

Conditional Adaptation Targets

1. By 2030, all buildings improved and prepared for extreme climate events, including drought, flooding and hurricanes.

2. By 2025, increase seawater desalination capacity by 50% above 2015 levels.
3. By 2030, 100% of electricity demand in the water sector[92] and other essential services (including health, food storage and emergency services) will be met through off-grid renewable sources.
4. By 2030, all waterways protected to reduce the risks of flooding and health impacts.
5. By 2030, an affordable insurance scheme is available for farmers, fishers, and residential and business owners to cope with losses resulting from climate variability.

Conditional Mitigation Targets

1. By 2020, finalize the technical studies with the intention to construct and operationalize a waste to energy (WTE) plant by 2025.[93]
2. By 2020, establish efficiency standards for the importation of all vehicles and appliances.
3. By 2030, achieve an energy matrix with 50 MW of electricity from renewable sources both on and off-grid in the public and private sectors.[94]
4. By 2030, all remaining wetlands and watershed areas with carbon sequestration potential protected as carbon sinks.

Unconditional Targets

1. Enhance the established enabling legal, policy and institutional environment for a low carbon emission development pathway to achieve poverty reduction and sustainable development.
2. By 2020, update the Building Code to meet projected impacts of climate change.

Support for Implementation

The conditional adaptation and mitigation targets presented in this INDC are contingent upon Antigua and Barbuda receiving international support for capacity building, technology transfer and financial resources, including through the Green Climate Fund (GCF), the Global Environment Facility (GEF), the Adaptation Fund and multilateral agencies and bilateral agreements. The cost of implementing the adaptation targets is estimated at approximately $20M USD per year for the next ten years, and the cost of mitigation is estimated at approximately $220M USD, however these figures require further analysis.

National contributions include establishing an enabling legal, policy and institutional environment to facilitate an efficient and effective transfer of resources to support implementation and achievement of the INDC targets. This enabling environment includes enactment of the Renewable Energy Act of 2015 and the Environmental Protection and Management Act (EPMA) of 2015, in addition to policies in energy and the environment such as the National Energy Policy and the Sustainable Energy Action Plan. National efforts have contributed to an enabling financing

[92] The water sector includes water generation (seawater desalination), distribution and usage, to ensure water delivery when grid electricity may be interrupted. Based on an informal assessment, water distribution and usage is equal to approximately 15% of GHG emissions in the electricity sector.

[93] Waste-to-energy is not considered part of the 50 MW renewable energy target.

[94] This target includes distributive renewable energy capacity to be used as backup energy by the commercial sector and some residences. The assumption is that the commercial sector has full backup capacity at approx. 20 MW to continue operations when grid electricity may be interrupted. Backup electricity generation is currently fossil fuel based.

environment through the Sustainable Island Resource Framework Fund (SIRF Fund), which was established under national environmental law. The Fund's executing agency, the Department of Environment, has achieved accreditation to the Adaptation Fund as a National Implementing Entity, and the Department is seeking direct access to the GCF through a fast-track application.

INFORMATION TO FACILITATE CLARITY AND TRANSPARENCY

Parameter		Information
Period of implementation		**Pre 2020 and 2020 – 2030**
Type of commitment		**We recognize that contributions from developed countries may be absolute economy-wide emission reduction targets relative to a base year, and that contributions from developing countries may be policies, measures and actions departing from business as usual. As a developing country, a small island developing state, and one of the lowest emitters in the world, Antigua and Barbuda presents conditional and unconditional policies, measures and actions (non-GHG target).**
Reference point		**Greenhouse Gas Emissions and Removals (Gg) for 2006**
Scope and coverage	**Emissions impact**	**Contributions will reduce GHG emissions in the energy sector, reduce dependence on fossil fuels, reduce the cost of energy and help alleviate poverty through increasing access to affordable and sustainable energy.**
	Sectors	**Sectors addressed in the adaptation and mitigation targets include: Energy, Tourism, Agriculture, Waste, Water, Transportation, Forestry and Land Use Change.**
	Greenhouse Gases (GHGs)	**The national GHG inventory covers Carbon Dioxide (CO2), Methane (CH4), Nitrous Oxide (N2O), and Hydrofluorocarbons (HFC).**
	Geographical boundaries	**Entire country**
Intention to use market-based mechanisms to meet target		**Antigua and Barbuda considers the establishment of an international market mechanism as an important complimentary option to reduce total costs associated with limiting GHG emissions and to assist global efforts limiting temperature to 1.5 degrees Celsius above pre-industrial levels. Antigua and Barbuda acknowledges the potential for a renewed and reformed Clean Development Mechanism to fulfill this roll through its existing structure. The final mechanism should be a robust system that guarantees transparency and environmental integrity, and delivers real,**

	permanent and verified emission reductions and ensures that double counting is avoided.

Planning process

This initial draft INDC was developed through a Cabinet mandate, where the Cabinet of Antigua and Barbuda also reviewed the adaptation and mitigation targets. The Technical Advisory Committee (TAC), was the primary drafting and review committee in the development of this initial INDC. The TAC is an inter-agency, multi-stakeholder advisory committee that includes fifteen government agencies, three NGOs and community interest groups, and one private sector coalition representative.

Additional consultations were arranged with public, private, and civil society stakeholders, through meetings, workshops, public awareness and online publication.

Antigua and Barbuda recognizes the importance of Principle 10 of the Rio Declaration on transparency, access and accountability in environmental matters through participation of all concerned citizens, at the relevant levels, as well as to involve the community by encouraging public awareness and participation by making information readily available.

Antigua and Barbuda's INDC is a working document and will be updated periodically, as appropriate. This initial draft INDC will be supported by a technical road map and additional technical assessments to facilitate the drafting of policies, regulations, and standards for implementation.

Assumptions and Methodological Approaches

The full implementation of Antigua and Barbuda's INDC is made on the assumption of an ambitious and equitable multilateral agreement being reached among Parties that provides the means of implementation to enable Antigua and Barbuda to access international support through climate finance, and an agreement that stimulates investments, technology transfer and capacity building.

The methodologies used to estimate GHG emissions in relevant sectors correspond to the 2006 IPCC Guidance for Conducting National Greenhouse Gas Inventories and assume Global Warming Potential (GWP) values for a residence period in the atmosphere of 100 years pertaining to the Second Assessment report of the IPCC.

Consideration on Fairness and Ambition

Antigua and Barbuda's INDC is fair, ambitious, and science-based, and is therefore a responsible contribution toward the global efforts of meeting the objectives of the UNFCCC to limit the average temperature rise to 1.5 degrees Celsius above pre-industrial levels, and to enable and support the implementation of adaptation actions aimed at reducing vulnerability and building resilience in vulnerable countries.

The ambitious adaptation and mitigation targets presented in this INDC represent a national commitment towards addressing the global climate change challenge. Antigua and Barbuda's emissions are negligible in a global context (less than 0.002% of global GHG emissions), and as a small island developing state (SIDS) the country is highly vulnerable to climate trends

and impacts. Antigua and Barbuda aspires to increase national resilience to climate change through implementing integrated mitigation and adaptation actions.

Antigua and Barbuda reaffirms its commitment to the AOSIS position that, "Research clearly shows that unless we act immediately, the opportunity to keep global warming below the crucial 1.5 degree Celsius threshold could be irrevocably lost." The country believes in the principle of common but differentiated responsibilities and respected capabilities (CBDR) to address the global climate challenge.

ACCOMPANYING INFORMATION ON ANTIGUA AND BARBUDA'S INDC

General Information

Antigua and Barbuda is a small island developing state (SIDS) in the Caribbean Sea with a population of 90,000, of which 1,200 people reside in Barbuda. The country's economy is heavily dependent on natural resources, low-lying coastal zones, and favorable climate conditions to support the tourism sector, which accounts for about 80% of output gross domestic product (GDP), about 70% of direct and indirect employment and 85% of foreign exchange earnings. Antigua and Barbuda is exposed economically, environmentally and socially to projected climate change impacts.[95]

Climate models for the Caribbean highlight the need for downscaled climate data. Temperature projections from a Regional Climate Model (RCM) indicate more rapid increases in temperatures over Antigua and Barbuda compared to the Global Climate Model (GCM), as the improved spatial resolution in the RCM allows the land mass of the larger Caribbean islands to be represented, whilst the region is represented only by 'ocean' grid boxes at GCM resolution. RCM projections indicate increases of 2.4°C to 3.2°C in mean annual temperatures by the 2080s.[96] Analysis of climate change for the island also projects accelerated coastal erosion and inundation, lower average annual rainfall, increased rainfall intensity causing flooding and a likely increase in tropical storm intensity.

Accompanying Information on Adaptation Actions

Antigua and Barbuda's development strategy is guided by a national physical development plan, a requirement under the Physical Planning Act of 2003, and is periodically updated. In 2012, Cabinet approved the Sustainable Island Resource Management and Zoning Plan (SIRMZP) to serve as the updated national physical development plan, which presents a forward-looking strategic, national spatial development framework that addresses current development issues, and provides a platform for feasible private and public sector development initiatives, reflecting local cultural values and aspirations over the next twenty years. While complementing the SIRMZP strategy, adaptation targets presented in this INDC are incremental efforts to the national physical development plan as the targets elevate ambition beyond development, to build resilience through adaptation interventions in preparation for projected climate impacts.

[95] **CARIBSAVE 2015, Draft National Vulnerability Analysis for Antigua and Barbuda.**
[96] **CARIBSAVE 2012, Climate Change Risk Atlas Profile for Antigua and Barbuda (CCCRA), p. 14.**

Since the year 2001, Antigua and Barbuda has been up to date with its commitments to report to the UNFCCC and is now in the process of preparing its Third National Communication to the UNFCCC, to be presented by the end of 2015. Antigua and Barbuda has presented two National Communications, the first in 2001 and the second in 2011, which highlight climate change present and future impacts. The National Communications elaborate in detail the impact that climate change will have on weather- and climate-sensitive sectors. Antigua and Barbuda is currently developing its biennial update report (BUR), which will be submitted to the UNFCCC by the end of 2016.

Drought is a major concern for the country. Historically, the water sector in Antigua and Barbuda has been vulnerable to shortages as a result of droughts every 5 to 10 years coupled with contamination from saltwater intrusion that threatens groundwater supplies. Some wells have already been capped to address the issue of saltwater intrusion.[97] Antigua and Barbuda lie in a zone that is expected to receive 30-50% less average annual rainfall by 2090 compared to late 20th century norms,[98] and in the Caribbean, sea level rise has been observed at between 1.5 and 3 mm per year, which is projected to accelerate in the future.

Climate impacts will exacerbate freshwater scarcity, and adaptation interventions in the water sector are of national priority. Desalination reliance has already grown to account for 60% of national water supply, and this ratio is the most viable option for enhancing water resources.[99] During times of drought, desalination can account for up to 90% of freshwater supply. Antigua and Barbuda have the goal to, **by 2025, increase seawater desalination capacity by 50% above 2015 levels**, from approximately 5.4 million to over 8 million US gallons per day (GPD) to counteract freshwater scarcity in Antigua and Barbuda.

Given that desalination is the primary adaptation solution to Antigua and Barbuda's freshwater challenges, and that its ability to meet demand is contingent on a stable and uninterrupted energy supply, implementing resilience in energy systems for water resources is a critical adaptation measure. Off-grid renewable energy resources can enhance resilience in the water sector. **By 2030, 100% of electricity demand in the water sector – and other essential services including health, food storage and emergency services – will be met through on and off-grid renewable sources** to enhance resilience to drought and hurricanes.
The need for adaptation in the water sector is not limited to freshwater supply. In recent years, the impact of floods in Antigua and Barbuda have become particularly acute, in part due to climate variability affecting the frequency and severity of storms and rainfall extremes, and to development that has increased impervious surface cover and constricted drainage.[100] The health sector is exposed to climate impacts through vector borne diseases and the spread of water-borne illnesses, where trends suggest increases in Antigua and Barbuda.[101] **By 2030, all waterways will be protected to reduce the risks of flooding and health impacts**.

[97] **CARIBSAVE 2012, Climate Change Risk Atlas Profile for Antigua and Barbuda (CCCRA), p. 36.; Environment Solutions Limited (ESL) 2014, National Adaptation Strategy and Action Plan to Address Climate Change in the Water Sector in Antigua and Barbuda, p. 11.**
[98] **CARIBSAVE 2015, Draft National Vulnerability Analysis for Antigua and Barbuda, p. 9.**
[99] **ESL 2014, National Adaptation Strategy and Action Plan to Address Climate Change in the Water Sector in Antigua and Barbuda, p. 174.**
[100] **UNHABITAT 2011, Antigua and Barbuda: National Urban Profile, p. 23.**
[101] **CARIBSAVE 2012, Climate Change Risk Atlas Profile for Antigua and Barbuda (CCCRA), p. 189.**

Climate models projecting hurricane trends have generally determined that there will be an increase in intensity, if not frequency, of hurricanes in the Atlantic and Caribbean.[102] As such, hurricanes will pose an increasing threat to Antigua and Barbuda's economy. Over 15 years, between 1995 and 2010, six hurricanes resulted in economic losses and damages on the twin island state totaling US $335 million (Hurricane Luis in 1995, Hurricane Georges in 1998, Hurricanes Jose and Lenny in 1999, Hurricane Omar in 2008, and Hurricane Earl in 2010).[103] Physical infrastructure in Antigua and Barbuda must be adapted to the dynamic threats of water scarcity, heavy rainfall events, and more intense storms and hurricanes. **By 2030, all buildings will be improved and prepared for extreme climate events, including drought, flooding and hurricanes**.

Physical adaptation measures will not always be enough to prevent significant loss and damage to the infrastructure and economy of Antigua and Barbuda. As a coastal economy, one-meter sea level rise (SLR) would impact 10% of major tourism resorts, all seaports, and 2% of major road networks in Antigua and Barbuda. The fisheries sector sustains significant losses during hurricanes, and will be negatively impacted by ocean acidification, SLR, and increasing sea surface temperatures. The recent annual influx of Sargassum seaweed to Antigua and Barbuda's windward shores, which may be a result of climatic factors, is an unanticipated slow onset event with significant economic repercussions in tourism and fisheries. The agricultural sector is also particularly vulnerable to climate impacts. A drought in 2010 resulted in an overall loss of crops by 15%, with some crops sustaining losses up to 50%, while later that year excessive rain incurred losses to the crop sector totaling US $1 million.[104] A loss and damage mechanism is integral to building resilience to climate change in Antigua and Barbuda. **By 2030, an affordable insurance scheme will be available for farmers, fishers, and residential and business owners to cope with losses resulting from climate variability**.

Accompanying Information on Mitigation Actions

Without any known fossil fuel resources, Antigua and Barbuda relies almost exclusively on imported fossil fuels for energy: heavy fuel oil in electricity generation; gasoline and diesel in transport; and liquefied petroleum gas (LPG) for cooking. This has resulted in high emissions and high fuel costs. In 2006, Antigua and Barbuda's national emissions totaled 945.5 Gg CO_2, of which 92% were derived from fuel combustion in the energy sector.[105] In addition, the cost of fossil fuel imports, valued at US $165.4 million in 2013, or equivalent to 13.7% of the country's GDP, is a financial burden on the country's economy. The cost of electricity has risen to over US $0.40 per kWh,[106] and consumers in Antigua and Barbuda pay among the highest electricity prices in the world. High electricity rates inhibit adaptation strategies, such as seawater desalination; the provision of essential services; small businesses and low- and middle-income households; and economic growth.

However, in recent years, Antigua and Barbuda has made important strides in its sustainable energy policy. A National Energy Policy (NEP) was approved in November 2011, serving as the

[102] CARIBSAVE 2012, Climate Change Risk Atlas Profile for Antigua and Barbuda (CCCRA), p. 28.
[103] CARIBSAVE 2015, National Vulnerability and Impact Assessment, p. 44.
[104] CARIBSAVE 2012, Climate Change Risk Atlas Profile for Antigua and Barbuda (CCCRA).
[105] Antigua and Barbuda's GHG Inventory for the Third National Communication to the UNFCCC.
[106] IRENA Renewables Readiness Assessment (RRA) Background Paper, Working Draft, Antigua and Barbuda.

main policy for renewable energy (RE) and energy efficiency (EE) development. The NEP sets out the national approach to achieving its vision that, "By 2030 Antigua and Barbuda will meet the needs of the present generation while safeguarding the environment and enabling future generations to meet their own energy needs. All citizens and residents will have access to affordable, efficient, socially responsible and reliable forms of energy". This strategic plan proposes to exploit local energy resources and reduce fossil fuel dependence.

In March 2013, Antigua and Barbuda released a Sustainable Energy Action Plan (SEAP), to foster energy conservation and efficiency, diversification of energy sources, sustainable energy consumption and generation as well as the utilization of renewable energy sources. In 2015, Parliament enacted the Renewable Energy Act of 2015, to establish a legal, economic and institutional basis to promote the use of renewable energy resources. Towards this end, Antigua and Barbuda will, **by 2030, achieve an energy matrix with 50 MW of electricity from renewable sources both on and off-grid in the public and private sectors**.

Domestic and industrial waste is a growing environmental concern in Antigua and Barbuda, whereas technological assistance could reverse this trend and create new opportunities. A preliminary review of annual waste streams to the sanitary landfill suggests that some 80,000 tonnes annually of feedstock could be available for conversion to energy if an appropriate facility were available, mitigating CO_2, N_2O and CH_4 emissions. Antigua and Barbuda's goal is to, **by 2020, finalize technical studies with the intention to construct and operationalize a waste to energy (WTE) plant by 2025.**

Land use change and forestry contribute seven percent of national emissions, which can be mitigated through GHG emissions removal by carbon sinks. The Environmental Protection and Management Act of 2015 establishes the legal backing such that, "Where the area is protected as a carbon sink it shall follow the principles developed by the UNFCCC."[107] **By 2030, all remaining wetlands and watershed areas with carbon sequestration potential protected as carbon sinks**.

In 2014, the transport sector consumed over one quarter of the country's fossil fuel imports, 20% of which were gasoline and 11% diesel.[108] The NEP addresses this emissions sector by *inter alia* recommending the use of vehicles with higher fuel efficiency and lower emissions, and support for hybrid, flex-fuel for electric vehicles as national targets. Antigua and Barbuda aims to, **by 2020, establish efficiency standards for the importation of all vehicles and appliances**.

Consideration of INDC Mitigation/Adaptation Co-benefits

Antigua and Barbuda recognizes the co-benefits of adaptation and mitigation in the area of low carbon development as an efficient and cost-effective strategy for sustainable development. National circumstances highlight the country's exposure and vulnerability to climate impacts, and the ways in which mitigation actions, namely on and off-grid renewable energy, can increase resilience in critical sectors such as energy, water, health, and emergency services. Similarly, mitigation actions can have adaptation co-benefits. For example, expanding the protection of

[107] Section 53(8) of the Environmental Protection and Management Act of 2015 of Antigua and Barbuda.
[108] IRENA Renewables Readiness Assessment (RRA) Background Paper, Working Draft, Antigua and Barbuda, p. 9.

wetlands and watersheds to sink GHG emissions also serves as an adaptation strategy by enhancing water retention and reducing the risks of climate impacts, namely flooding and storm surge.

Additional Information on Support for Implementation

Antigua and Barbuda requires international support from multilateral and bilateral sources, including through the Green Climate Fund (GCF), the GEF and the Adaptation Fund, for capacity building, climate finance and technology transfer to be able to strengthen its current programs, policies and regulations, to develop and implement new initiatives, and to fully assess and address the impacts of climate change, as defined in the adaptation and mitigation targets. Additional activities requiring support for implementation include, *inter alia*:

- Technology, human resources and financial capacity assessment and road map;
- Support for the development of a Technology Strategy and Road Map that includes repurposing, decommissioning, and disposing of stranded assets;
- Comprehensive assessment on the national costs of adaptation and mitigation to climate change;
- Elaboration of a National Adaptation and Technology Plan;
- Enhancing Measurement, Reporting and Verification (MRV) processes;
- Development of standardized baselines to assess and monitor the impacts and benefits of implementing the INDC adaptation and mitigation initiatives;
- Support for data collection, storage and management; and
- Support for education, training, public awareness, public participation, public access to information, and international cooperation throughout implementation of the INDC targets.

Antigua and Barbuda expresses that this INDC is provisional and an updated version will be submitted as necessary. Antigua and Barbuda reserves the right to adjust this INDC, including information and parameters, before finalization under a new global agreement.