Working together in a changing climate

Vulnerability Impact and Adaptation Analysis in the Caribbean (VIAAC)

National Vulnerability Analysis for Antigua and Barbuda

Prepared by The CARIBSAVE Partnership with funding from United Nations Environment Programme: Regional Office for Latin America and the Caribbean (UNEP-ROLAC)

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List of Acronyms

ADRM	Agriculture Disaster Risk Management
AEWS	Agriculture Early Warning System
AIDS	Acquired immunodeficiency syndrome
ALP	Antiguan Labour Party
APUA	Antigua Public Utilities Authority
ARC	Antigua Rainforest Company
ARCT	Antigua Rainforest Canopy Tour
BPW	Body Pond Watershed
CAMI	Caribbean Agro-Meteorological Initiative
CANARI	Caribbean Natural Resources Institute
CARIBSAVE	Caribbean Sectoral Approach to Vulnerability and Resilience
CariCOF	Caribbean Climate Outlook Forum
CARICOM	Caribbean Community
CARIWIN	Caribbean Water Initiative
CBI	Caribbean Basin Initiative
CDB	Caribbean Development Bank
CDEMA	Caribbean Disaster Emergency Management Agency
CDM	Comprehensive Disaster Management
CDPMN	Caribbean Drought and Precipitation Monitoring Network
CPA	Country Poverty Assessment
CTCN	Climate Technology Centre and Network
DCA	Development Control Agency
DFATD	Department of Foreign Affairs Trade and Development
EAG	Environmental Awareness Group
EC	Eastern Caribbean
ECCB	Eastern Caribbean Central Bank
EIA	Environment Impact Assessment
EIMAS	Environmental Information Management and Advisory System
ESAL	Environmental Solutions Antigua Limited
FAO	Food and Agriculture Organisation
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GEF	Global Environment Fund
GOAB	Government of Antigua and Barbuda
GWP-C	Global Water Partnership Caribbean
HDI	Human Development Index
HFA	Hyogo Framework of Action
HIV	Human Immunodeficiency Virus
IMF	Inter-Monetary Fund
ISFNS	Information and Early Warning System for Food and Nutrition Security
IPCC	Inter-Governmental Panel on Climate Change
IWRM	Integrated Water Resource Management
LAC	Latin America and the Caribbean
NBSAP	National Biodiversity Strategy and Action Plan
NEMMA	North East Marine Management Area
NEMS	National Environmental Management Strategy

NEOC	National Emergency Operations Centre
NEST	National Economic and Social Transformation
NODS	National Office of Disaster Services
NPRS	National Poverty Reduction Strategy
OAS	Organisation of American States
OECS	Organisation of Eastern Caribbean States
PAHO	Pan-American Health Organisation
PSIA	Poverty and Social Impact Assessment
REGATTA	Regional Gateway for Technology Transfer and Climate Change Action in Latin America and the Caribbean
RRACC	Reduce Risks to Human and Natural Assets Resulting from Climate Change
SIDS	Small island Developing States
SIRMM	Sustainable Island Resource Management Mechanism
SIRMZP	Sustainable Island Resource Management Zoning Plan
SLR	Sea level rise
SPREP	South Pacific Regional Environment Programme
UNDP	United Nations Development Programme
UNEP-ROLAC	United Nations Environment Programme – Regional Office for Latin America and the Caribbean
UNFCCC	United Nations Framework Convention on Climate Change
UN-HABITAT	United Nations Human Settlement Programme
UNISRD	United Nations International Strategy for Disaster Reduction
UPP	United People's Party
USAID	United States Agency for International Development
VAT	Value added tax
VIA	Vulnerability, Impact and Adaptation
VIAAC	Vulnerability Impact and Adaptation Analysis in the Caribbean
WFCA	Walling Forest Conservation Area
WHO	World Health Organisation
WTO	World Trade Organisation

Executive Summary

By the middle of the 21st century, the Caribbean region is expected to be warmer by between 2°C to 3°C (IPCC, 2014). Like other small islands developing states (SIDS) in the Caribbean, Antigua is vulnerable to climate hazards such as hurricanes, drought and extreme rainfall and temperature changes. These hazards present challenges to development processes, particularly those related to the agriculture, water resources and health sectors. Contemporary vulnerabilities of these sectors and associated livelihoods are products of coupled economic and environmental interactions – double - exposure. Such interactions can heighten vulnerabilities at various levels in the society. A critical overview of the status of the vulnerability of these sectors shows that climate change is significantly impacting livelihoods that directly and indirectly dependent on ecosystem services.

To this end, The Regional Gateway for Technology Transfer and Climate Change Action in Latin America and the Caribbean (REGATTA) supports countries in this region in addressing climate change through the exchange of knowledge, the development of pilot projects, and the provision of advisory services in adaptation and mitigation. REGATTA accomplishes these goals in collaboration with a set of regional Knowledge Centres for climate change technology transfer. REGATTA also contributed to the implementation of the Climate Technology Centre and Network (CTCN) in Latin America and the Caribbean (LAC).

In response to priorities conveyed by government authorities during the first REGATTA Roundtable meeting, the United Nations Environment Programme - Regional Office for Latin American and the Caribbean (UNEP-ROLAC) is working with governments and regional Knowledge Centres to conduct climate change vulnerability, impact, and adaptation (VIA) analyses in each of the four sub-regions of LAC. The national VIA in Antigua and Barbuda are to:

1. Conduct a climate change Vulnerability Impact and Adaptation analysis in water resources, agriculture and the health sector at the national scale;
2. Identify adaptation options for national action;
3. Support national policies and development planning processes, with the results of the VIA analysis.

To effectively achieve these objectives, detailed climate variability analysis was combined with national scale analyses of vulnerability (exposure, sensitivity and adaptive capacity) and adaptation options. The preliminary findings are presented below

Climate Variablity

The climate analysis for Antigua is a product of national and regional rainfall and temperature trends and implications for vulnerability. Specifically, the analysis included: (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-October 2014 and (d) National and regional wet and dry season analysis.

- Current climate trends from 1986-2010 for the eastern Caribbean including Antigua and Barbuda indicate a +0.3C / decade increase in daily maximum temperature and daily minimum temperature (also see Stephenson et al. 2014). However, there is no clear statistical trend in annual precipitation

- Antigua and Barbuda lie in a zone that is expected to receive 30-50% less rainfall in 2090 with respect to late twentieth century rainfall normals. The drying signal has been attributed to a strengthening Caribbean Low Level Jet and a relatively cooler tropical North Atlantic sea surface temperature compared to tropical Pacific sea surface temperatures.
- After a decade of favorable rainfall conditions, drying was observed during the early to mid-1990s. This drying trend could be seen through low standardized precipitation index (SPI) values during that period. Recently, very low SPI values that indicate drought conditions were also observed in 2009 and 2014.
- Average rainfall between May and December throughout the Lesser Antilles represents 80% of annual totals, whereas the Greater Antilles receive only about 60% of annual rainfall during the same period.
- Monitoring SPI in real time at various time intervals can help to alert residents of possible drought conditions. For example, due to the decrease of expected late season rainfall, 2009 rainfall totals were approximately 25% less than normal. In contrast, rainfall totals in 2010 were about 25% higher than normal.
- A slight decrease in remotely sensed vegetation “greenness” (measured by derived Normalized Difference Vegetation Index, NDVI) occurred in the later part of 2009 in response to the drought conditions. An NDVI difference map between 2010 and 2009 December NDVI values shows that the 2009 drought caused lower NDVI values throughout most of Barbuda and along the northern section of Antigua
- On average maximum NDVI values for Antigua occur late in the year during December as a lagged response to the average peak rainfall during the late summer. Inter-annual variability in rainfall amounts and related vegetative response does occur within Antigua.

Vulnerability Conditions

The assessment of climate change vulnerability at the national level is based on primary data from national stakeholders and key informant interviews. Stakeholders were brought together to discuss the exposure, sensitivity and adaptive capacity of the three focus sectors. This information was combined with secondary data in NVIVO qualitative analysis software to characterized sector-specific vulnerability.

Health and Water Resources

- There is a consensus among national stakeholders that the projected climate changes will lead water shortages and increased risk to health and well-being.
- Projected higher temperatures are usually more favourable to various bacteriological and epidemiological agents therefore increasing the possibility of the spread of various communicable and infectious diseases.
- The projected increase of approximately 1.5oC-2.0o C by 2030 and 2050 places the elderly, persons with cardiac and respiratory problems, persons working with outdoors engaged in strenuous activity, and persons living and working in poor ventilated areas at risk of morbidity or mortality due to heat stress
- Increased flooding will contribute to creating an environment conducive for the development and spread of vectors such as the Aedes aegypti mosquito. Antigua and Barbuda is expected to be at risk from increased incidences of vector borne diseases such as Yellow Fever and Dengue Fever.
- Drought conditions would result in increased risk of the transmission of diseases such as cholera, typhoid, and bacterial dysentery. A major concern is the contamination of underground water storage from sewage by salmonella, gastroenteritis, shigellosis, and campylobacter.

- Projected SLR can have devastating impact on critical water supply and communication infrastructure. It is anticipated that 2% of communication networks and 100% of seaport lands will be at risk from 1 m SLR.
- Despite the fact that the southwest areas are categorised as wetter regions in Antigua and Barbuda, the average potential evapotranspiration exceeded effective precipitation (estimated at 70% of actual) in 11 months of the year. This contributed to constrained plant growth due to inadequate water supply, which significantly affected agricultural crop production.
- Water resources will be even more stressed. The quantity and quality of water will be compromised by:
- Decrease in rainfall
    - Evaporation of surface water storage
    - Saline intrusions in the fresh water aquifers of the coastal zones and in Barbuda where the main water supply is ground water.
    - Watersheds impacted by drought
- The particular location identified as the most vulnerable to drought was the southeast of Antigua between English Harbour and St. James.
- Some of the areas which are most affected by flooding and mudflows included Osbourn/north Pigotts areas; North Sound leading into Fitches Creek; Parts of Paynters Community; York's New Extension; Bolands, Halcyon Road in the vicinity of McKinnon's and Yorks Village, Cashew Hill Buckleys Road and Bath Lodge in Jennings, Grays Farm, Green Bay and Golden Grove.

Agriculture

- There is a consensus among stakeholders that the effects of climate change on agriculture in Antigua will be both direct and indirect. The country is a net importer of food, and climate change impacts in supply countries will affect the price and availability food. Local farmers are already feeling the effects of climate change which will is affecting domestic food production and food security.
- Periods of drought have had devastating effects on livelihoods within agriculture industry. The agriculture sector is highly vulnerable to climate related events, low annual rainfall and high evaporation and transpiration rates. Period of drought require irrigation for continued yields and moderate levels of production and if not feasible result in extensive crop losses.
- Despite the sector's low contributions to GDP and the reliance on food imports, the sector is a significant source of local foods supply and plays a major role in economic growth and diversification efforts.
- The fisheries sub-sector is vulnerable to hurricanes, high winds and extreme wave action but also indiscriminate actions such as pollution, wetland destruction, and unplanned development
- Continued land degradation and destruction of biodiversity are critical problems for Antigua and Barbuda and could significantly affect the future sustainable development of Antigua and Barbuda.

1 Introduction

1.1 Project Background and Approach

The Regional Gateway for Technology Transfer and Climate Change Action in Latin America and the Caribbean (REGATTA) supports countries in this region in addressing climate change through the exchange of knowledge, the development of pilot projects, and the provision of advisory services in adaptation and mitigation. REGATTA accomplishes these goals in collaboration with a set of regional Knowledge Centres for climate change technology transfer. REGATTA also contributed to the implementation of the Climate Technology Centre and Network (CTCN) in Latin America and the Caribbean (LAC).

In response to priorities conveyed by government authorities during the first REGATTA Roundtable meeting, the United Nations Environment Programme - Regional Office for Latin American and the Caribbean (UNEP-ROLAC) is working with governments and regional Knowledge Centres to conduct climate change vulnerability, impact, and adaptation (VIA) analyses in each of the four sub-regions of LAC.

In furtherance of its mandate, UNEP-ROLAC provided technical assistance to conduct VIA analyses in three countries of the Caribbean sub-region, which include Antigua and Barbuda, The Commonwealth of Dominica and The Republic of Haiti.

The CARIBSAVE Partnership is the executing agency for the implementation of the Caribbean VIAs. In Antigua, CARIBSAVE is working with the Environment Division in the Ministry of Agriculture, Housing, Lands and the Environment. Local stakeholders selected water resources, agriculture, and health as priority sectors for the vulnerability analyses.

The main objectives of the national VIA in Antigua and Barbuda are to:

- Conduct a climate change VIA analysis in water resources, agriculture and the health sector (priority sectors) at the national scale;
- Identify adaptation options for national action;
- Support national policies and development planning processes, with the results of the VIA analysis.

The VIA provided the understanding of Antigua and Barbuda's exposure to climatic events based on current climate variability and future change. The VIA also identified:

- the impact of land use changes related to major economic activities like tourism and agriculture on vulnerability;
- key ecosystem services that contribute to livelihoods of national and local populations;
- the impact of activities related to these livelihoods such as tourism, agriculture and fishing on key ecosystem services;
- the sensitivity of water resources, agriculture and health to current climate variability and future climatic changes;
- natural, social, economic, political, and human capital related to adaptive capacity; and
- nationally appropriate adaptation options to be integrated into strategies and policies.

The VIA analysis complements and reinforces ongoing research and planning processes in Antigua and Barbuda. Specifically the VIA will contribute to the country's Third National Communication on Climate Change to the United Nations Framework Convention on Climate Change (UNFCCC).

1.2 Vulnerability Assessment Approach and Framework

Vulnerability is a function of the character, magnitude, and the rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity. As a result, particular areas or communities may demonstrate differing degrees of vulnerability, which forms the basis for conducting VIA analyses.

The REGATTA regards VIA analysis as a critical tool, which is designed to assist decision-makers in effectively planning for climate change by evaluating the extent and magnitude of the expected impacts and identifying practical and feasible measures to manage anticipated changes (REGATTA, 2014). There is no single approach for conducting VIA analysis; however a framework was developed under the REGATTA initiative which is based on an extensive review of the climate change VIA analyses and implementation of 4 VIA projects in the LAC region. The framework captures the key components that a VIA should entail to produce results that can be used for adaptation planning process (Figure 1) (REGATTA, 2014).

Within the VIA framework critical aspects of vulnerability include exposure, sensitivity, and adaptive capacity. This VIA analysis has followed the VIA Methodological Framework (Figure 1), which has been adapted to the local Antigua and Barbuda context, sector of analysis and utilised various methods to assess each component of the assessment

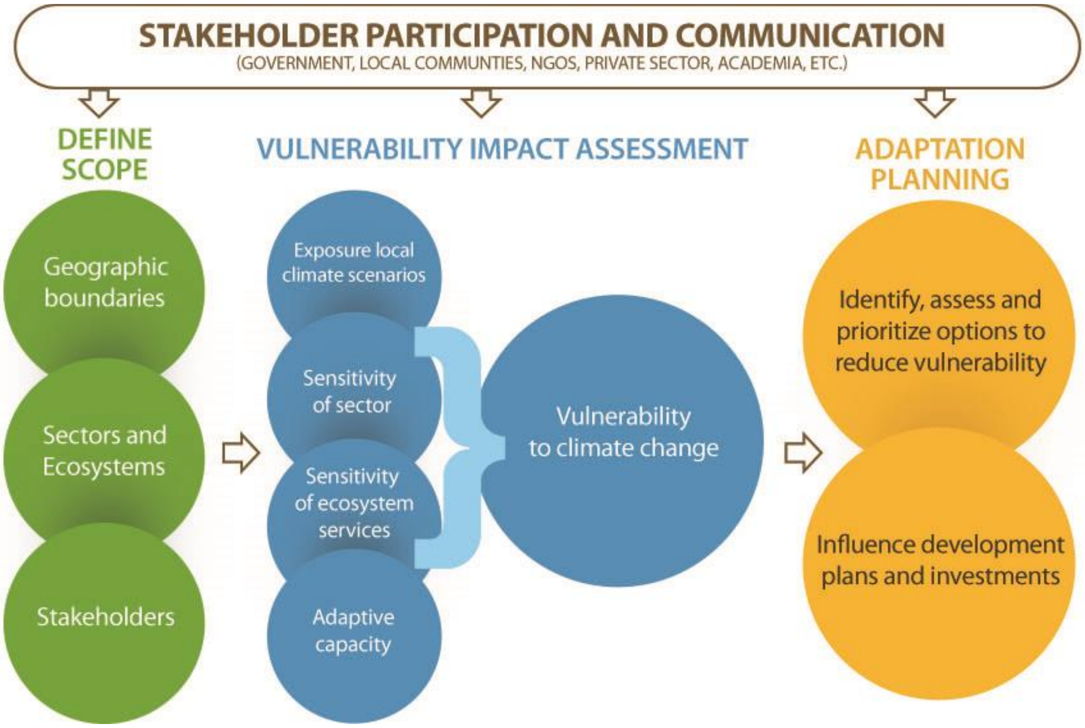

Figure 1a – REGATTA VIA Analysis Methodological Framework (REGATTA, 2014)

1.3 Overview of Analysis Process

A strong emphasis was placed on the use of existing information, stakeholder consultations, and local knowledge. Existing studies, projects and other secondary sources of information for conducting VIA analysis relevant to Antigua and Barbuda was reviewed. Data and information gaps were filled as far as was feasible within the resource limits of the project and proxies were used where appropriate. However, value was added through analyses and outputs relevant to both local and national level decision makers.

Collaboration among stakeholders in conducting a VIA analysis lessens the occurrence of simple mistakes which that reduces the effectiveness of adaptation actions. Therefore, national level consultations and workshops were conducted to:

- agree on objectives and information needs
- discuss ongoing and planned initiatives and policies of relevance to this project;
- discuss vulnerability indicators and criteria for consideration of implementable adaptation options and
- provide an indication of the type of information policy marker require.

During the national stakeholder consultations, stakeholders were asked to identify vulnerabilities, provide reasons for these existing vulnerabilities, and identify opportunities for synergies on adaptation measures or strategies.

Vulnerability indicators were developed in order to measure and monitor vulnerability and to account for the diverse socio-economic and environmental situation and processes that shape vulnerability and available capacities within Antigua and Barbuda. A vulnerability scoring framework was developed to guide the selection of draft indicators for water resources, agriculture, and health (priority sectors). The most appropriate indicators selected by stakeholders for each priority sector were used to guide the vulnerability assessment.

A preliminary identification of adaptation options was undertaken for each sector (water resources, agriculture, and health). These identified adaptation options strengthened ongoing policy and planning processes and utilised data from the literature review and expert opinion.

Participatory stakeholder involvement in the identification and prioritisation of adaptations option yielded valuable information about the priorities and expectations. As a result each possible option for Antigua and Barbuda was prioritised at the national scale participatory scenario planning- workshop where preliminary findings were strengthened and new options were identified.

The climate analysis is a product of national and regional rainfall and temperature trends and implications for vulnerability. Specifically, we analyse: (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-October 2014 and (d) National and regional wet and dry season analysis.

2 National Context

2.1 Climate variability analysis

The twin-island state of Antigua and Barbuda is the most central of the leeward island chain (from Virgin Islands to Dominica) within the Caribbean Region and has an exclusive economic zone of approximately 110,071 sq. km.

Differences in exposure to climate hazards vary among islands, depending on their physical form. The culture, ecosystems, populations, and therefore vulnerabilities are different for each island. It is therefore critical to understand the context-specific conditions for each island when considering risk (IPCC, 2014).

The island of Antigua experiences a bimodal annual rainfall pattern that is characteristic of the Caribbean. Rainfall peaks occur during the late spring and late summer period separated by a mid-summer rainfall minimum known as the "mid-summer drought" (Magaña et al. 1999) (Figure 2).

In general, the climate of the Caribbean can be classified as dry-winter-tropical with Antigua exhibiting similar patterns. Despite a general Caribbean climate, sub-regional variations in rainfall do exist (Jury et al. 2007).The seasonal variation in rainfall throughout the Lesser Antilles including Antigua and Barbuda is classified by low precipitation amounts during the winter months and early spring followed by increasing rainfall from the late spring into fall with maximum rainfall occurring between September and October.

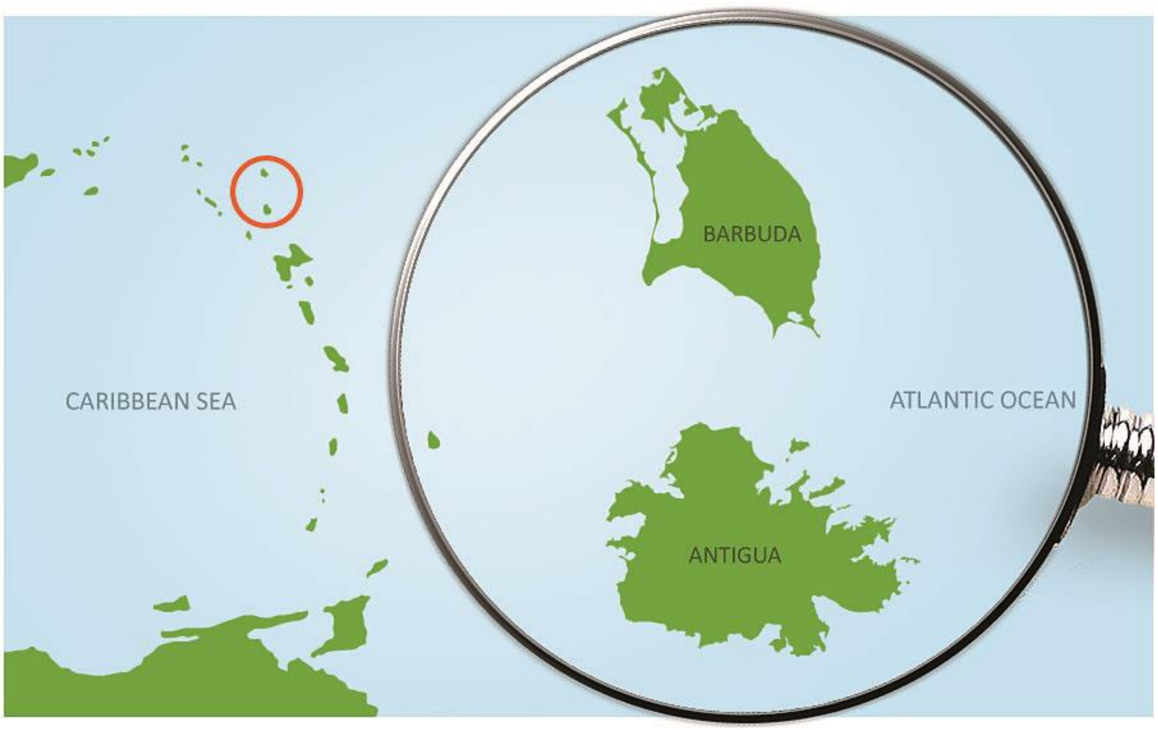

Figure 1b – Geographic location of Antigua and Barbuda

Average rainfall between May and December throughout the Lesser Antilles represents 80% of annual totals, whereas the Greater Antilles receive only about 60% of annual rainfall during the same period.

Inter-annual variability in rainfall amounts and related vegetative response does occur within Antigua. Monthly rainfall rates derived from NASA's Global Precipitation Climatology Project (GPCP) illustrate periods of low and high rainfall from 1979-2014 (Figure 3). After a decade of favorable rainfall conditions, drying was observed during the early to mid-1990s. This drying trend could be seen through low standardized precipitation index (SPI) values during that period (Figure 4). Recently, very low SPI values that indicate drought conditions were also observed in 2009 and 2014. In general, monitoring SPI in real time at various time intervals can help to alert residents of possible drought conditions.

The period between January to March is characterised as the dry season as typically less than 20% of the annual rainfall occurs during this period. The wet season, generally between August to November receives approximately 45-50%. May-July and December are characterised as the intermediate months and receive an average of 30-35% of the total annual rainfall

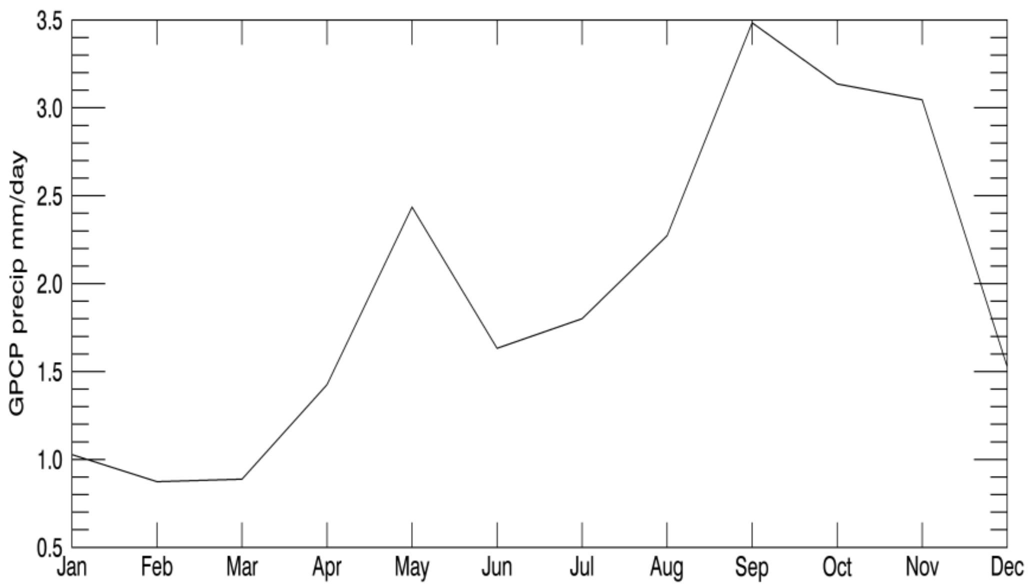

Figure 2 – Annual rainfall cycle (1979-2014) derived from a single NASA Global Precipitation Climatology Project (GPCP) grid cell containig the island of Antigua. Units are in mm/day.

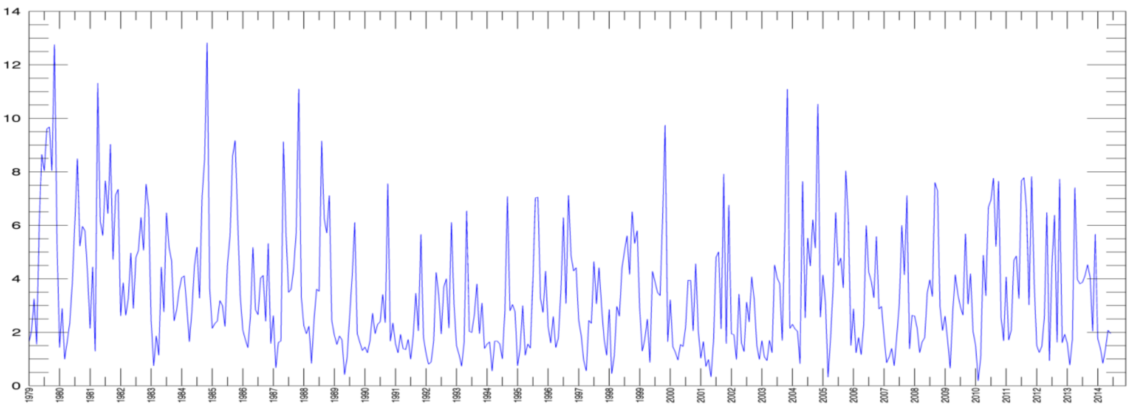

Figure 3 - Monthly precipitation time series derived from a single NASA Global Precipitation Climatology Project (GPCP) grid cell containing the island of Antigua from January 1979-October 2014. Units are in mm/day.

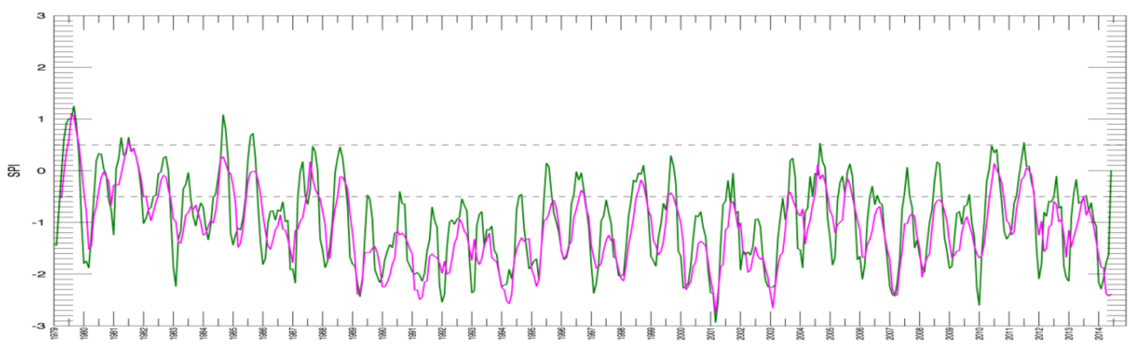

Figure 4 - Standardized Precipitation Index (SPI) calculated from monthly precipitation time series from a single NASA Global Precipitation Climatology Project (GPCP) grid cell containing the island of Antigua from January 1979-October 2014. SPI for three months (green) and for 7 months (magenta) are plotted above.

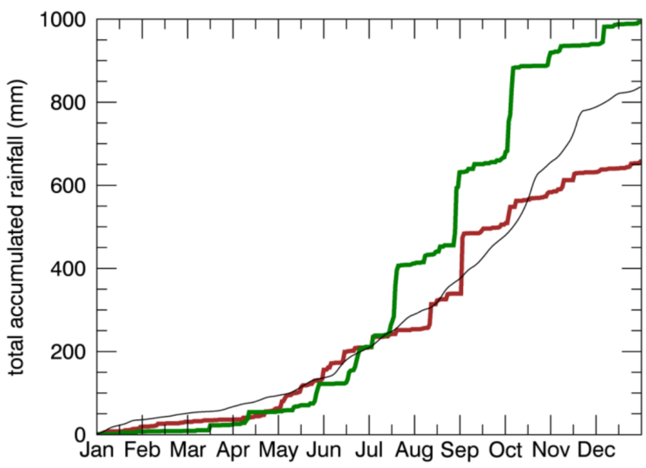

Figure 5 - Accumulated annual rainfall calculated from the remotely sensed NASA TRMM precipitation grid cell over the island of Antigua for 2009 (red), 2010 (green), and the 1998-2009 climatology (black). Rainfall was normal up until mid-summer during both 2009 and 2010. However, 2009 experienced approximately 25% less rainfall than normal during the later rain season while 2010 experienced approximately 25% more rainfall than normal. Dry spells can be represented by horizontal lines throughout the annual accumulated daily rainfall time series. Steep vertical lines show when rainfall events occurred.

The drought during 2009 in Antigua can be placed into context with normal conditions through an annual accumulated rainfall analysis (Figure 5). Rainfall conditions during 2009 were normal until October when expected late season rainfall did not occur. Thus, rainfall during the latter part of the season is critical towards providing expected rainfall conditions. Due to the decrease of expected late season rainfall, 2009 rainfall totals were approximately 25% less than normal. In contrast, rainfall totals in 2010 were about 25% higher than normal.

A slight decrease in remotely sensed vegetation "greenness" (measured by derived Normalized Difference Vegetation Index, NDVI) occurred in the later part of 2009 in response to the drought conditions (Figure 6). An NDVI difference map between 2010 and 2009 December NDVI values shows that the 2009 drought caused lower NDVI values throughout most of Barbuda and along the northern section of Antigua (Figure 7). On average maximum NDVI values for Antigua occur late in the year during December as a lagged response to the average peak rainfall during the late summer.

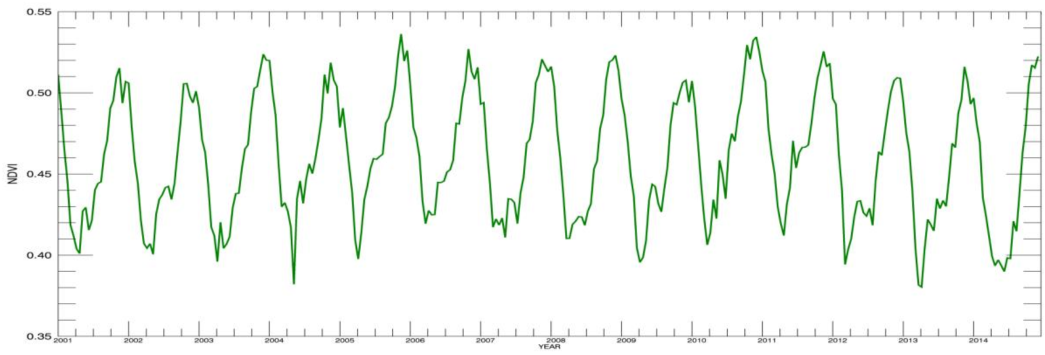

Figure 6 - Remotely sensed Normalized Difference Vegetation Index (NDVI) time series from January 2001 to late December 2014 derived from the Terra-MODIS satellite at 250 meter spatial resolution. NDVI time series is computed from an area average of all 250 meter MODIS pixels covering the island of Antigua.

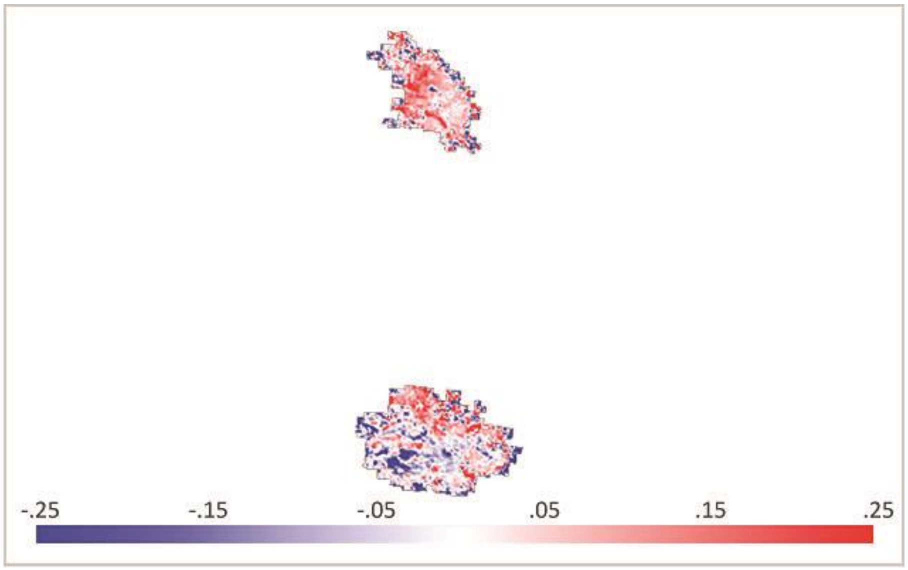

Figure 7 - NDVI difference between December 2010 NDVI minus December 2009 NDVI for the islands of Antigua and Barbuda.

Current climate trends from 1986-2010 for the eastern Caribbean including Antigua and Barbuda indicate a +0.3C / decade increase in daily maximum temperature and daily minimum temperature (Stephenson et al. 2014).However, there is no clear statistical trend in annual precipitation. Despite current stabilized rainfall trends, there is a strong overall Caribbean drying signal in late century climate model projections (Taylor et al. 2013; Rauscher et al. 2008). Antigua and Barbuda lie in a zone that is expected to receive 30-50% less rainfall in 2090 with respect to late twentieth century rainfall normals.

The drying signal has been attributed to a strengthening Caribbean Low Level Jet and a relatively cooler tropical North Atlantic sea surface temperature compared to tropical Pacific sea surface temperatures. A warmer tropical Pacific is indicative of an El Nino state which has been known to negatively impact Caribbean rainfall in the season before peak tropical Pacific warming (Giannini, Kushnir, and Cane 2000)(Figure 8).

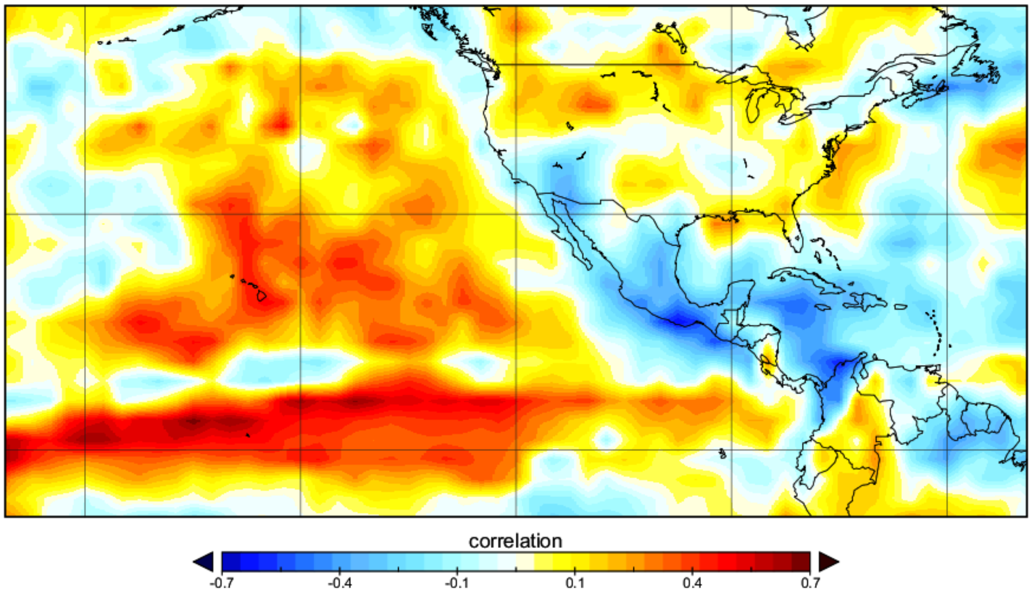

Figure 8 - Spatial correlation between July rainfall and the following December Nino 3.4 index.

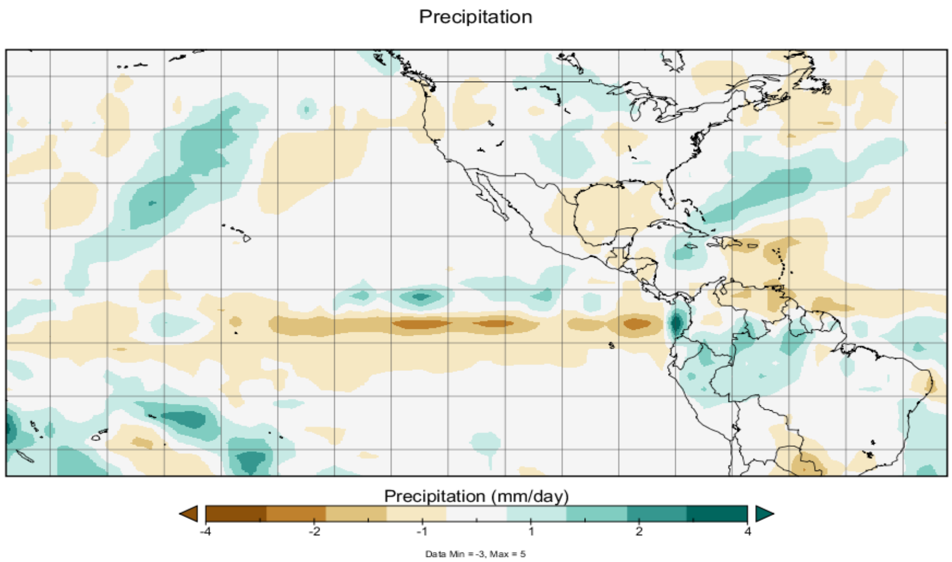

Figure 9 - Dry composite: 2001, 1989, 2007, 1999, 2003

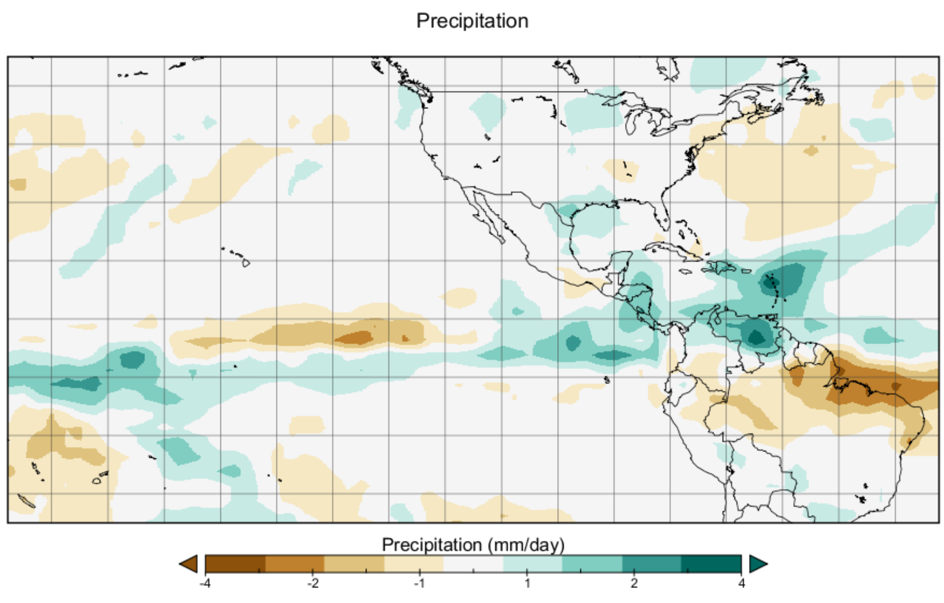

Figure 10 - Wet composite: 1987, 2004, 1993, 2012, 1981

GPCP rainfall composites (mm/day) from top 5 dry May years and top 5 wet May years from 1979-2014 in Antigua.

Wet and dry May composites are in phase with a wet or dry Pacific Inter-Tropical Convergence Zone. The climatological peak of early season rainfall during May guides the decision to composite on wet/dry Mays.

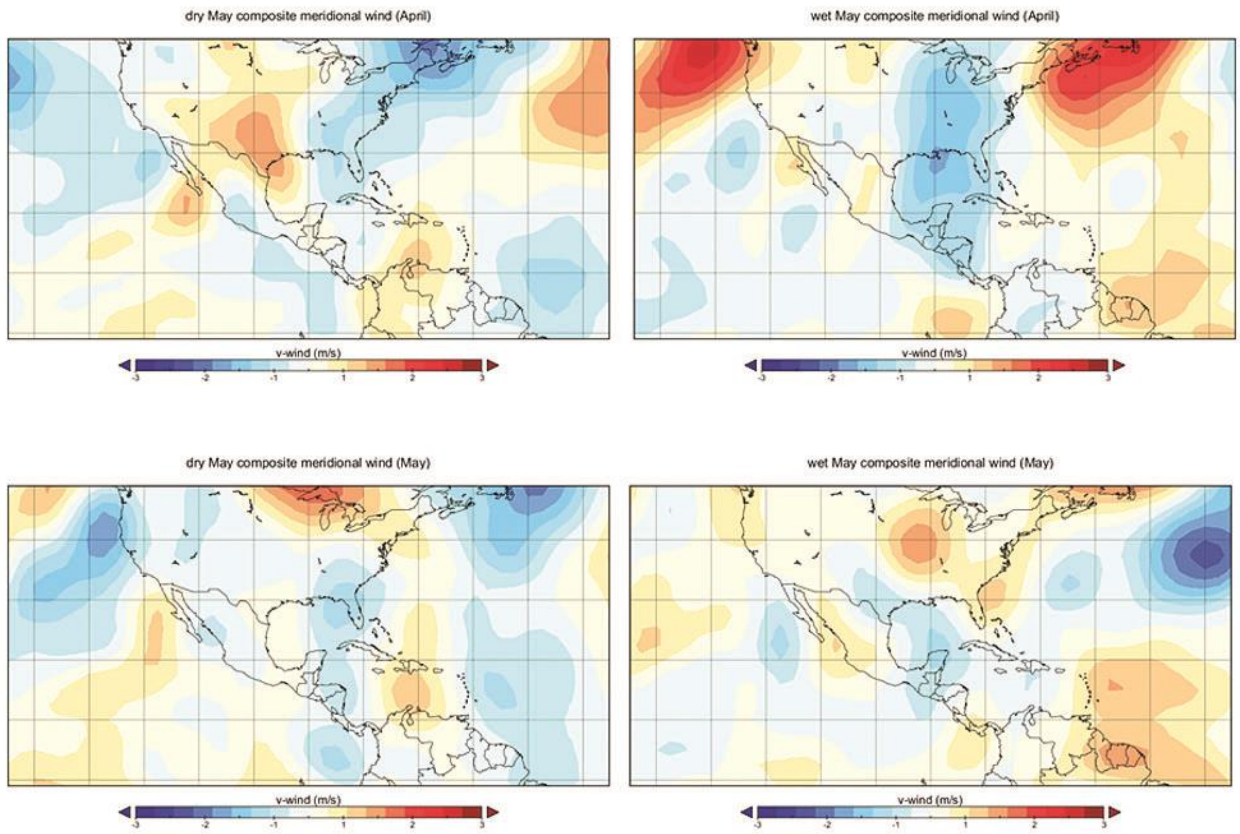

Figure 11 - Dry early season rainfall (left) is punctuated by lower tropospheric northerly flow (blue shading) at the 850hPa level during April and May. Wet early season rainfall (right) is punctuated by moist southerly flow from the tropics (red shading).

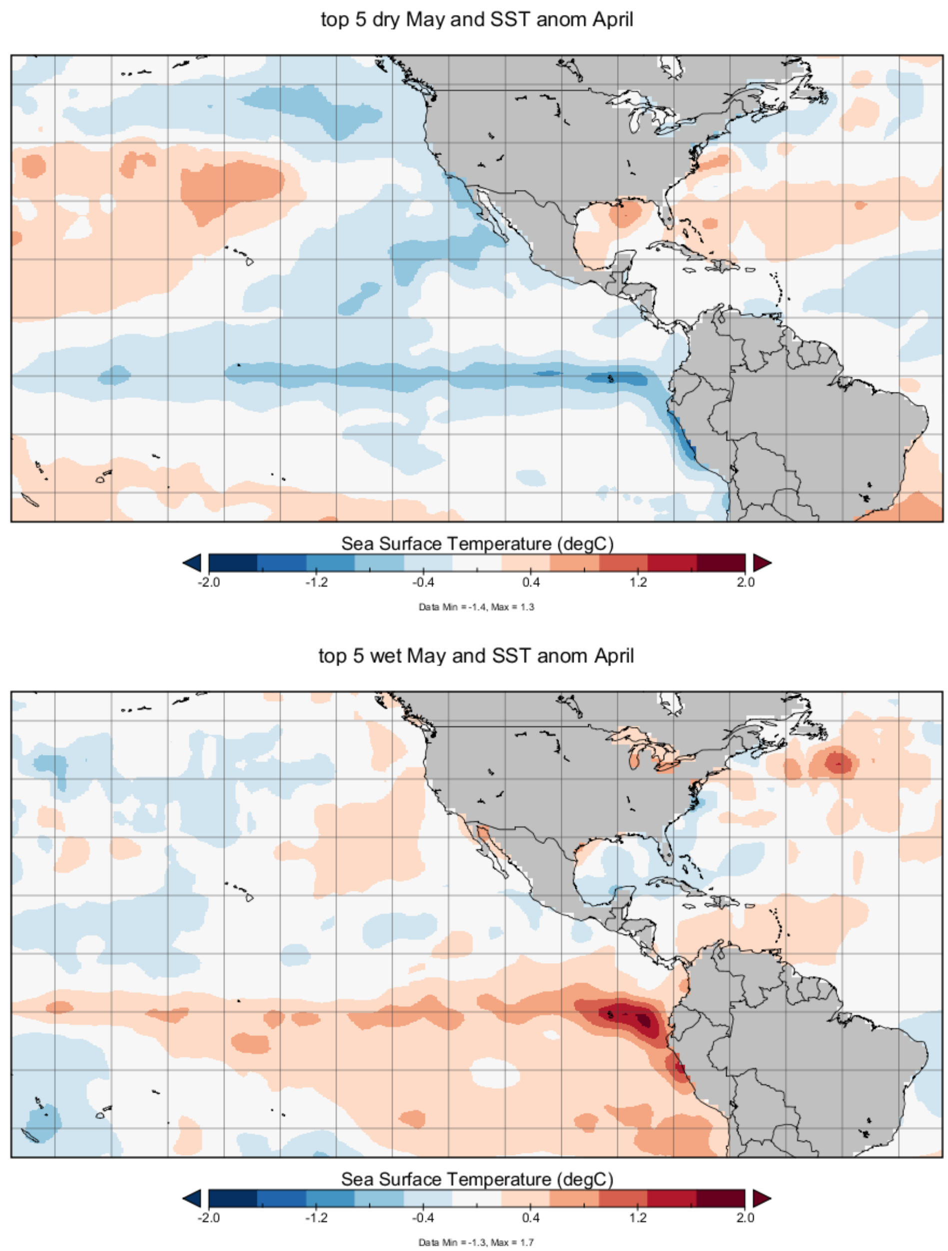

Figure 12 - 1 month lead time April sea surface temperature anomalies from dry (top) and wet (bottom) May composites.

Dry composites are consistent with a cooler equatorial Pacific during April and a warmer equatorial Pacific during April for wet composites. In addition sea surface temperatures in April are warmer than normal throughout the southern Caribbean Sea during wet composite years.

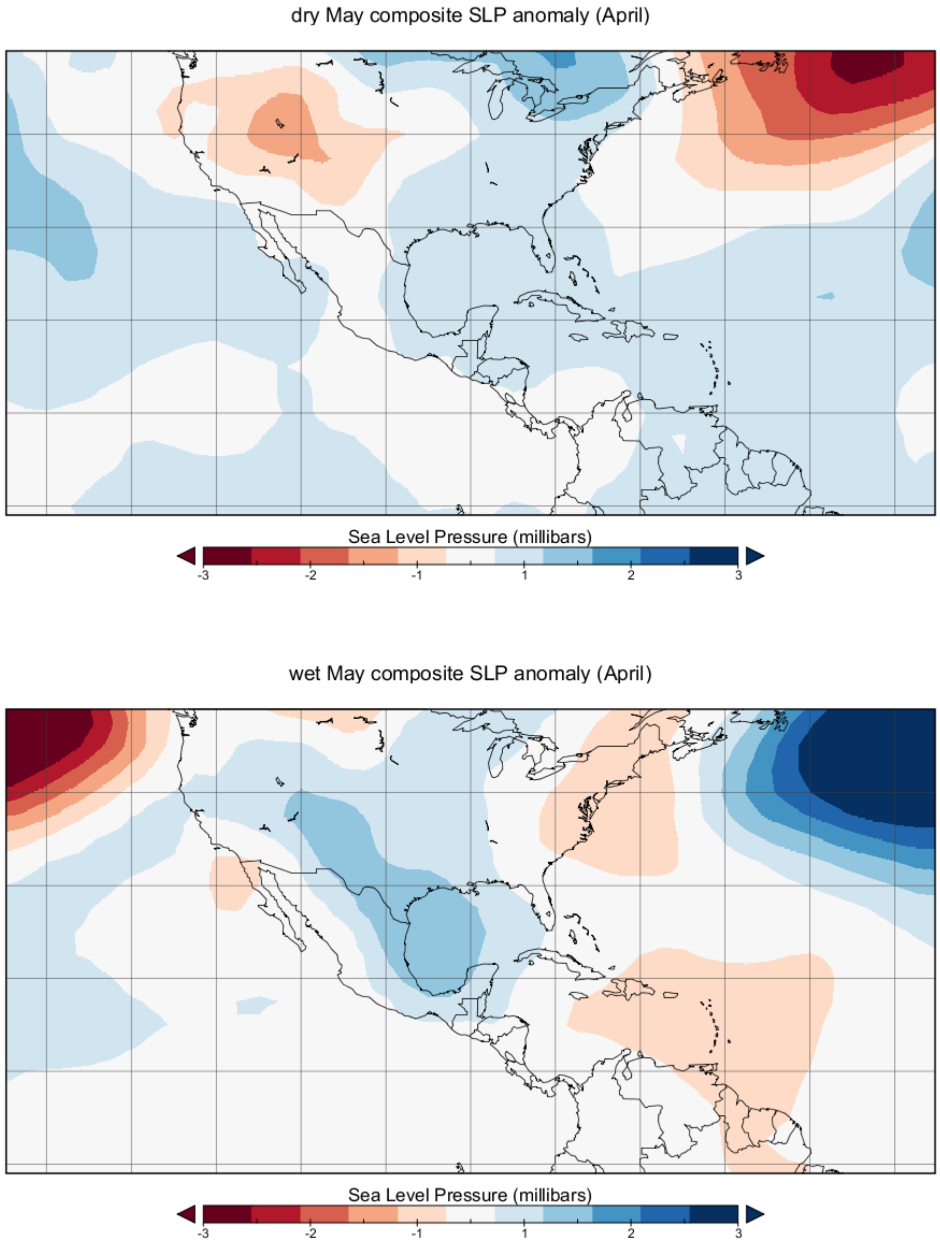

Figure 13 - 1 month lead time April sea level pressure anomalies from dry (top) and wet (bottom) April composites.

Higher sea level pressures throughout the Caribbean during April may lead to drier conditions for Antigua during May from enhanced subsidence. Lower sea level pressures throughout the Caribbean during April may lead to wetter conditions in May.

One of the main differences between the two islands is that Barbuda receives lower amounts of rainfall annually due to its topography. Barbuda is one of the driest islands in the Caribbean Region. The limestone nature of Barbuda and the estimated 750 mm of rainfall per year contribute to the island being more prone to drought. Barbuda's dry season ranges from December to July, while the wet season rages from August to November (GENIVAR, 2011).

Recent observations by the Antigua and Barbuda Meteorological Service include:

- A decline in June precipitation
- A shift in the direst months from February to March
- A levelling of the rainfall peak in September and a consistent but minor peak in rainfall in May (Simpson et al, 2012).

Over a thirty-year period (1984- 2013), it was noted that the months of September through to November have the highest 30 year means (1984-2013) for rainfall (131.2 mm, 142.4 mm and 139.7 mm respectively) which coincides with the active part of the hurricane season. February is typically the driest month of the year having the recorded 42 mm the lowest amount of average monthly rainfall for the period 1984 – 2013.

Projections under the SRES A2 and B2 emission scenarios demonstrate an increase in rainfall during the latter part of the wet season (November-January) in the northern Caribbean (north of 22°N) and drier conditions in the southern Caribbean, with drying in the traditional wet season (June –October). The lengthening of the dry periods and increasing frequency of drought are expected to increase demand for water across the Caribbean Region (IPCC, 2014).

Annual rainfall gradually increased to 99 mm in May before decreasing again in June to an average of 64.2 mm (mid-summer dry spell). The peak rainfall season is from September to November. Due ENSO cycle, there is the possibility of very wet years in Antigua and Barbuda (Mitchell, 2009). El Niño and La Niña events are characterised by warmer and cooler than average sea surface temperatures in the tropical Pacific respectively and they are associated with changes in wind, pressure and rainfall patterns (Nurse, 2011).

2.2 Socio-demographic Conditions

Risks due to climate change are as a result of climate related hazards (climate trends and extremes) and the vulnerability of exposed communities, countries and systems (as it relates to livelihoods, infrastructure, ecosystem services and governance systems). For example, poverty is a critical factor in determining vulnerability to climate change and extreme events (IPCC, 2014).

The 2001 National Census estimated the population of Antigua and Barbuda at 70,737 with 33,642 males and 37,094 females. The preliminary data from the 2011 Census of Population and Housing estimated the population of Antigua and Barbuda at 86,295, consisting of 41,481 males and 44,814 females. This implies that between 2001 and 2011 Antigua and Barbuda's population increased by 18.8% (GOAB, 2012a). The country has a life expectancy rate of 72 and 74 years for males and females respectively. The population can be described as youthful with 28% of the population below 15 and only 7% over 65 years (GOAB, 2012a).

The National Country Poverty Assessment (CPA) (conducted in 2007) set a vulnerability line at 125% of the poverty line. This vulnerability line indicated the number of persons who are at risk of falling into poverty, should an unanticipated event such as a natural disaster or some type of economic shock occurs. The CPA indicated that based on the vulnerability line that an additional 10% of the population was expected to fall below the vulnerability line in the event of unanticipated catastrophe such as natural or manmade disasters (Goodwin, 2009 and UN-HABITAT, 2011).

The introduction of sale tax in 2007; increased food and fuel prices in 2008 along with increased import duties in 2009 amplified hardship across the country. In 2006, the poverty line for Antigua and Barbuda was estimated at EC $2 449.00 (US $917) per annum or EC 6.71 (US $2.51) per day and the impoverished portion was estimated to be 3.7% of the population (GOAB, 2011 and UN-HABITAT, 2011). St. John's City and St. Philip in Antigua possessed higher than average poverty levels in 2011 (UN-HABITAT, 2011).

Some major social problems that have affected the country include: percentage of the population infected with HIV/AIDS; serving as a transhipment point for international nacro-trafficking industry between South America and North Atlantic countries; and environmental degradation.

The Caribbean has experienced an epidemiological transition, which pose tremendous threat to the regional health situation. Incidences of diseases, which are primarily based on physiological malfunction, have increased and have overtaken incidences of diseases, which have their originals in the physical environment (Kairi Consultants Limited, 2007).

In addition, the Caribbean region has the second highest HIV prevalence in the world only second to Saharan Africa. AIDS epidemic continues to be the leading cause of death among adults 25-44 years in the Caribbean, and has orphaned approximately 250,000 children (CARICOM & U.S. Government, 2010). In 2012, in Antigua and Barbuda there were 216 persons with advanced HIV. Between January-December, 2013, 33 persons in Antigua and Barbuda were diagnosed with HIV/AIDS. The percentage of persons aged 15-24 and 15-49 years who were infected with HIV in 2013 was 12.12% (4) and 70% (23) respectively (GOAB, 2014a). The impact of these health issues on the youthful population of Antigua and Barbuda can have a crippling impact on the labour force and the country's overall economic system, therefore reducing the human capital and adaptive capacity of the country to climate change.

The recent economic review by the Caribbean Development Bank (CDB) indicated that violent crimes involving firearms was a major challenge for Antigua and Barbuda because it could potentially exacerbate the socio-economic situation within the country by severely affecting the tourism industry (Gore-Francis, 2013).

Despite these social issues in 2007 Antigua and Barbuda, ranked 57th on UNDP's Human Development Index making it the second highest ranked in the OECS during that year. The human development ranking in 2007 was based on the life expectancy at birth of 73.9 years, a literacy rate of 85.8% and a GDP per capita of US$12,500.00 in 2004/2005. This demonstrates that Antigua and Barbuda possesses the potential to improve its social conditions and its overall adaptive capacity to climate change

2.3 Governance and Institutional Arrangements

Antigua and Barbuda has a British parliamentary system of government and there are three branches of government, which include Legislative, Executive, and Judicial (UN-HABITAT, 2011). The Legislative branch consists of the House of Representatives (Lower House) which is responsible for introducing legislations and the Senate (Upper House) made up of 17 senators, which reviews and provides approval for the proposed legislation. The members of the House of Representatives are elected by popular vote during general national elections. The Executive Branch of government is formed from the Legislative Branch. The Prime Minister is responsible for creating an executive government through the appointment of other Members of Parliament to serve as his Cabinet Ministers (UN-HABITAT, 2011).

The Judicial branch of government includes a Magistrate's Court for minor offences and a High Court for major offences. The Judicial branch is designed to be independent of the Legislative and Executive branches although the Office of the Attorney General appoints the Magistrates.

General elections are constitutionally mandated every 5 years (GOAB, 2009a). The Antiguan Labour Party (ALP) won the last elections held on 12th June 2014, by winning 14 of 17 seats while the United People's Party (UPP) captured the remaining 3 seats.

Barbuda is governed by an 11 member council, which is given legal and institutional authority by the Barbuda Local Government Act CAP 44 of the Laws of Antigua and Barbuda. The major responsibility of the Council includes management of agriculture and forestry; overseeing public health, facilities, and services; the administration and regulation of public utilities; and the collection of financial assistance (Government of Antigua and Barbuda, 2012b).

2.3.1 Institutional Arrangements for Climate Change

The Caribbean Planning for Adaptation to Climate Change (CPACC) project contributed significantly to changing the approach to the implementation of internationally funded climate change projects in the Caribbean. CPACC contributed to capacity building for climate change through various workshops and the development of a draft policy for management of climate change impacts in the Caribbean.

With increased awareness of the various conventions, the GOAB took actions to improve the institutional arrangements for the implementation of the provisions of the conventions at the national level. These actions included the establishment of a coordinating mechanism for all the conventions; building capacity at the national level and the establishment of an Energy Desk with the responsibility of addressing the sector that is the greatest contributor of greenhouse gas emissions (GHG) (GOAB, 2009a).

The responsibilities for implementation of the UNFCCC now reside with the Environment Division. In 2005, the Environment Division became the technical agency for the implementation of the provision of the Convention (GOAB, 2009a). Other institutions involved in international negotiations and other activities related to the conventions include: the Meteorological Office (focal point for the IPCC) and the Ministry of Foreign Affairs (New York Mission) (GOAB, 2009a).

Since 2009 the GOAB have demonstrated its commitment to the effective management of the issues, which develop as a result of climate change and other environmental factors through the implementation of various policies, plans and programmes. These include: the completion of the draft environmental legislation, the development of the National Physical Development Plan and an Energy policy. The GOAB also made a public commitment through the UNFCCC's Copenhagen Accord in 2010 to reduce the country's GHG emissions by 25% of its 1990 level by 2020.

2.4 Changes in Economic Conditions

The Eastern Caribbean Central Bank (ECCB) characterised Antigua and Barbuda as a middle-income developing country due to its moderately high standards of health care, education, access to services and infrastructure, and economic growth. Antigua and Barbuda's economy is service based and is heavily reliant on tourism and government services.

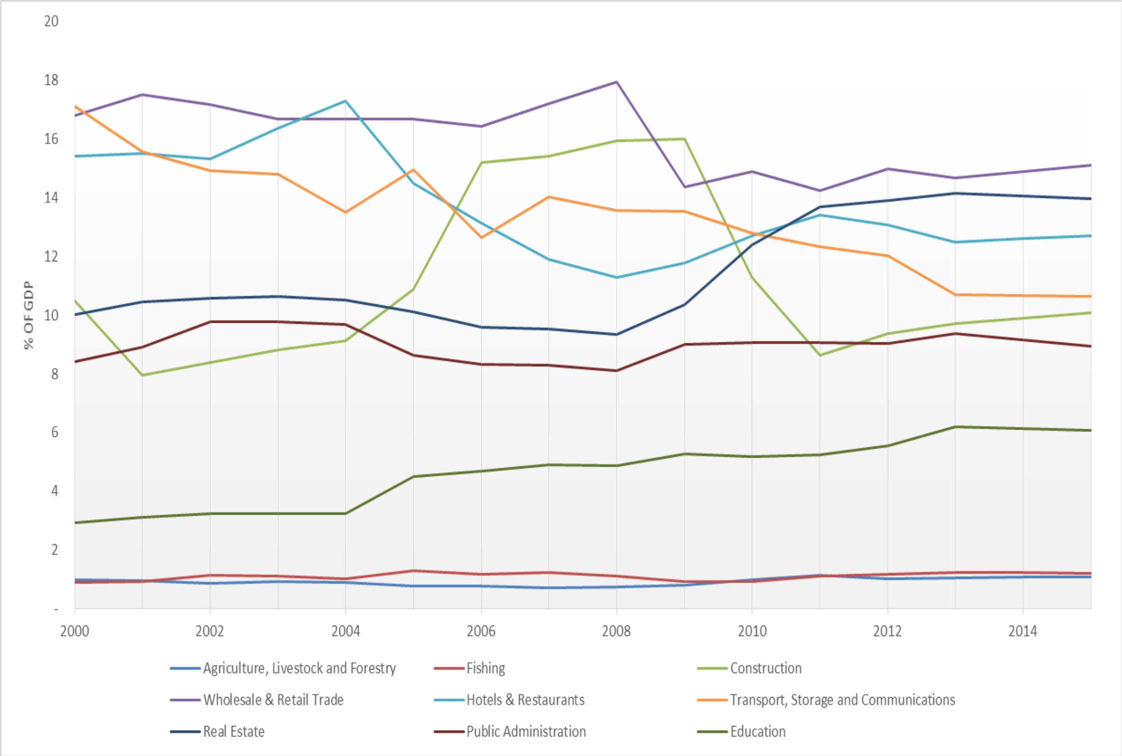

Figure 14 - Contribution to Gross Domestic Product by Economic Activity in Current Prices (%) for the year 2013 (ECCB, 2014)

In 2013, wholesale and retail trade was the highest contributor of GDP, and accounted for 14% (Figure 14). Real estate, renting and business activity; and hotel and restaurants contributed 13% and 12% of the GPD respectively in 2013 (ECCB, 2014). The contribution of GDP from both the agriculture, livestock and forestry subsector; and fishing subsector in 2013 was 1%. ECCB projections indicated that wholesale and retail will continue to be the highest contributor for the GDP in the next 2 years, and will contribute 14.88%, and 15.09% for 2014 and 2015 respectively. It is projected that real estate, renting and business activity and hotel and restaurants will account for 14.04% and 12.59% respectively for 2014 and 13.95% and 12.69% respectively for 2015. In addition agriculture, livestock and forestry; and fishing are expected to contribute 1.07% and 1.22% in 2014 respectively and 1.09% and 1.21% in 2015 respectively (ECCB, 2014).

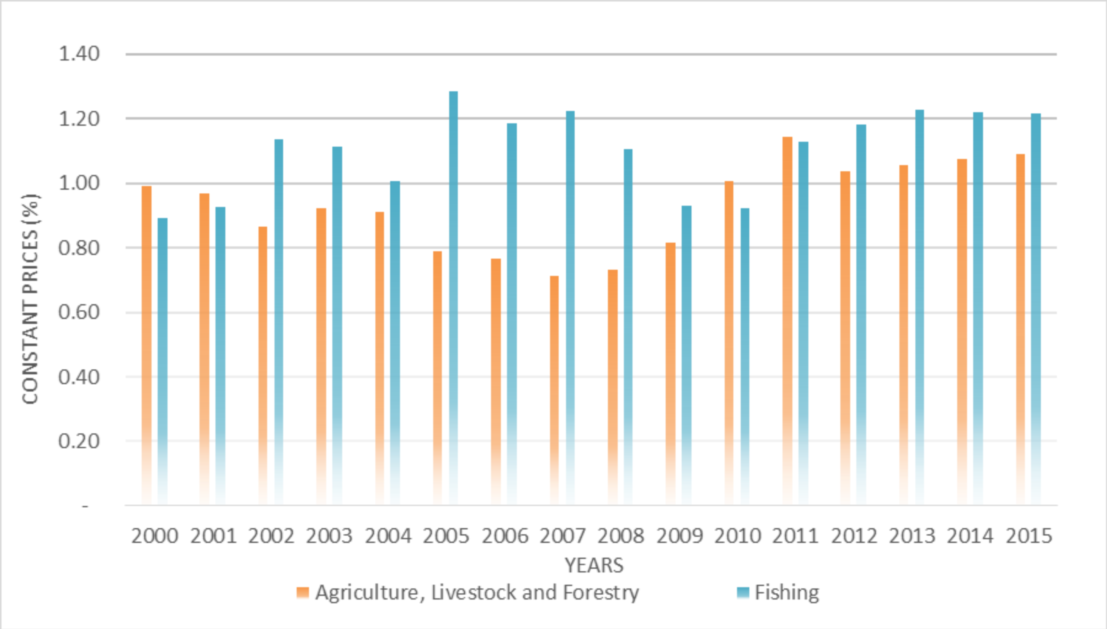

Figure 15 - Contribution to Gross Domestic Product by specific economic activity in current prices (%) for the period 2000-2013 and projected for 2014-2015 (ECCB, 2014)

During the period 2000-2013, the agriculture, livestock and forestry; and fishing contribution to GDP was minimal even though fishing records a higher contribution than agriculture, livestock and forestry (Figure 15). Between 2005 and 2007 agriculture, livestock and forestry recorded the lowest contribution to GPD. The Government of Antigua and Barbuda tried to reverse this trend for the agriculture, livestock and forestry sector in 2007 by reorganising the agricultural sector, placing greater emphasis specifically on small farmers and domestic and external markets (Simpson et al, 2012). The Government also attempted to diversify the economy away from sugar cane. These attempts have attained some years of success, especially in 2003, 2006, 2010, and 2011, which experienced growth rates of 11.24%, 10.07%, 14.38%, and 13.30% respectively in the agriculture sector (ECCB, 2014). Despite the fact that the agriculture, livestock, and forestry sector experience significant growth rates the contribution of GDP from 2003-2013 was minimal and is projected to remain minimal between 2014 and 2015.

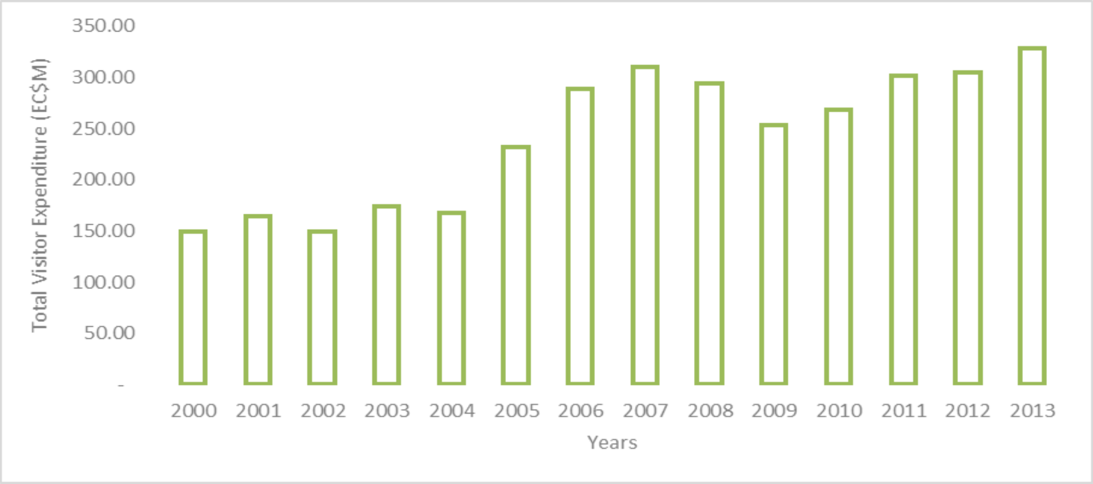

Figure 16 - Annual Tourism Expenditure (EC$M) between 2000 and 2013

The hotels and restaurant contribution to GDP during the period 2000-2013 was the second highest after wholesale and retail trade due to high levels of visitor expenditure. The total tourism expenditure fluctuated between 2000 and 2013 (Figure 16). The highest tourism expenditure was recorded for 2013 with 328.72 EC million and followed closely with 310.40 EC million in 2007. The increase in tourism expenditure in 2007 was mainly due to increased private sector construction projects for the 2007 World Cup. The Tourism industry in 2009 was severely affected due to the decline in tourist arrivals, foreign direct investment (FDI) inflows, remittances, and fiscal revenue. While the tourism sector is a sensitive industry, it does provide positive benefits to the country such as high levels of employment and can rebound relatively quickly after an external shock.

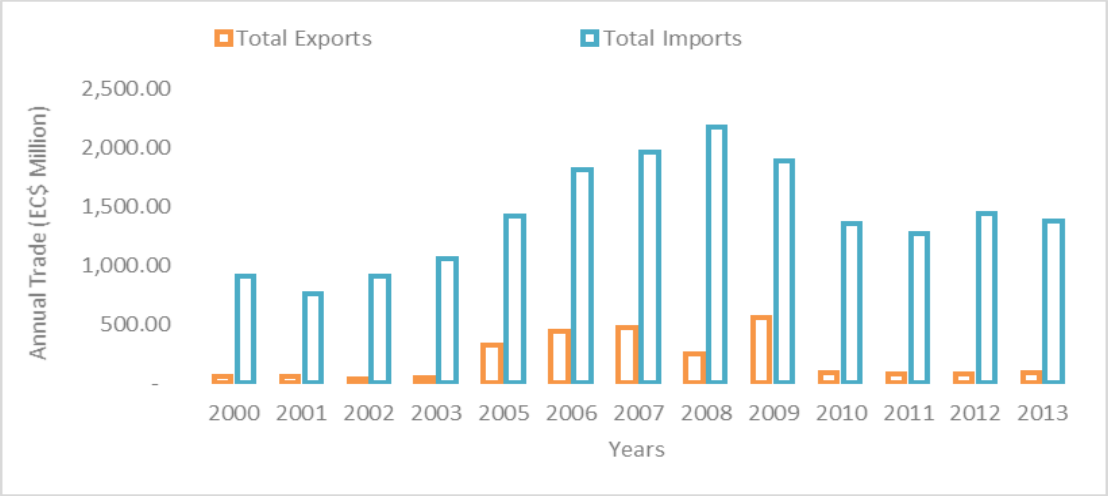

Figure 17 - Annual Trade (EC$Million)-Exports and Imports for 2000-2013

Antigua and Barbuda's economy is highly dependent on imports. From 2000-2013 total imports have significantly exceeded total exports, leading to continuous negative trade balances (Figure 17). The dependence on trade makes the economy of Antigua and Barbuda highly sensitive to changes within global trade and the global trading system.

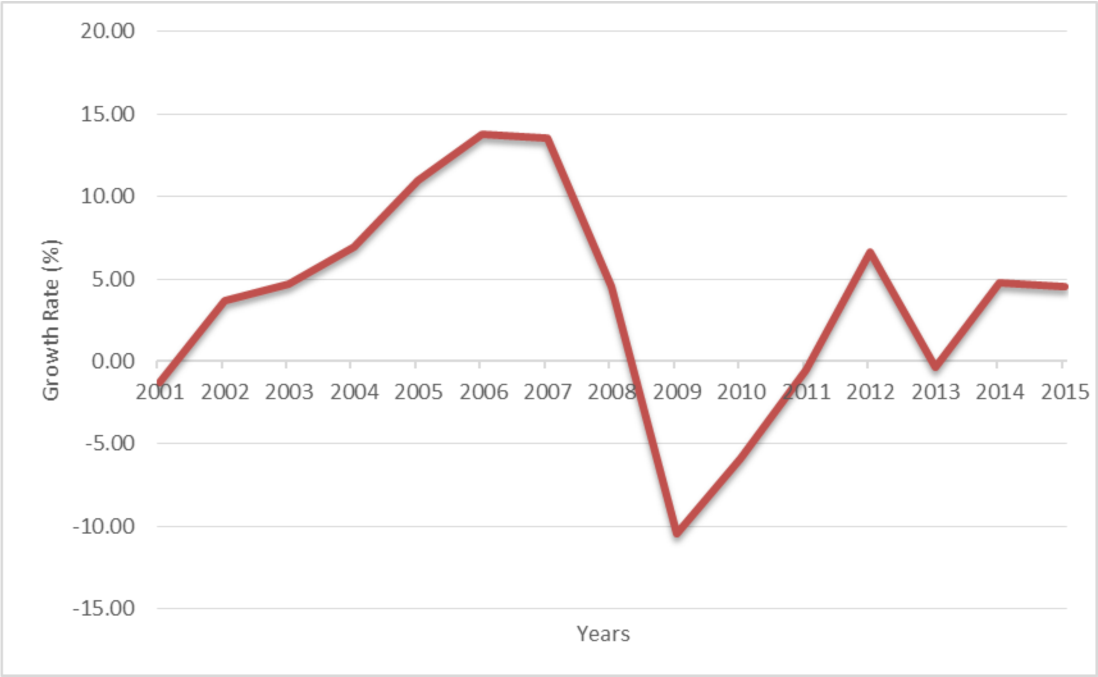

Figure 18 - Annual percentage growth rate of GDP at market price for 2000-2015 (2000-2013 actual and 2014-2015 projected) (ECCB, 2014)

From 2002-2007 the economy of Antigua and Barbuda experienced continuous growth (Figure 18). However between 2008 and 2011, Antigua and Barbuda's economy experienced a decline because of the global financial crisis, combined with the collapse of the Allen Stanford group of companies (Simpson et al, 2012). In 2009, the Poverty and Social Impact Assessment (PSIA) indicated that the global economic crisis, contributed to loss of employment and income, reduced inflows of payments and increased prices (GOAB, 2011). The overall fiscal deficit increased from 6% of GDP in 2008 to approximately 19% in 2009 and public debt increased to 115% (IMF, 2010).

In 2010, the Government implemented some measures to address this fiscal crisis, which included: 20% increase in petroleum product base; and increase in import duties and excise tax on alcohol and tobacco (IMF, 2010). These measures contributed to increased growth in 2011 and 2012. The growth rate of wholesale and retail trade increased from -4.81% to 11.69% in 2012, which contributed to the overall growth rate in GDP. Mining and quarry sector grew significantly from -19.30% in 2011 to 5.97% in 2012. From 2011-2012 the construction section increased from -23.99% to 15.57%. The implementation of the Construct Antigua and Barbuda Initiative contributed significant to improved growth within the construction sector. The percentage growth rate of GDP declined in 2013 due to significant declines in vital sectors such as the whole sale and retail trade and the hotel and restaurant sectors. The growth rate for wholesale and retail trade declined from 11.69% to -0.63% from 2012-2013. Similarly in 2012-2013 prices; expansion of the Value Added Tax (VAT) sector declined from 3.36% to -2.85% (ECCB, 2014). The Antigua and Barbuda's economy demonstrated signs of improvement and growth the growth rate for the hotel and restaurant in 2014 and is projected to experience an annual percentage growth rate of GDP for 2015 is 4.52%.

2.5 Land use change

Changes in land use are one of the most significant human manipulations of the earth's system. Usually changes in land use and land cover results in negative consequences for ecosystems and for the persons who depend on these ecosystems. As a result, land use change has a direct impact of the vulnerability of socio-ecological systems to biophysical, economic, and environmental perturbations and their abilities to cope with disturbances. Land use changes can increase the vulnerability of people and infrastructure to climate change and natural disasters (Kaplan, 2011). Land use changes within the agriculture and tourism sectors and the resultant impact will have a direct impact on their vulnerability to climate change. For example, land use change to accommodate greater coastal development and population densities within the tourism industry will contribute to increased vulnerability.

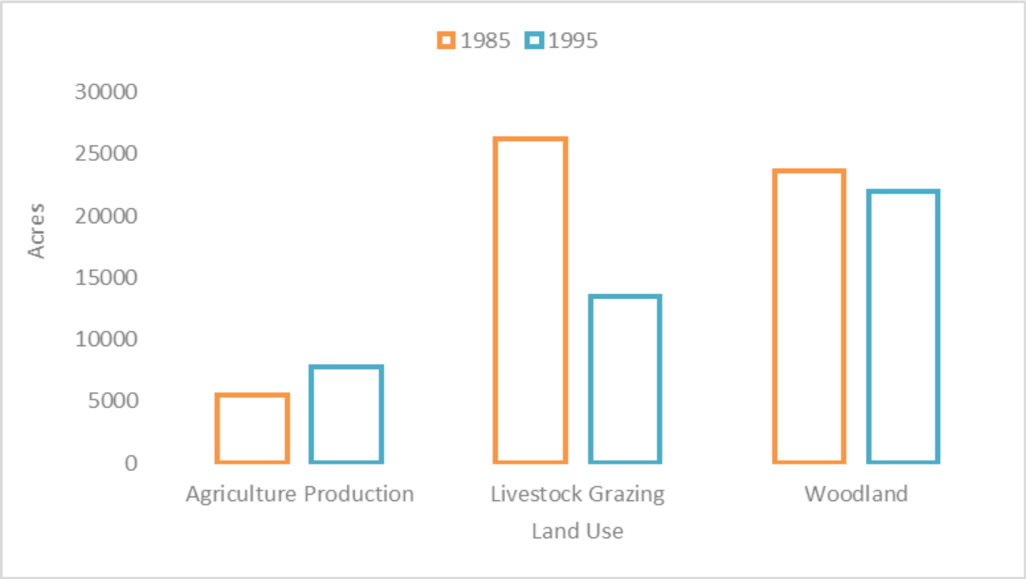

Figure 19: Changes in specific land use between 1985 and 1995 (Environment Division, 2014)

Between 1985 and 1995, the land utilised in agricultural production in Antigua and Barbuda experienced a 40.7% increase (Figure 19). Conversely, lands used for livestock grazing decreased by 48.6% during the same period. In addition, woodland areas decreased slightly by 6.9% as a result of unsustainable cutting (Figure 19) (GOAB, 2009b).

After 1995 agriculture lands previously under sugar cultivation were increasingly being used for residential and commercial development. Flat, adequately drained lands, which were suitable for agriculture, were usually preferred building sites due to the ease and reduced cost of construction (GENIVAR, 2011).

Between 1984 and 2007 the total number of agriculture holdings decreased by 73.57% from 4,639 in 1984 to 1,226 in 2007.
Agriculture holdings decreased most drastically in the South Central Agricultural Division were there were 731 holdings in 1984 and only 85 in 2007, a decline of 88%. (GOAB, 2012c).

Between 2000 and 2005, the permanent and temporary cropland remained at 24,711 acres (10,000 hectares) (GOAB, 2009b). In 2009, croplands covered 2,226 acres (2,226 ha) (8.5%), improved pasture, 957 ha (3.6%), rough grazing, 17,154 acres (6,942 ha) (26.4%), and mixed scrub/rough grazing, 6,981 acres (2,825 ha) (10.8%) (GOAB, 2009b). In 2010, cultivated areas with food crops and vegetables were 600 acres (243 hectares) and 1,200 acres (486 hectares) respectively. In addition, pineapples were cultivated on 124 acres (50 hectares). The land used for agricultural crops decreased from 7,740 acres in 1995 to only 6,855 acres in 2010 (Banhan & Lewis, 2013).

Although the agriculture holdings and the land used for agriculture crops has decreased the total cultivated acreage increased from 2009-2013, with a drastic increase from 2009-2010 (Figure 20). The total acreage of land under agricultural production in 2013 was 3,277.52 acres with Belvidere and Breaknock having the largest acreage (542.1) and Double Hole having the smallest acreage (10.62).

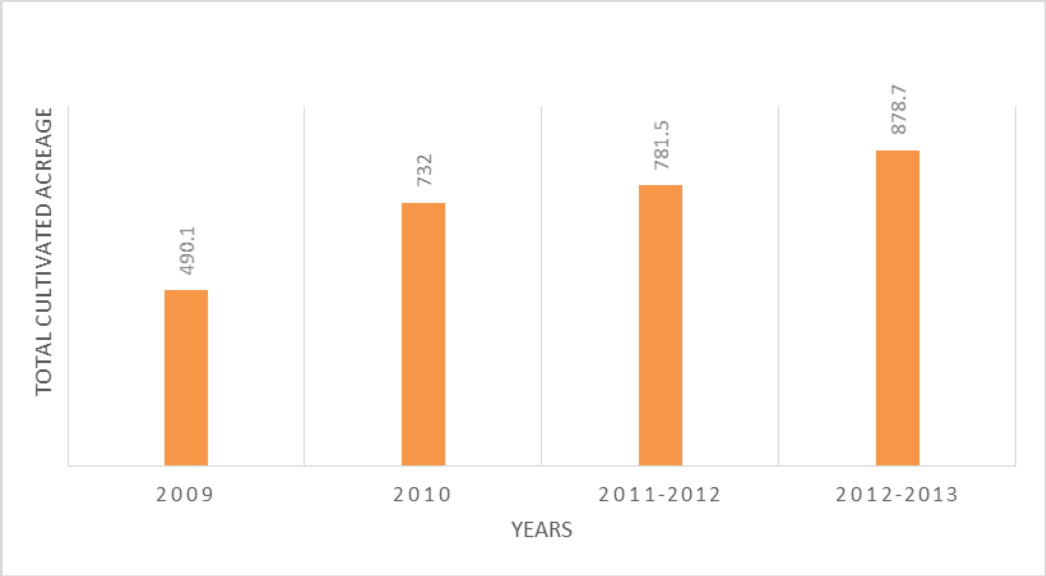

Figure 20: Changes in Total Cultivated Acreage between 2009-2013

The acreage of land under agricultural production has also changed in Barbuda. The amount of land occupied by human settlement increased from 269 acres in 1985 to 882 acres (227.9% increase) in 2010. In In Antigua and Barbuda swamp and mangrove, acreage decreased from 2,164 acres in 1985 to 2,142 acres in 2005 and slightly increased to 1,161 acres in 2010. In Barbuda in 1985 swamps and mangroves occupied 9,214 cares. Mangrove and swamps in Barbuda now occupy 14,468 acres while dry forest areas occupy only 3,896 acres (Banhan & Lewis, 2013). Class II and III lands, which were categorised as favourable agricultural land, were considered available opportunities for urban development, leading to a dramatic decline in the agriculture sector. In addition, there is need for the Government to provide institutional and physical support for the fishing industry to assist fisher folk in providing products of sufficient quality and quantity for domestic and international markets (GENIVAR, 2011) (Figure 20).

Forests in Antigua and Barbuda are comprised mostly of secondary vegetation including species of Spanish Oak (Inca Iaurina), Silk Cotton (Ceiba pentadra), Turpentine (Bursera simaruba) and Logwood (Haematoxylon campachianum). The present condition of the forest is a direct result of historically clearing of the Antigua's forests for sugar cultivation (Environmental Solutions Antigua Limited, 2008). A baseline study conducted in 2009 identified that approximately 90-95% of the forest in Antigua was cleared and converted to agricultural crop and pasture lands (GOAB, 2009b).

The remaining 5-10% of forests in Antigua and Barbuda is threatened because of:

- Increased demand for boat building
- Extraction of wattle for fish pots
- Fuel wood and charcoal production
- Deforestation resulting from mining and sand dredging activities

White Cedar forests in particular, is decreasing at rate of 3% per annum because of the demand for the construction of fishing vessels (GOAB, 2009b). After the loss of thousands of fish pots during Hurricane Luis, demand for wattle exceeded supply, which threatened the forest (GOAB, 2009b). However, in the southwest volcanic region, the forest coverage is decreasing at a slower rate, approximately 1-2% per annum. In addition, the habitat and biodiversity in the Gaynors area in the east of Antigua is threatened by increased clearing of land for agricultural development (GOAB, 2009b).

It has been difficult in assessing the percentage of the forest, which is impacted by human activity (GOAB, 2009b). Selective logging is permitted for lumber and charcoal production. However, there are difficulties in determining the actual area disturbed from logging operations and therefore statistics are based on expert judgment (GOAB, 2009b).

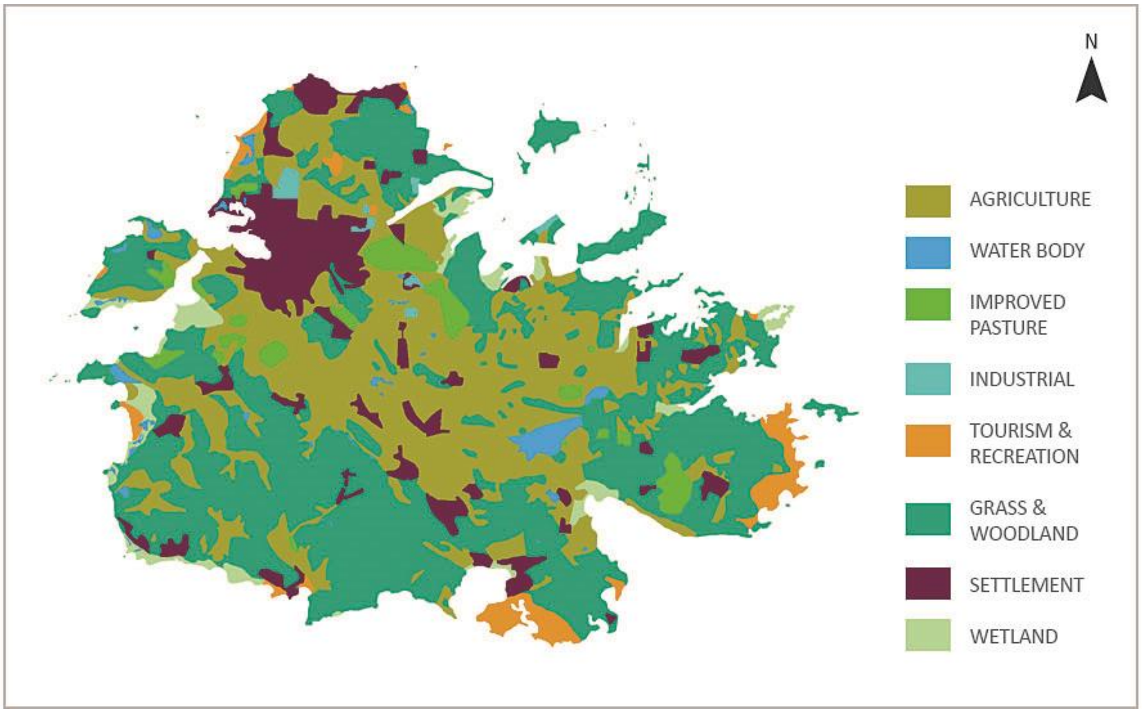

Figure 21: Land use patterns for Antigua in 2010

The development of the tourism sector in Antigua and Barbuda has has also resulted in changes in land use patterns. Between 1985 and 1995, industrial land acreage increased from 381 to 584 acres and hotel and golf course increased from 1,133 to 2,699 acres. The urban/rural areas increased dramatically from 6,627 to 17,189 acres as a result of an increase in residential areas (Figure 21)(GOAB, 2009b).

The decline in agricultural lands contributed to people seeking livelihoods in other sectors. By 1985, approximately 60% of the work force was employed in public or private services including 23% in tourism and trade (Williams, 2003). The expansion of the acreage used for tourism continued into the 1990s with the total acreage increasing by 138% by 1995.

There are pockets of tourism facilities and activities throughout Antigua but the major current concentrations of tourism facilities are located at Dickenson Bay and Runaway Bay; Deep Bay/Galley Bay; Jolly Beach and English Harbour/Falmouth Harbour.

It is expected that demands for lands for housing, agriculture, tourism development, commercial space and other related uses are likely to increase in the future based on current trends (GOAB, 2009a). Current land use and settlement patterns and plans appear to be in favour tourism and residential development while agricultural lands and environmentally sensitive areas have been reduced significantly (GOAB, 2009a).

2.6 Ecosystem Services

Ecosystems provide a multiple of services, which are not only of vital importance to the environment but also, provide tangible benefits to society (ESAL, 2009a). These services include:

- Supporting services: primary and secondary production and biodiversity;
- Provisioning services: food, fibre and medical products;
- Regulating services: carbon sequestration, climate and water regulations, erosion and flood protection, air and water purification and disease and pest control; and
- Cultural and recreational services: swimming, hiking, bird watching and site seeing

Therefore, GOAB has recognised that Antigua and Barbuda's ecosystems do provide vital services to Antigua and Barbuda's main economic activities within the tourism and agriculture industry. The GOAB has had significant success in the protection of natural resources, because of collaboration with international and regional organisations, which established a system of protected areas and developed other policies for natural resource protection and management (GOAB, 2009b). There are 6 designated protected areas in Antigua and Barbuda based on their historical and ecological values, which include:

- Nelson's Dock Yard National Park,
- the North East Marine Management Area (NEMMA),
- Cades Bay Marine Reserve,
- Codrington Lagoon National Park, and
- Diamond Reef Marine Park and Palaster Reef Marine Park (UNEP, 2000 and Gore-Francis, 2013).

There are other smaller protected areas, which include:

- the Devil's Bridge National Park (244 acres),
- Green Castle Hill National Park (87 acres) and
- the Fort Barrington National Park (85 acres) (Gore-Francis, 2013).

The ecosystems present within Antigua include freshwater, swamp/mangrove, woodland and corals (ESAL, 2009a) (Figure 22). The interactions between the various ecosystems are evident. The woodland ecosystems located in the north-eastern area (uplands) in Antigua usually drain into intermittent coastal streams, which in turn drain into wetlands, beaches, and coral reefs. Most of the woodlands are located in the southwest region of the island. The mangrove ecosystems on the western side of the island have been damaged by pollution and physical destruction. A Healthy mangrove ecosystem can be found on the southwest (Cades Bay) and northeast region of the island (Figure 22).

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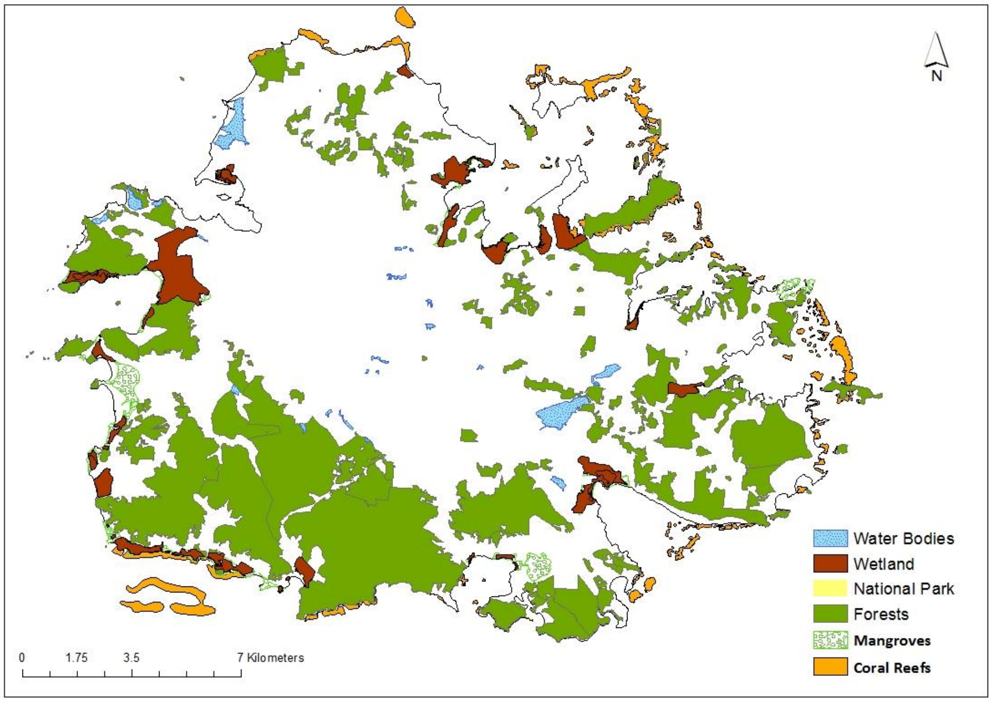

Figure 22: Ecosystems of Antigua

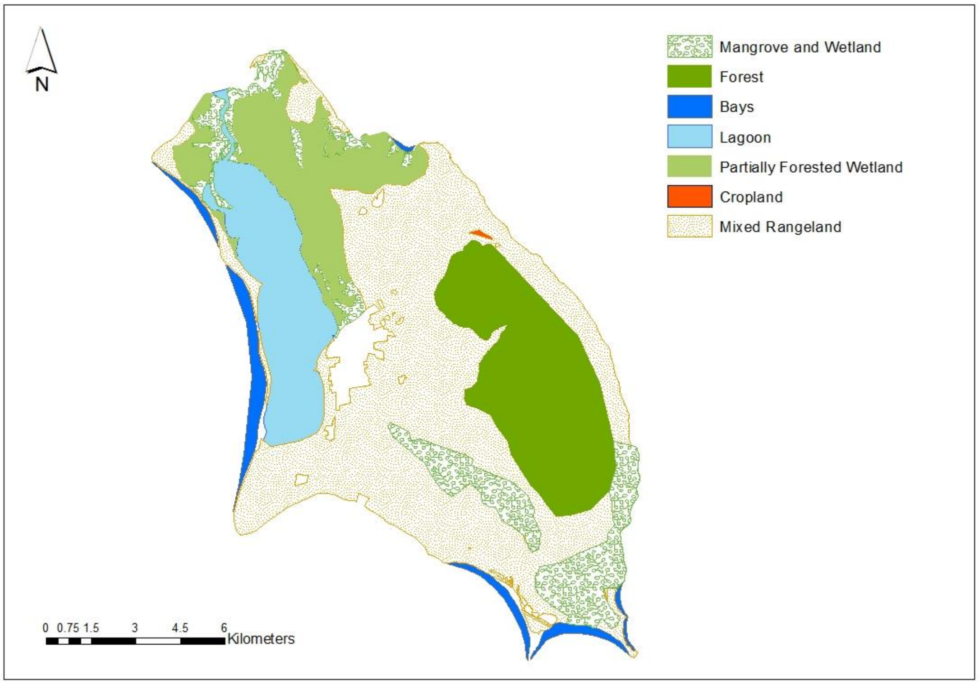

Figure 23: Ecosystems of Barbuda

Coral reefs are located around both islands and coverage varies from 15.820 km2 - 25.4519 km2 (GOAB, 2009a) There are 4 main types of coral reefs found in Antigua and Barbuda, which include:

- Barrier reefs located on the southern shore, parallel to a steep slope at the edge of the narrow shelf;
- Bank barrier reefs located on the north eastern and south western flanks;
- Fringing reefs located on the eastern, northern and southern coasts; and
- Patch reefs mainly found in Barbuda (GOAB, 2009a).

Reef development is better on the windward east coast of Antigua due to high wave energy, which ensures circulation of nutrients, coupled with the absence of muddy sediments (Gore-Francis, 2013). Conversely, the leeward side of Antigua is poorly developed due to the absence of favourable environmental conditions.

There are 36 mangrove sites in Antigua and 9 sites in Barbuda (GOAB, 2009b). In Antigua, the sites range from very small single layer stands of trees to large, complex swamps (Figure 22). In Barbuda, there is the luxuriant 352 ha fringe mangrove of Codrington Lagoon (Figure 23). Four species of mangroves exist in Antigua and Barbuda, which includes: Red Mangrove (Rhizophora mangle), Black Mangrove (Avincennia germinans), White Mangrove (Laguncularia racemosa) and Buttonwood (Conorcarpus erectus) (GOAB, 2009b).

3 Climate change vulnerability and impact

Despite future emissions, the earth's system is already committed to further warming, mainly due to past emissions and inertia in the climate system. Large –scale warming of approximately 4°C or above will increase the likelihood of severe, widespread, and irreversible impacts to which it would be difficult to adapt. Climate change impacts will increase risk of death, injury, ill health, or disrupt livelihoods in the Caribbean region and other SIDS as a result of storm surges, coastal flooding and sea level rise. (IPCC, 2014). The high diversity of the Caribbean islands in relation to physical and human resources and their response to climate related drivers implies that climate change impacts, vulnerability, and adaptation will be different for the various Caribbean islands. Due to the fact that majority of the Caribbean island including Antigua and Barbuda have had difficulties with dealing with the effects of climate variability; developing pragmatic adaptation solutions to cope with. present and future changes is an absolute imperative. Understanding the vulnerability of Antigua and Barbuda through the VIA analyses will help the country to better plan for climate change adaptation

Island vulnerability depends on climatic factors but also socio-economic, physical, and ecological stressors and interactions between them. Physical characteristics can create inherent vulnerabilities to landslides and storm surge risks. Socio-economic vulnerabilities are related to pollution and sanitation. Ecological stresses such as habitat loss and degradation, invasive species, pollution and over exploitation can harm biodiversity and reduce the ability of ecosystems to bounce back after shocks. To understand climate vulnerability on islands, it is necessary to assess all of these dimensions of vulnerability. Islands faced with multiple stressors can be assumed to be at more risk from climate impacts (IPCC, 2014).

3.1 Exposure

3.1.1 Increased climate variability

Detailed climate modelling projections for Antigua and Barbuda as it relates to climate variability indicated an increase in average atmospheric temperature and reduced average annual rainfall (Simpson, et. al., 2012) (Table 1 and 2).

Antigua and Barbuda: Country Scale Changes in Temperature												
	Observed Mean 1970-99	**Observed Trend 1960-2006**		***Projected changes 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

Table 1 - Observed and GCM projected changes in temperature for Antigua and Barbuda.

Antigua and Barbuda: Country Scale Changes in Precipitation												
	Observed Mean 1970-99	**Observed Trend 1960-2006**		***Projected changes 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

Table 2 - Observed and GCM projected changes in precipitation for Antigua and Barbuda.

In terms of atmospheric temperature, the insular Caribbean can expect an increase of 1.8-4.0°C by 2099 (Gore-Francis, 2013). Specifically air temperature within the insular Caribbean will increase by 1.8-4.0°C by 2099. Air temperatures in Antigua and Barbuda are expected to increase by 1.3°C by 2050 and by 1.0-3.5 °C by the end of the century

In recent years, maximum and minimum temperatures in Antigua and Barbuda have increased providing strong supporting evidence of climate change. It is anticipated that the warming trend will continue, which will increase the frequency of hot days and reduce the frequency of cool nights (Gore-Francis, 2013).

The annual range for the mean temperatures is small (less than 3.1°C), with peak temperatures values occurring between August and September (Figure 24). It has been observed that maximum temperatures for Antigua and Barbuda are increasing at a slightly faster rate than minimum temperatures (GOAB, 2009a and Antigua and Barbuda Meteorological Servcie, 2014). It was estimated that as early as 1990-1995 average annual temperatures in some Caribbean countries had increased by at least 0.5°C and even extended to ≥1°C (DFATD, SREP & CARICOM, 2005).

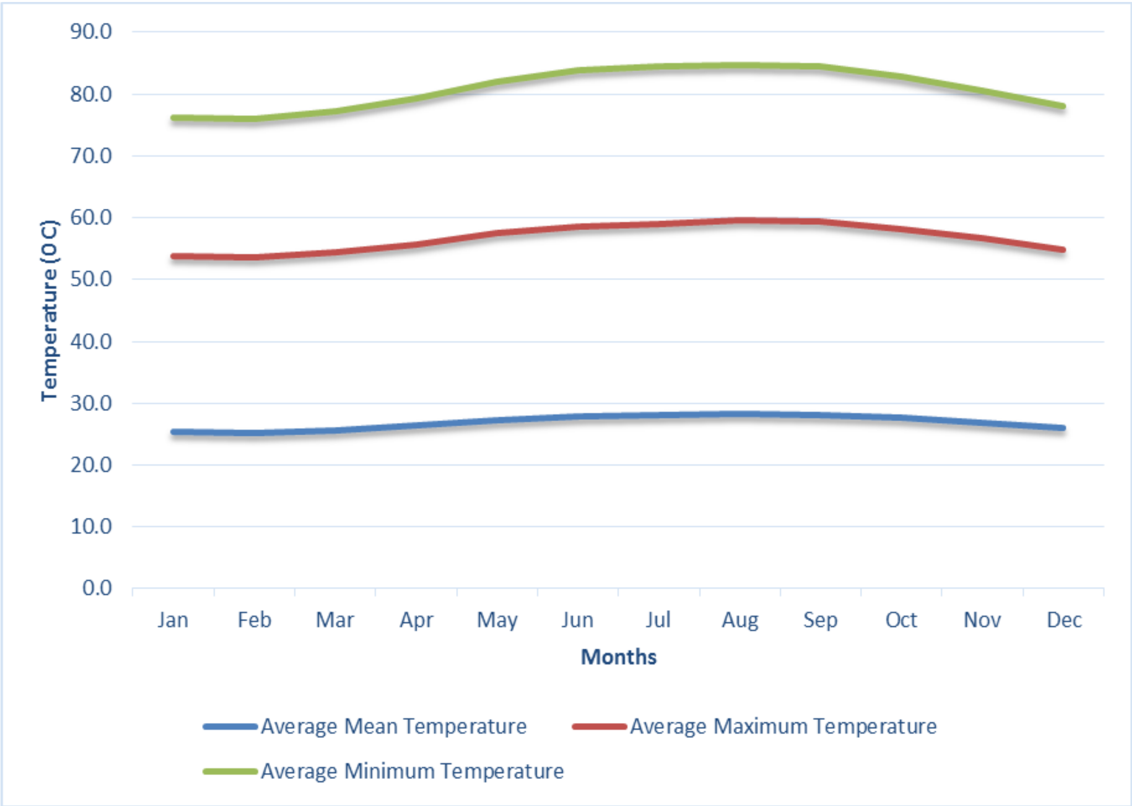

Figure 24: Monthly variation in maximum, minimum, and mean temperature (1995-2013). (Meteorological Services, 2014)

The lack of significant topographic variability of the Antigua and Barbuda landmasses has resulted in increased exposure to the effects of wind and rain (The World Bank, 2010). Evapotranspiration rates are high because of steady winds and high temperatures, with average rates between 87 mm/month in November and 143 mm/month in March (Mitchell, 2009). Even in the wetter southwest region of Antigua, the average potential evapotranspiration exceeded effective precipitation (estimated at 70% of actual) in 11 months of the year (Mitchell, 2009).

3.1.2 Tropical Storms and Hurricanes

Hydro-meteorological hazards pose the greatest risk to Antigua and Barbuda, and historic disaster records in Antigua and Barbuda demonstrate that hurricanes and tropical storms are the highest-cost hazards in terms of loss of life and economic losses. It is projected that the maximum wind speed of the strongest hurricane is projected to increase by 5% (low scenario) and 15% (high scenario) which would increase the impact in terms of loss of life and other economic losses.

A significant number of extreme hydro-meteorological events of different level of impacts have affected Antigua and Barbuda between 1971 and 2012 (Table 3) (The Government of Antigua and Barbuda, 2001b, 2009, Gomes, 2008; The World Bank, 2010; Solomon et al, 2011; Simpson et al, 2012; Antigua and Barbuda Meteorological Office, 2014).

YEAR	EVENT	ECONOMIC LOSS/DAMAGES (EC$
1995	Hurricane Luis	346.55 million
1998	Hurricane Georges	200 million
1999	Hurricane Jose and Lenny	247.43 million
2008	Hurricane Omar	48.6 million
2010	Hurricane Earl	52,106,336.73

Table 3 - Economic loss/damage of events, which occurred between 1995 and 2010

A significant number of extreme hydro-meteorological events have had significant economic impact on Antigua and Barbuda (Table 3). Hurricane Luis (1995) was the most devastating system and it resulted in 17% decrease in tourist arrivals that year; 7,000 were unemployed; 90% of buildings were destroyed and damages amounted to US $128.35 million or 30.49% of the GDP (Solomon et al, 2011 and Gores-Francis, 2013). During the passage of Hurricane Luis (1995), farmers and households experienced the greatest negative impact (GOAB, 2001b). The areas, which were mainly affected during the passage of Hurricane Luis (1995), included: Cades Bay, Orange Valley, Parham Lodge and BelvedereI Body Pond.

During the passing of Hurricane Omar (2008), there were 4 landslides in the Fig Tree Drive area. The largest landslide occurred west of the Antigua Canopy Tours and was approximately 60 m in length and 40 m at the widest point. In addition, there were landslides in several other communities including Folly Ghaut, Crabb Hill and Ebenezer (Antigua and Barbuda NODS, 2008).

During the passage of Hurricane Earl 2010, 7.78 inches of rain was recorded within 24 hours and 12 persons had to be evacuated as a result of flooding (Antigua and Barbuda NODS, 2010). During the passage of Hurricane Earl (2010), 259 persons occupied the shelters and another 51 persons sort shelter with friends and family.

The agriculture sector was severely impacted after the passage of Hurricane Earl (2010), due to damage to vegetable and tree crops, seedlings, farm infrastructure and irrigation equipment (Antigua and Barbuda NODS, 2010). Crops and economic losses were also high after the passage of Hurricane Earl (2010) as a result of flood and wind damage (Table 3).

Flood caused major problem for citrus production. The waterlogged conditions predisposed the plants to fungal and bacterial rots from the soil and reduced the fertility of the soil due to the washing away of the topsoil (Plate 1). Restoration and replacement costs for the crop subsector resulted in $12,310,000.00 EC.

Plate 1 – Impact of floodwater on citrus production in Christian Valley (Antigua and Barbuda National Disaster Office, 2010

After the passage of Hurricane Earl (2010) the fisheries industry reported tremendous damage to infrastructure and equipment, which mainly occurred at:

- English Harbour,
- Jolly Harbour,
- Keeling Point,
- Point Wharf,
- Bryson Wharf,
- Emerald Voce, and
- Codrington Wharf (Barbuda).

3.1.3 Sea level rise and storm surge

Sea level rise poses one of the most widely recognised climate change threats to low-lying coastal area in small islands where majority of the communities and infrastructure is located in coastal zones and with limited relocation within the island (IPCC, 2014).

Globally, sea level have risen faster than at any time during the previous two millennia. Sea level rise projections in the Caribbean region under an intermediate low-emissions scenario (RCP4.5) are similar to global projections of between 0.4 and 0.7 m, ranging from 0.5 and 0.6 m (IPCC, 2014). A rise in sea level as low as 0.1 m could likely result in a decrease in aquifer thickness of more than 10 m therefore contributing to a substantial decline in fresh water availability (Simpson et al, 2012).

SLR scenarios of 1 m and 2 m, and beach erosion scenarios of 50 m and 100 m were projected for Antigua and Barbuda (Table 4). Ten percent (10%) of the major tourism properties, 2% of road networks, and 100% of seaports in Antigua and Barbuda are at risk from 1 m SLR. In addition, with 100 m of erosion due to 1 m SLR, 44% of the major tourism and 65% of sea turtle nesting sites will be impacted (Simpson et al, 2012) (Table 4).

		Major Tourism	Sea Turtle Nesting Sites	Airport Lands	Major Road Networks	Seaport Land
SLR	1.0 m	10%	12%	0%	2%	100%
	2.0 m	18%	18%	100%	6%	-
Coastal Erosion	50 m	34%	50%	-	-	-
	100 m	44%	65%	-	-	-

Table 4 - Impacts associated with 1 m and 2 m SLR and 50 m and 100 m beach erosion in Antigua and Barbuda (Simpson et al, 2012)

The issue of coastal squeeze remains a concern for many small islands as there is a constant struggle to manage the requirements for physical development against the need to maintain ecological balance (IPCC, 2014). The high density of tourism development on the coast increased the vulnerability to climate change and SLR as well as the risk of degradation of coastal and marine biodiversity (Simpson et al, 2012). A reduction in the width of the beach buffer zone due to SLR 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 SLR and storm surge on beaches increases the vulnerability of species of marine turtles, iguanas, and shore birds (Simpson et al, 2012).

Population growth and urbanisation have contributed significantly to the scarcity of hazard free or low hazard zones (UNEP, 2000). This contributed to a reduction in resilience to associated climate change impacts such as storm surge. In addition, storm surge events have caused tremendous damage to coastal infrastructure (Solomon et al, 2011). Majority of Antigua and Barbuda's tourism infrastructure is located along the coast, which increases the vulnerability of the tourism industry to stormsurge. For example, 39 of the 55 tourism accommodation in Antigua and Barbuda have beachfront locations (UNEP, 2000). Important resorts and central infrastructure such as ports and airports, which are located less than 6 m above sea level are at high risk from SLR, and storm surge.

Development in high vulnerability, hazard prone areas resulted in high risk and partial adaption, which mainly consisted of costly structural measures. A vulnerability score based on location factors of settlements resulted in 34% of the major settlements within Antigua and Barbuda being classified as low vulnerability, 28% as moderate, and 19% as high vulnerability.

The areas at greatest risk to SLR and storm surge in Antigua include Dickenson Bay, Fort Bay, and Runaway Bay (Figure 25). In Barbuda, Cocoa Point (Figure 26), Palm Beach and Palmetto Point, are at risk to SLR and storm surge, with Low Bay at greatest risk (Simpson et al, 2012).

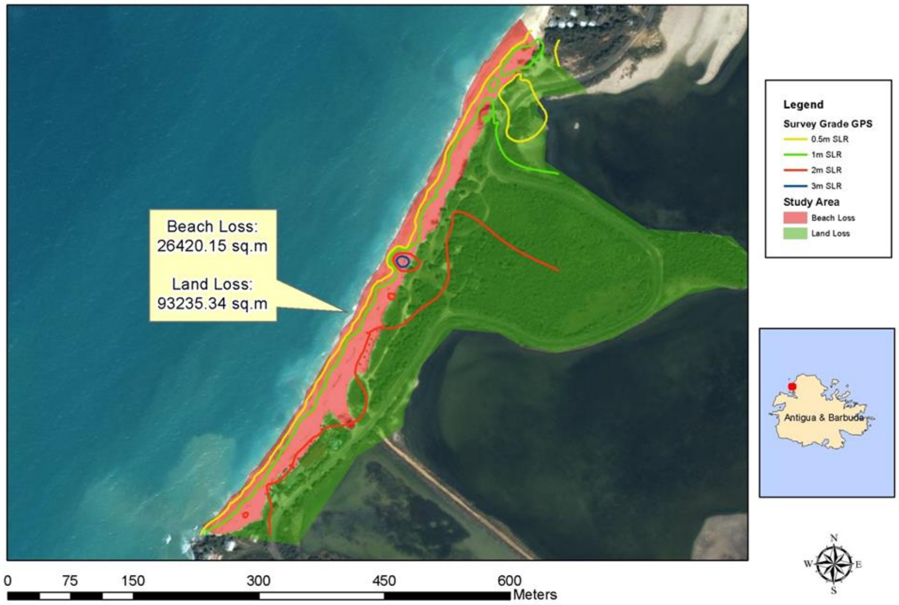

Figure 25: Total Land and Beach Loss due to SLR at Runaway Bay Beach, Antigua (Simpson et al, 2012)

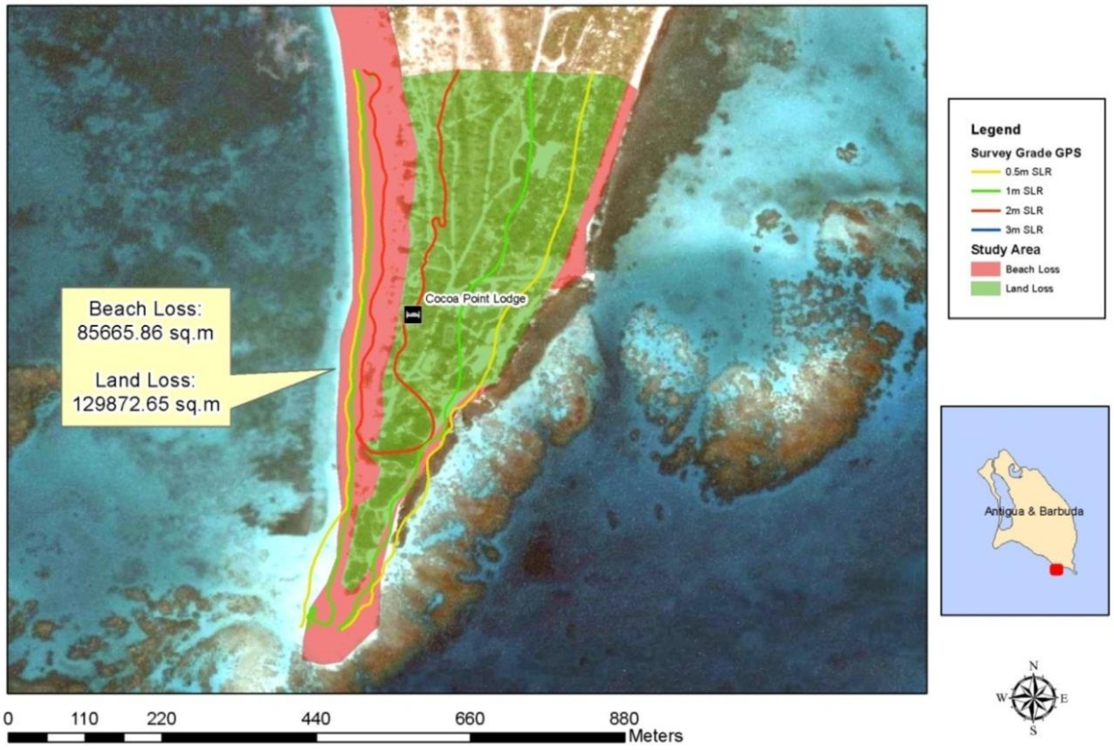

Figure 26: Total Land and Beach Loss due to SLR in Coco Point, Gravenor Bay, Barbuda (Simpson et al, 2012)

A major impact of storm surge on some beaches in Antigua and Barbuda was severe sand loss (Solomon et al, 2011). Between 1996 and 2001, Palm Beach in Barbuda experienced erosion at an alarming rate of 0.8 m/year. Palm Beach can be expected to experience increased rates of erosion in the future (Simpson et al, 2012).

Hurricane Luis (1995) resulted in storm surges of up to 15 feet (5 meters) (GOAB, 2001b). Based on storm surge vulnerability by return period for the 10-year period, the entire coast with the exception of Fitches Creek/Parharm Harbour would be within the low storm surge vulnerability zone (storm surge heights of 0.1-0.5 m). Fitches Creek/Parham Harbour would lie within the medium storm surge vulnerability zone of 0.5-1.5 m (GOAB, 2001b). For the 25-year return period majority of the coast would lie within a moderate vulnerability storm surge zone (GOAB, 2001b). In addition, Hanson's Bay and Jolly Harbour area would be subject to intrusions of moderate storm surge and the southwestern section of Parham Harbour would lie within the high vulnerability zone (3.0 m). In addition, the 50-year return period would increase the intrusion of moderate surge around Hanson's Bay, Jolly Harbour, and Parham Harbour. The 100-year return period would increase the vulnerability of Hanson's Bay area and result in high storm surge throughout the Parham area (GOAB, 2001c).

3.1.4 Flooding

The impact of floods is in recent times has become a critical concern for Antigua and Barbuda (Solomon et al, 2011). The reasons for the increase in flood concern in Antigua and Barbuda included:

- increased frequency of cyclones due to the impact of climate change and global warming;
- the construction of homes in unsuitable areas such as swamps, low lying and flood prone areas;
- blockage of the natural flow of the water course, ponds, wetlands and catchment;
- the blockage of constructed drains by solid waste and uncontrolled vegetation growth and soil deposits (Solomon et al, 2011).

Issues such as reclamation of lands, sand mining and the lack of a comprehensive system to control flooding and sedimentation have also increased Antigua and Barbuda's vulnerability to coastal flooding (Gomes, 2008). Some of the areas, which are most, affected by flooding and resultant mudflows include: Osbourn/north Pigotts areas; North Sound leading into Fitches Creek; Parts of Paynters Community; York's New Extension; Halcyon Road in the vicinity of McKinnons and Yorks Village (Figure 27); Cashew Hill area and Golden Grove (Figure 28) (Solomon et al, 2011 and Simpson et al, 2012). Specific parts of low lying coastal cities, such as areas in the vicinity of St. John are most vulnerable to flooding and erosion. These areas include: Perry Bay, Green Bay (Figure 27), Fibrey, Lower North Street, Lower Villa, Lower Fort Road, and Yorks (Solomon et al., 2011). The North Sound Bridge and North of Bendals Bridge lie within the high flood vulnerability zones (GOAB, 2001c).

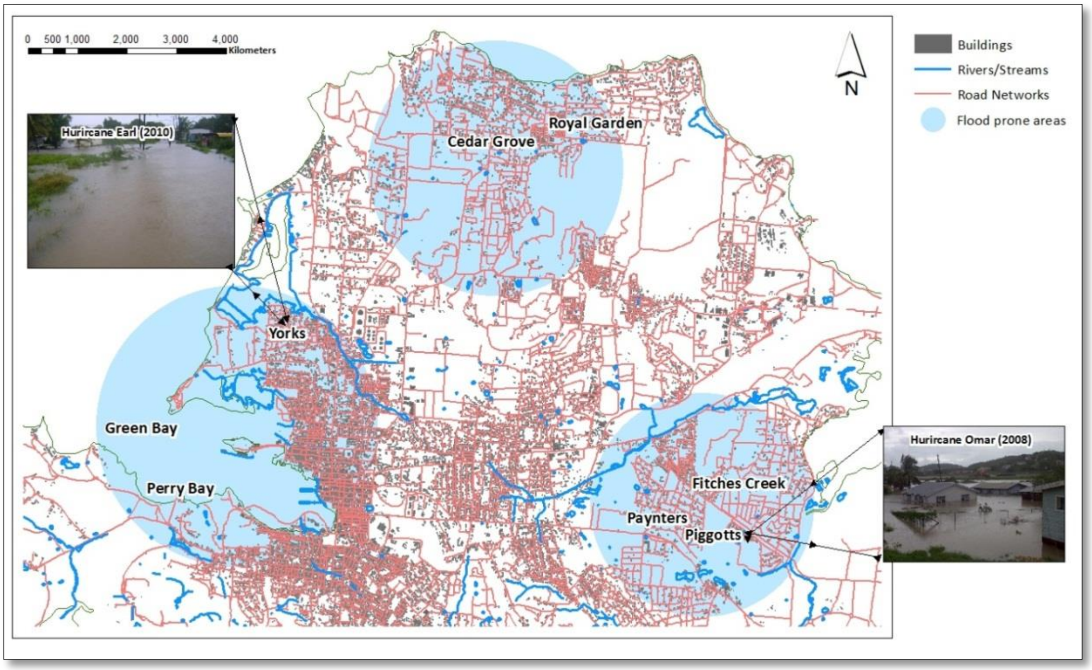

Figure 27: Some of the areas which are mostly affected by flooding

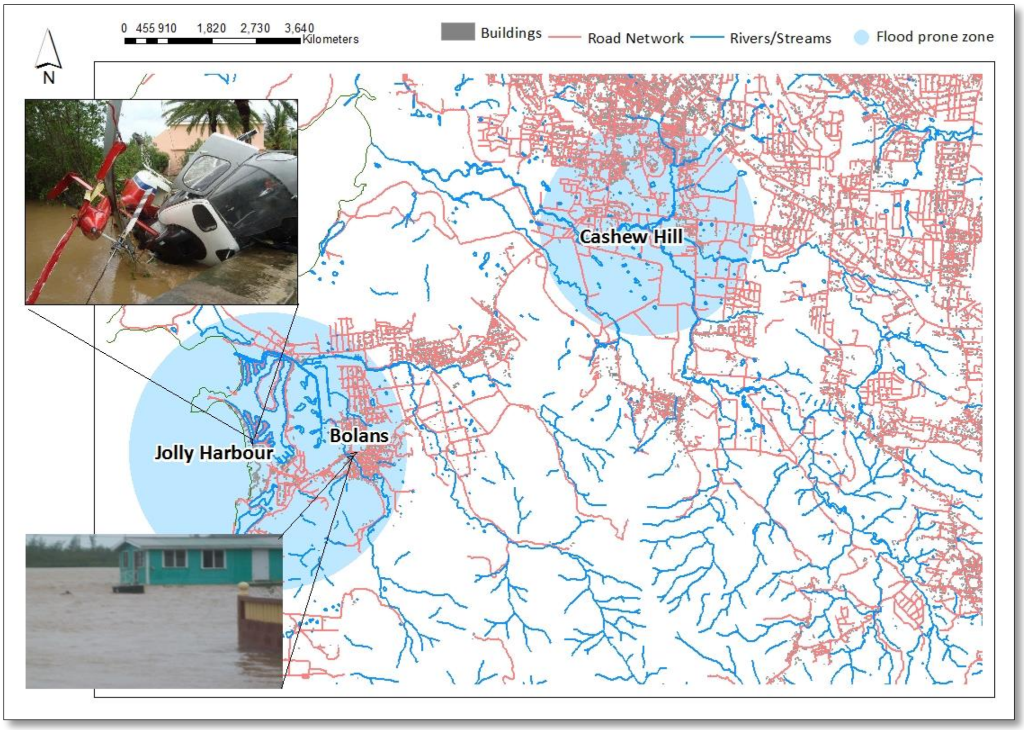

Figure 28: Some other flood prone areas

Hurricane Lenny (1999) resulted in 23 inches of rain over 2.5 days, which caused massive flooding (GOAB, 2000 and 2001c). This further contributed to mudslides, which accounted for approximately 5 million cubic feet of soil loss.

One of the biggest challenges facing Antigua and Barbuda was the need to relocate people due to the threat of flooding (Solomon et al, 2011). Flood water levels were approximately between 4 to 12 feet during the passage of Hurricane Omar (2008). During the passing of Hurricane Omar 1,339 homes were flooded, of which 33% (411), 41% (549) and 26% (348) were categorised as level 3, 2 and 1 impacts[1] respectively (Antigua and Barbuda NODS, 2008). Four homes, located in close proximity to watercourses in Jennings, Buckleys Road, and Bath Lodge, were washed away by floodwaters during Hurricane Omar. Many homes in Piggotts, Bolands, and Grays Farm were also flooded during Hurricane Omar, which contributed to 5,088 persons being affected by floodwaters. Even vehicles and transportation infrastructure was impacted by floodwaters during Hurricane Omar. Forty-seven vehicles were partially or totally submerged (Antigua and Barbuda NODS, 2008).

The flood situation within the communities of Piggotts, Green Bay (Figure 27), and Boland (Figure 28) has been very severe due to construction and development of residential buildings without adequate consideration of hazard vulnerability, which is exacerbated by improper drainage (Antigua and Barbuda NODS, 2008).

[1]Level 4 damage/impact: Totally destroyed and impossible to repair. Level 3 damage/impact: the house is unlivable unless repairs have been carried out. In the event that household and personal items are not in a condition equal to the initial state before the event, immediate assistance is required. Salvaging certain items is a possibility. Level 2 damage/impact: the house is livable with minor repairs and these repairs are done without outside intervention. Level 1 damage/impact: No assistance required.

During Hurricane Omar (2008) 98 homes in Pigotts, St. Georges were affected by floodwaters which amounted to 468 persons being impacted. Sixty-two persons were evacuated from flooded areas near the Pigotts Main Road, Burma Road and Paynters West. Paynters West has a history of folding since Hurricane Lenny (1999) but during the passage of Hurricane Omar (2008) the flood situation was much more extensive. Damages in Potters, New Wintropes, Barnes Hill were minimal; and flooding was less severe (Antigua and Barbuda NODS, 2008).

Eighty-two persons were evacuated from Grays Farm (rural west area) during Hurricane Omar. The water levels reached at least 4-9 feet in this area. Four hundred and forty-five homes, totaling 1,355 persons in the Grays Farm area were impacted by floodwaters during Hurricane Omar (2008) (Antigua and Barbuda NODS, 2008). During this flood event, the longest drainage system in a developed community in Antigua was compromised in some areas, which exacerbated the situation. It is projected that that similar rainfall events would result in similar setbacks or lead to a worse situation. The impact of the floodwaters to Five Islands and Golden Grove New Extension was less severe (Antigua and Barbuda NODS, 2008).

During Hurricane Omar (2008), 52 people were evacuated from Bolans, St. Mary south due to flooding and were sheltered at the Jolly Beach Hotel. 197 homes were affected by the floodwaters, which amounted to 711 persons being impacted. In addition, 11 vehicles were flooded (Antigua and Barbuda NODS, 2008). During Hurricane Omar (2008) road networks were also damaged by floodwaters for example, the road leading to Roses was damaged about half a mile. In the Bolan Village, specifically in the area called Ally (narrow strip of land between the watercourse and the road), was flooded. In some cases, flooding was due to the obstruction of the water passage by fencing and other properties (Antigua and Barbuda NODS, 2008). Similar flood conditions were experienced during Hurricane Earl (2010) (Figure 27) (Antigua and Barbuda NODS, 2010).

West Palm Beach area has a history of flooding since the passage of Hurricane Lenny (1999) because of poor drainage, unsuitable infrastructure and improper integrated planning (Antigua and Barbuda NODS, 2008). There is evidence that flooding in this area was exacerbated due to the construction of the Jolly Harbour Development. Despite the fact that flood impact at Jolly Harbour was minimal, the helicopters, which were stationed there, were submerged and sustained considerable damage. Two of the helicopter needed to be repaired and two needed to be replaced (Figure 28) (Antigua and Barbuda NODS, 2008).

During the passage of Hurricane Omar (2008), the impact of floodwaters to Urlings Village was very severe due to the added threat of land slippage. Floodwaters and the movement of landslide material during the passage of Hurricane Omar (2008) affected 10 homes in Urling Village. Land slippage damaged roads and 2 bridges (Antigua and Barbuda NODS, 2008). Some of major areas of concern due to the risk of flooding and the associated risk of landslides included: Freetown, Folly Ghaut, Buckleys Bridge, Dog Farm, and North South (Between Mathews and Roman Hill) (Antigua and Barbuda NODS, 2008).

During Hurricane Omar, 10 homes in Jennings were damaged due to floodwaters. Two were washed way from the foundation, 5 in Bethesda Village and 3 in Urlings sustained moderate roof damage (Antigua and Barbuda NODS, 2008).

Of the 476 families, which were impacted by Hurricane Earl, 396, 76, and 4 properties sustained level 1, 2 and 3 damage respectively. A total of 1,312 persons were impacted by this event. There was also flooding in several areas in rural north including: along Friars Road, along the watercourse from Wood's Mall pond down towards Junk Yard Cocks, Cedar Grove and Royal Garden (Antigua and Barbuda NODS, 2010). The York's Community area is characterised as low lying and flood prone. Additional water runoff from new developments in the area coupled with inadequate drainage and silting exacerbates the problem.

During Hurricane Earl (2010), the residents in Bendals were blocked in from both ends due to floodwaters, from Bathlodge and Big Creek. The flood situation was so severe that Bathlodge road was submerged by 5 feet of water and Big Creek was described as a sea of water (Plate 2) (Antigua and Barbuda NODS, 2010).

Plate 2: Impact of flood Water on Big Creek during the passage of Hurricane Earl (2010) (Antigua and Barbuda National Disaster Office, 2010)

Figure 29: Flood prone risk zone in Perry Bay (Antigua and Barbuda National Disaster Office, 2010)

Two of the most severely affected areas by flood impact during Hurricane Earl (2010) were Perrybay (Figure 29) and Bolans. The depth of the water varied from 2-3 feet to 8-10 feet (Antigua and Barbuda, 2010). It should be noted then even with working pumps, the area still experienced some level of flooding.

In addition flooding of agricultural fields at various stages of production during the passage of Hurricane Earl (2010), resulting in severe damage to crops, seedlings and soil, ultimately affected the agricultural industry.

3.1.5 Drought

The lengthening of the dry periods and increasing frequency of droughts are expected to increase demand for water across the Caribbean Region. Under an intermediate low-emissions scenario (RCP4.5) a decrease in rainfall of about 5-6% is projected for the Caribbean region by the end of the century. This signals a potential future threat to agriculture and water availability for the Caribbean region (IPCC, 2014).

Decreases in precipitation are projected for the Caribbean region, which is likely to experience shorter rainy seasons and precipitation in shorter duration, intense events interspersed with longer periods of relatively dry conditions. In addition it has been determined that the Caribbean region has experienced a significant increase in the number of consecutive dry days has been found for the Caribbean region. This is an indication that period of drought are becoming increasingly common (Simpson et al, 2012).

Antigua and Barbuda are two of the driest islands in the Caribbean region owing to their geographic position and topographic features. The low levels of rainfall combined with porous limestone geology make the islands vulnerable to hydrological drought (Solomon et al, 2011). Antigua and Barbuda has a long history of droughts. Overall rainfall has decreased significantly, evaporation rates are high and therefore the impact of drought has become more severe recently in Antigua and Barbuda (Simpson et al, 2012).

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1984	Severe	Severe	Severe		Serious	Serious	Serious		Serious	Serious	Serious	Serious
1985	Serious	Serious		Serious	Serious	Serious	Serious	Serious				Moderate
1986	Moderate	Serious	Serious	Serious		Severe	Severe	Severe			Severe	Severe
1987	Severe		Moderate	Moderate	Moderate							
1988				Slight	Slight	Slight	Slight	Slight				
1989			Moderate	Moderate	Moderate		Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
1990		Moderate	Moderate	Moderate		Serious	Serious	Serious				Serious
1991	Serious	Serious	Moderate	Moderate	Moderate							
1992	Moderate	Moderate	Moderate									
1993	Slight	Slight	Slight	Slight	Slight	Slight	Serious	Serious	Serious			
1994												
1995						Serious	Serious	Serious			Serious	Serious
1996	Serious				Serious	Serious	Serious	Moderate	Moderate	Moderate	Moderate	Moderate
1997									Moderate	Moderate	Moderate	
1998		Moderate	Moderate	Moderate	Slight	Slight	Slight	Slight	Slight			
1999												
2000				Severe	Severe	Severe						
2001										Severe	Severe	Severe
2002					Severe	Severe	Severe			Severe	Severe	Severe
2003												
2004												
2005			Moderate	Moderate	Moderate	Moderate						
2006		Moderate	Moderate	Moderate								
2007	Moderate	Moderate	Moderate	Slight	Slight							
2008	Slight	Slight	Slight									
2009		Moderate	Moderate	Moderate	Moderate	Moderate	Serious	Serious	Serious			
2010	Moderate	Serious	Serious	Serious							Moderate	Moderate
2011		Moderate	Moderate	Moderate								
2012	Serious	Serious	Serious					Serious	Serious	Serious	Serious	Serious
2013	Serious	Serious	Serious									

Table 5 - Severity of Drought Conditions 1984-2013 (30-year period) (Antigua and Barbuda Meteorological Service, 2014)

Drought conditions from 1874-1949 exacerbated the health situation and contributed to the death of 14 people (GOAB, (2001c). In 1984 Antigua and Barbuda experienced a period of severe drought between January to March, with extreme low rainfall 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 serious drought conditions (Table 5). During the drought period, 1983-1984, all surface reservoirs were depleted and the ground water supply only produced one sixth of the constrained national demand (UNEP, 2000 and Simpson et al, 2012). In addition during this period of drought farmers were forced to abandoned their crops lands and allowed their livestock to fend for themselves (UNEP 2000).

Prevailing drought conditions between 1984-2001 contributed to the rapid loss of vegetative cover and led to further land degradation (GOAB, 2001c). In 2000, annual rainfall records in Barbuda totalled less than 706 mm for ten years (Simpson et al, 2012). To combat future impending drought conditions the Government installed a desalinating plant at Crabbes Peninsula between 1893 and 1984. In addition, during the dry season ground water resources are reduced to as low as 30% of yield potential.

The agriculture sector is highly vulnerable to climate related events such as drought, tropical storms and associated flooding. During periods of low annual rainfall and high evaporation and transpiration rates, the agriculture sector requires irrigation for continued yields and moderate levels of production (Simpson et al, 2012). In 2010, onion and tomato crops in Antigua and Barbuda decreased by 25% and 30% respectively, due to water stressed conditions (Roberts, 2013).

Drought vulnerability zones for the country was determined based on environmental, meteorological; hydrological, infrastructural and human and land use. Based on the drought vulnerability zones the northeast and southwest of Antigua are most vulnerable to drought (GOAB, 2001c) (Figure 30). The specific location identified as the most vulnerable to drought was the southeast of Antigua between English Harbour and St. James (GOAB, 2001c).

Most of the development in Barbuda occurred within the zone of high drought vulnerability (Figure 31). In addition, the town of Codrington and the entire south coast from River Port to Cocoa Point in Barbuda are located within the high drought vulnerability zone. Agricultural and tourism development within Palmento in Barbuda were located within the zone of low drought vulnerability

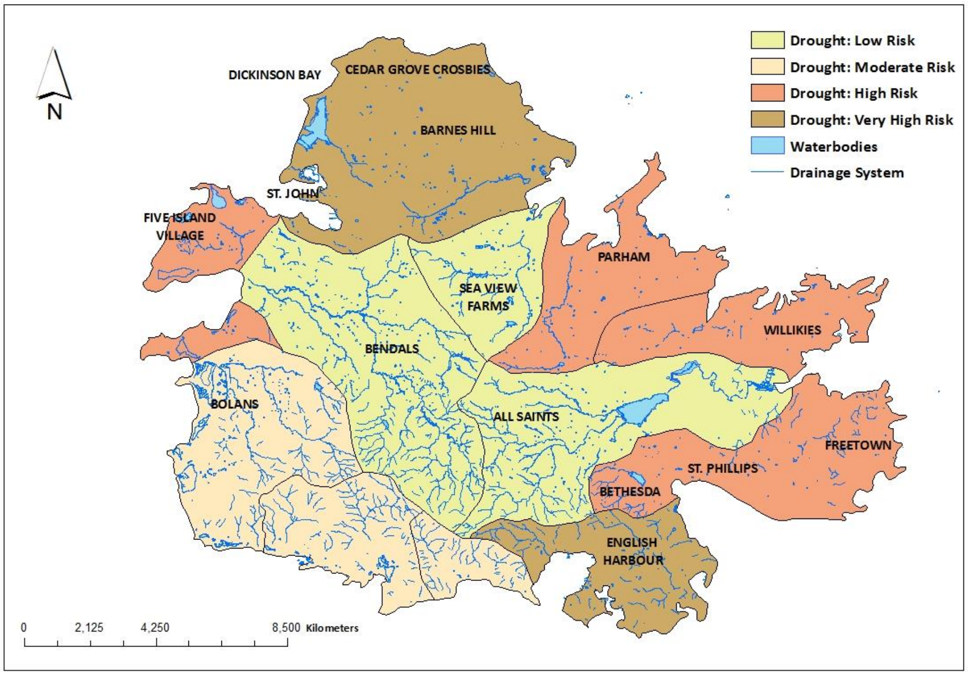

Figure 30: Drought risk profile Antigua

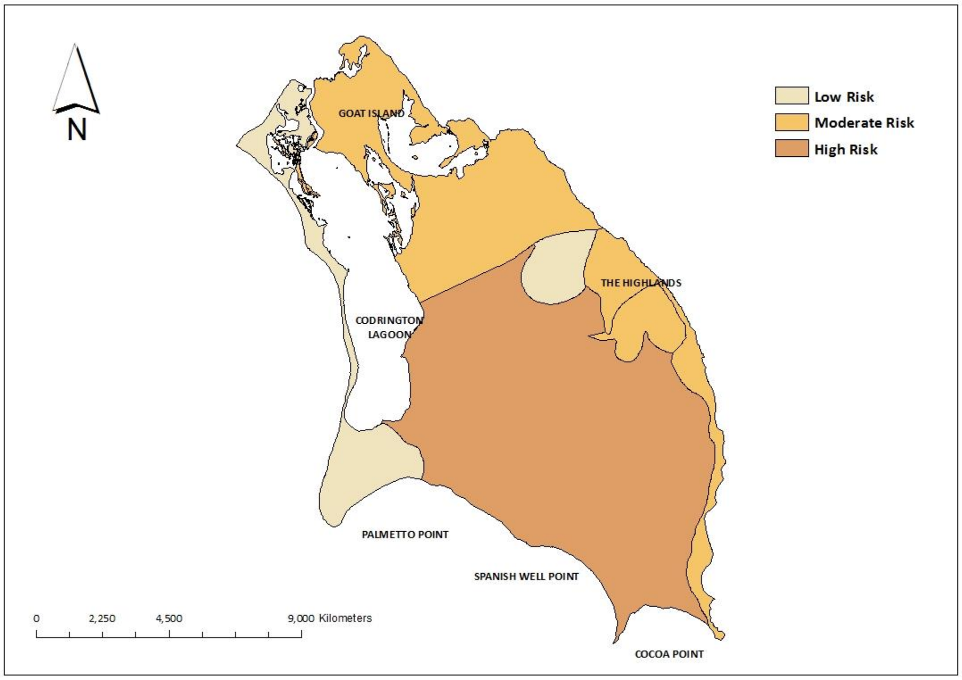

Figure 31: Drought risk profile Barbuda

3.2 Sensitivity to Current Variability and Future Change of Priority Sector

3.2.1 Water Resources

Fresh water supplies in small islands have always been a challenge due to the topography and geology of islands and capacity to store water resources. Rapidly growing demand, land use change, urbanisation, and tourism are already placing siginificant strain on limited freshwater resources. In addition mismanagement of water resources in the Caribbean occur on a backdrop of decreasing rainfall and increasing temperature (IPCC, 2014).

The provision of a safe and adequate supply of water has been a significant challenge for Antigua and Barbuda because of is particular vulnerability to a reduction in availability (Gomes, 2008 and the GOAB, 2009a). The average annual rainfall for Antigua and Barbuda is 1,016 mm and the current water output is estimated to range between 18,640 m3 and 20,460 m3 per day (4.9 to 5.4 million US gallons per day) (Simpson et al, 2012). Of the water, withdrawals used, the domestic sector, industry and other purposes constitute 60%, 20%, and 20% respectively. As a result, water withdrawal per capita is estimated to be 80 m3 per year (Simpson et al, 2012).

Climate change has adversely affected the watersheds (GOAB, 2009a). In addition to issues with water management and the removal of vegetation cover, increased saline intrusion due to climate change can exacerbate the water situation in Antigua and Barbuda (The World Bank, 2010). The main impacts of climate change on water resources in Antigua and Barbuda included:

- increase stress on limited available water supply specifically during the dry season;
- saline intrusions in the fresh water aquifers located within the coastal area;
- increased evaporation from surface water storage;
- increased damage to water distribution infrastructure,
- increased vulnerability of watersheds due to increasing drought conditions,
- increased dependence on desalinated water to supply growing demand;
- inadequate reservoir design and catchment management; and
- high vulnerability to flooding

Antigua and Barbuda is mainly karstic in nature and as such, the water is maintained in a Ghyben-Herzberg lens. A , Ghyben-Herzberg lens is a section of fresh water floating above salt water, which is replenished by rainfall (The World Bank, 2010).

Antigua's 86 watersheds (Figure 32) can be categorised into 13 larger watershed, Potworks (4000 ha) and Big Creek (3160 ha) being the two largest (Cooper & Bowen, 2001 and the GOAB, 2009a). The four other watersheds that are of importance include Fitches Creek, Christian Valley, Parham, and Bethesda (Cooper & Bowen, 2001). These 6 watersheds occupy 43% of the land area and contain 80% and 90% of the groundwater supplies and the surface water storage respectively (Cooper & Bowen, 2001 and the GOAB, 2009a) The watersheds are considered to be quite short, as the largest one is not more than 11 km (Cooper & Bowen , 2001).

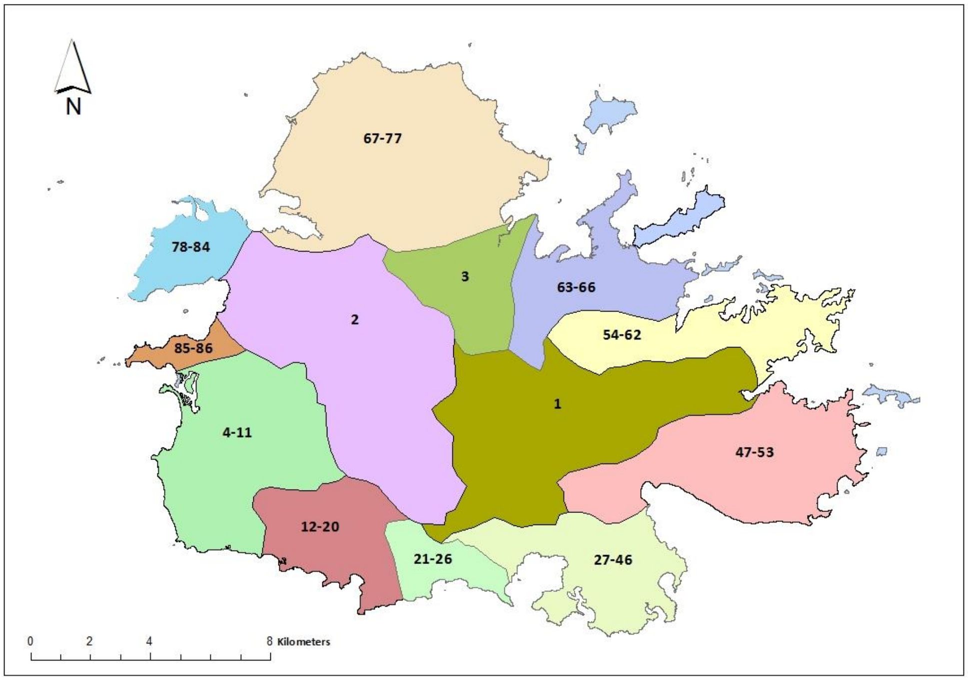

Figure 32: Antigua Watersheds

Approximately 70% of Antigua's daily water supply during the wet years and 100% during the very dry periods is obtained from desalination water, with the remainder supplied by surface storage and wells (GWP-C, 2013).

A number of factors contribute to current water shortages in Antigua and Barbuda, which includes:

- insufficient storage during rainfall events,
- limited number of distribution pipes,
- limited number of treatment plants, and
- key water resources challenges (GWP-C, 2013)

Watersheds in Antigua and Barbuda have been subjected to various stresses including pollution from agriculture and settlements, which contributed to:

- degradation of the watershed,
- reduced water supply,
- the siltation of reservoirs and
- reduced rates of recharge for aquifers.

In Barbuda, the nature of the soil and topography makes surface run off minimal and as such, there are 10 watersheds. Barbuda is categorised as an arid island with the absence of permanent streams and a few seasonal lakes and inland depressions. Therefore, its main water supply is based on ground water, which was increasingly threatened by saline intrusions). The total reservoir storage capacity is only equivalent to approximately 1-year's water demand and is highly dependent on full annual replenishment to prevent shortages (Gomes, 2008). The relative slight changes in temperature and precipitation for Barbuda, coupled with the collective effects of evapotranspiration and soil moisture could result in massive reductions in runoff. Unfortunately increased intense rainfall in Barbuda is not always an effective means of replenishment as it often leads to increased runoff and the risk of flash flooding (Gomes, 2008).

3.2.2 Food security

Given the global interdependence of countries, the impact of climate change on resources or commodities in one place will have significant effects on prices, supply chains, trade, investment, and political relations in other places. Therefore, climate change will progressively threaten food security and economic growth in complex ways especially in SIDS (IPCC, 2014).

Maintaining the health of the watersheds is critical to the sustainable development of the agriculture sector particularly as it relates to food security (ESAL, 2008). Even in irrigated areas, the limited supply of water has stunted plant growth and fruits sizes (ESAL, 2008). Since Antigua's average evaporation has been significantly higher than the annual average rainfall, supplemental irrigation was necessary to sustain yields. Antigua's rainfall reliability even during the wet season experienced frequent dry periods that were sufficiently serious to impact crop production.

Antigua and Barbuda has experienced increase in the frequency and intensity of floods and droughts. This has contributed to increase concern about the impact of climate change due to the fact that the agricultural sector is primarily rain-fed. This therefore creates an significant link between climate change and food security in Antigua and Barbuda given the potential of climate change to increase the risk of reduced food supply and income disruptions and reduced stability of domestic food supplies. In addition major of these losses are borne by producers who are already small and vulnerable which impacts the rehabilitation efforts in the sector (GOAB, 2012a).

A significant shortage of agricultural labour due to competition from more profitable sectors such as tourism, gaming, and construction; and the acute shortage and high price of available water supplies for irrigation (ESAL, 2008) are key factors attributed to the decline of sector. Periods of limited rainfall contributed to overgrazing of pastures and upper watershed areas by livestock. This led to over exposure of topsoil, which resulted 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. Irrigation is expected to be more critical with the anticipated increase in temperature extremes due to climate change.

3.2.3 Biodiversity

The continued practice of indiscriminate cutting, clearing for agriculture; uncontrolled grazing and fires have contributed to severe degradation, accelerated erosion and reduced productivity of the land (Environment Division, GOAB, 2009a). In addition, poor farming practices have negatively affected biodiversity and has contributed to the overall decline in ecosystem health across the island (Mitchell, 2009).

Despite the fact that the fisheries sector was thriving economically 2005-2007 there were threats to the biodiversity of the resource and entire marine environment and ecosystem, which included:

- increased pressure from overfishing and destructive fishing methods;
- increase development of coastal hotels and marinas;
- pollution from land based and marine sources;
- habitat modification and physical destruction from natural events and human activity;
- overcrowding of the marine environment,
- decrease access to markets; and
- local and global market conditions (GOAB, 2009b and Gore-Francis, 2013).

The sea turtle populations (Green turtle (Chelonia mydas); Hawksbill Turtle (Eretmochelys imbricate) and Leather Back (Dermochelys coriacea) in Antigua and Barbuda have been affected by the destruction of critical nesting and foraging habitats because of coastal construction, sand mining, pollution and over fishing (Environment Division, GOAB, 2009b).

Invasive species threaten the biodiversity within Antigua and Barbuda. For example the biodiversity of the Wallings area, an important forest reserve area, is threatened by invasive species such as Lemon grass, goats, Indian Mongoose and the Black Rat (Rattus Rattus) (GOAB, 2009b). In 2010, citronella grass, was one of the most critical invasive species in Antigua and Barbuda because it covered over 345 acres of land, which threatened native species and exacerbated the problems experienced by farmers (Banhan & Lewis, 2013).

3.2.4 Health conditions

Many small island states suffer from climate sensitive health problems, including morbidity, mortality from extreme weather events and certain vector, food and water-borne diseases. Extreme weather and climate events such as tropical storms, storm surges, flooding and drought can have both short-terms and long-term effects on human health including injuries, increased disease transmission and health problems associated with deterioration of water quality and quantity (IPCC, 2014). From a climate change perspective environmental health management is of particular concern from a climate change due to the significant linkage between various climate sensitive diseases and the prevailing environmental conditions (GOAB, 2009a).

Malaria within the context of climate in the Caribbean can be considered significant due to its recent resurgence in several countries after near total eradication between 1958 and 1965. Between 2001 and2009 Antigua and Barbuda had one recorded case of Malaria. Between 2001 and 2009, there were 211,937 registered cases of dengue fever in the Caribbean (ECLAC, 2011). 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. In addition, greater occurrences of dengue fever in the warmer, drier period of the first and second years of El Niño events have been recorded (ECLAC, 2011).

Tropical island nations like those of the Caribbean region have weather conducive to the transmission of diseases such as malaria and dengue fever (IPCC, 2014) (Figure 33). There are indications that the wet season represented the period of greater risk for dengue fever transmission in the Caribbean. Drought conditions for example have contributed to water shortages, which have resulted in increased risk of the transmission of diseases such as cholera, typhoid and bacterial dysentery. Risk of infection from Cholera is influenced by temperature, precipitation and accompanying changes in salinity die to freshwater water or the addition of organic carbon or other nutrients. Heavy rainfall promotes the transmission of pathogens when there is not secure disposal of faecal waste (IPCC, 2014). This could exacerbate the situation in Antigua and Barbuda, where disposal of waste into the marine environment has been a significant challenge for costal water quality particularly after periods of heavy rainfall.

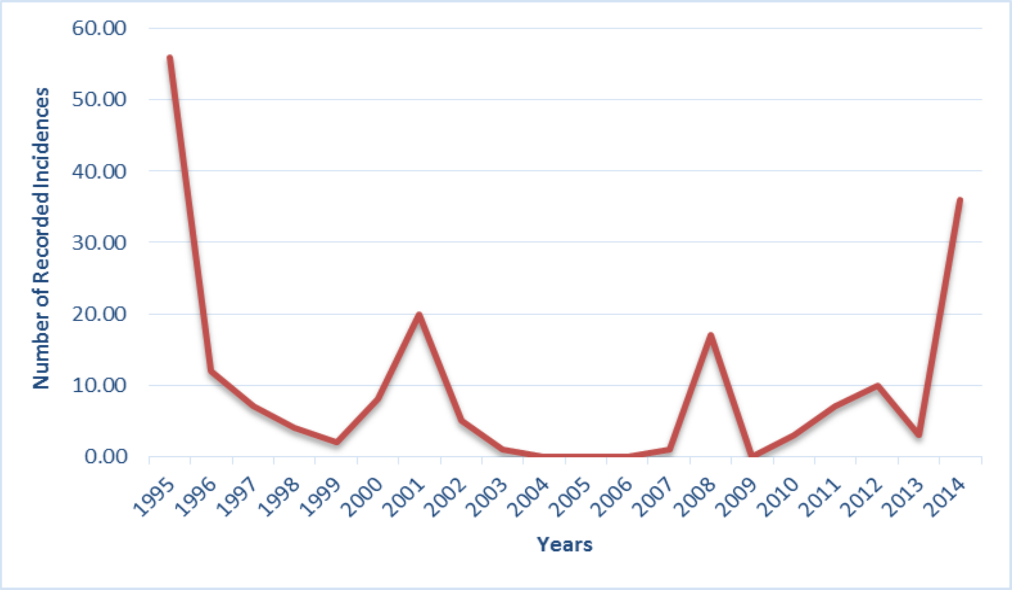

Figure 33: Number of Recorded Incidences of Dengue Fever in Antigua and Barbuda

Extreme variations in precipitation levels may result in higher concentrations of pathogens in local water resources. Flood conditions can result in increased pest populations and contamination of surface and groundwater (Simpson et al, 2012). Increased flooding has also contributed to biological contamination of water sources and an expansion of the habitat of vectors such as the Aedes aegypti mosquito. The results from an epidemic potential model run based on several scenarios of temperature changes (baseline, +1°C, +2°C and +4°C), indicated that the transmission of dengue fever was dependent upon both temperature and precipitation as well as temperature alone. Therefore, Antigua and Barbuda is expected to be at risk from increased incidences of vector borne diseases such as Yellow Fever and Dengue Fever (Solomon et al, 2011) (Figure 33).

The projected changes in temperature of approximately 1.5oC - 2.0oC by 2030 and 2050 could alter average temperature. The heat stress generated by altered average temperatures could serve as a major source of morbidity or mortality for high-risk groups. These high-risk groups include: the elderly, persons with cardiac and respiratory problems, persons working outdoors, and engaged in strenuous activity, and persons living and working in poor ventilated areas.

Higher temperatures create more conducive environment for the growth and development of some bacteriological and epidemiological agents. 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 (GOAB, 2009a).

There is a growing concern among island communities in the Caribbean that freshwater scarcity, more intense droughts and storms could lead to a deterioration in standards of sanitation and hygiene (IPCC, 2014) There are considerable challenges to environmental health management, which include improper disposal of solid waste and the rapid increase in waste volumes. Increased precipitation, combined with low water table and the percentage of the population, which use pit latrines, increased the chance of contamination from sewage systems. A major concern is the contamination of underground water storage from sewage by salmonella, gastroenteritis, shigellosis and campylobacter (Simpson et al, 2012).

3.2.5 Ecosystem Services

Coral reefs are shallow-water ecosystems that play an important role in the tropics, housing high levels of biological diversity as well as providing key ecosystem goods and services such as fish breeding ground, coastal protection, and appealing environments for tourism. Communities in tropical small islands such as Antigua and Barbuda derive benefits including food, livelihoods, construction materials, medicine, cultural value and tourism opportunities from them (IPCC, 2014). Therefore, the well-being of island communities within the Caribbean is linked the coral reefs' continuous function and productivity.

Coral reefs are one of the most vulnerable ecosystems and approximately more than 50% of the world's reefs are under medium or high risk of degradation. A wide range of climatic and non-climatic drivers affects coral reefs and negative impacts have been observed. The abundance of coral species that build reefs is in rapid decline and has decreased by over 80% on many Caribbean reefs.

Coral reefs in Antigua and Barbuda are in poor condition due to:

- impacts from high sedimentation;
- over fishing;
- destruction by the anchoring of boats;
- improper placements of fish traps;
- improper disposal of garbage;
- breakage by recreational diving and
- the release of partly treated sewage from coastal developments (GOAB, 2009b).

In addition to these impacts, climate change has exacerbated the situation and climbing global temperatures has resulted in bleaching events in Antigua and Barbuda (GOAB, 2009b). The 2005 bleaching event resulted in average coral cover being reduced from 16% to 7% by 2007. In addition, although previous extensive stands of elkhorn coral (Acropora palmate) existed only a few small colonies remain (Australia Caribbean Coral Reef Collaboration, 2012). It is anticipated that coral reefs in Antigua and Barbuda will experience thermal stress severe enough to cause bleaching every year after 2040. In addition, ocean acidification is projected to contribute to the decline of ~10% in coral calcification by 2040 (Australia Caribbean Coral Reef Collaboration, 2012).

The impact of costal tourism and other uses on wetlands is one of the major land and environmental issues facing Antigua and Barbuda. Jolly Pond in Antigua is one of the major wetland systems that were dredged and landfilled to create Jolly Harbour Marina and adjoining lands for real estate development (GENIVAR, 2011).

Like coral reefs, mangroves and sea grass environments provide a range of ecosystem goods and services and both ecosystems play a significant role in the wellbeing of small island communities. Mangroves in particular serve as a series of commercial and subsistence uses as well as providing natural costal protection from erosion and storm events (IPCC, 2014).

Various studies highlighted changes in wetland coverage in Antigua and Barbuda. In 1980, wetlands covered 11% of Antigua and Barbuda. In 1991, it was estimated that wetlands covered only 3% in Antigua and 22% in Barbuda (GOAB, 2013a). Between 1980 and 1995, dry forest and swamp areas in Barbuda covered 7,900 ha and mangroves a further 3,729 ha, most of which is contained within the Codrington lagoon (Cooper & Bowen, 2001). In 2004 the wetland coverage for Antigua was 3.22% (902 ha) and 5.04% (897 ha) in Barbuda (GOAB, 2010). In 2005, Food and Agriculture Organisation (FAO) estimated that wetland coverage in Antigua was reduced to 700 ha (GOAB, 2013a).

Mangrove forests in Antigua and Barbuda are mostly threatened by increased hotel and marine infrastructure on the coastline, which has contributed to the loss of red, white, and black mangrove forest species (GOAB, 2009b). The rate of decrease of the red mangrove forest is approximately 3-5% per annum. However, the threat to the red mangrove forest is more widespread in Antigua than Barbuda (GOAB, 2009b).

Some of the general threats to the mangrove and wetlands include:

- over grazing by livestock, including sheep, cattle, donkey and goats;
- pollution due to excessive nutrient or sewage discharge into coastal water and the unregulated and excessive use of pesticides; and
- physical and human activities (GOAB, 2013a).

Past efforts to protect the Codrington Lagoon were minimal at best (GOAB, 2009b). However, due to increase awareness about climate change, renewed efforts have been undertaken to prioritise the protection of such critical natural ecosystems (GOAB, 2009b).

Wetlands in Antigua and Barbuda are usually located near to attractive beaches, which are considered favourable for erecting marinas, hotels, and golf courses by developers. As a result, the sale prices of wetlands often do reflect its true value to the protection of fisheries and coastal erosion. As a result, wetlands are often sold as cheap real estate (Cooper & Bowen, 2001). Unfortunately, the Fig Tree Reservoir, part of Walling Forest appears to be unable to provide adequate habitat for several songbirds such as the American Redstart, Louisiana Thrush, and various warblers (Mitchell, 2009).

Table 6 – Stakeholder assessment of the biophysical and socio-economic impacts of climate change on water resources, agriculture, and health in Antigua and Barbuda

CLIMATE CHANGE EXPOSURE	CLIMATE CHANGE IMPACTS	
	Primary (biophysical) impacts	Secondary (socio-economic) impacts
Increased sea surface temperatures	Catchments: surface water loss Stronger, more frequent storms Biodiversity loss: coral bleaching Reduced fish stock: coral bleaching Reduced fish stock: species migration Poor marine ecosystem health Reduced fish stock Lower marine NPP	Disruption of livelihood activities: more frequent flooding Economic loss: damaged infrastructure – Decreased tourist arrivals Population displacement Water contamination Increased fishing expenses Loss of fisheries sector livelihoods Food insecurity: availability Decreased supply local food Loss of fisheries sector livelihoods Food insecurity: utilization
Sea level rise and storm surge	Decreased groundwater: saline intrusion Decreased groundwater: saline intrusion (r) Loss of land area Coastal flooding Loss of coastal ecosystem infrastructure Decreased groundwater: saline intrusion	Decreased value of tourism product Disruption of telecommunications systems Loss of (coastal) agriculture sector livelihoods income Loss of/damage to physical fishing assets (gear, sheds, boats) Decreased availability of potable water Less land area suitable for crop production Loss of income for coastal farmers, fishers Decreased land value Poor health status: prevalence of water and vector borne diseases Decreased availability of freshwater Decreased availability of potable water: increased water expense
Reduced average annual rainfall	More frequent drought conditions More frequent drought conditions Increased evapotranspiration Reduced livestock breeding Crop production failure, losses Increased pests and plant diseases More frequent drought conditions Decreased surface water availability Surface water contamination	Food insecurity: increased food import bill Poor health status: prevalence of water and vector borne diseases Decreased availability of potable water: increased water expense Decreased agricultural productivity Decreased productivity of workforce Increased intensity of agricultural production Loss of agriculture livelihood Increased food insecurity (increased food import bill) Health conditions (water and vector borne diseases) Increased food insecurity: increased food import bill) Loss of livelihood
More periods of intense rainfall	More frequent of flood events More frequent of landslide events More frequent flood events More frequent landslide events Increased soil erosion Increased siltation More frequent of flood events Infrastructure damage Loss of land area	Poor health status: increased water borne diseases Damaged infrastructure Decreased agricultural productivity Less land area suitable for crop production Decreased agricultural productivity: crop failure, damage Increased pests and plant disease outbreaks Increased health insurance costs Increased prevalence of water borne diseases (mosquito) Damaged hospital and clinics Difficulty accessing healthcare facilities
Tropical storms	Increased sedimentation, run off Surface water contamination Vegetation loss Crop failure, damage Reef and mangrove damage: intense rainfall	Water contamination Disruption of water distribution systems Reduced volumes of potable water Damaged pipelines, water catchments Crop/livestock loss and disruption of agricultural livelihoods Loss /damage to agriculture infrastructure Loss/damage fishing assets (gear, sheds, boats) Physical injury, loss of life Loss of fisheries sector livelihoods Loss of agriculture sector livelihoods Disruptions in delivery of medical care: loss of electricity

Water resources Agriculture Health

4 Adaptive Capacity

Adaptive capacity is the ability of the country to adjust to climate variability and extremes, to reduce potential damages, take advantage of opportunities, and manage the repercussions. Adaptive capacity represents potential rather than actual adaptation and therefore reduces a system's vulnerability to hazards occurring in the future or to hazards that involve slow change over relatively long periods (Adger et al, 2004). Within the climate change asset adaptation framework the following classes of capital: natural, social, economic, human and political capital underpin adaptive capacity.

4.1.1 Natural Capital

Natural capital is constantly changing, and its productivity can be enhanced or degraded through human and other influences. Land productivity, availability of water resources and the level of biodiversity significantly influence natural adaptive capacity. For example, the adaptive capacity of farmers (sustaining their livelihoods) is dependent on the amount of natural capital, which they have access to (Nelson et al, 2007).

The conservation and sustainable use of terrestrial and marine ecosystems is critical for maintaining the natural capital and increasing the adaptive capacity. Conservation initiatives contribute to increase knowledge about species abundance, location, and habitat requirements, which all add to the adaptive capacity of the country (GENIVAR, 2011). The sustainable use of the existing biodiversity within Antigua and Barbuda significantly contributes to the present and future quality of life even within the impending threat of climate change (GOAB, 2013a).

Combating environmental degradation is of critical importance to adaptive capacity because a substantial resource base is necessary to support and sustain the related economic activity. Ecosystems such as sea grass beds, mangroves and wetlands already under stress from physical impacts are already demonstrating impacts from climate change (GOAB, 2012a). The mangrove system in Antigua and Barbuda has already been devastated by natural (hurricanes droughts) and anthropogenic impacts (pollution and physical destruction). The current state of the mangrove system increases its risk to climate change, which has and will continue to affect this ecosystem (Gore-Francis, 2013).

Increased temperatures due to climate change have affected the productivity of the coastal areas (GOAB, 2009a). The main impacts of climate change on the coastal zone include:

- inundation of beaches and other coastal lands;
- increased coastal erosion; increased submergence and siltation of sea grass beds;
- coral reef degradation mainly as a result of bleaching; adverse impacts to human settlements and infrastructure due to increase storm activity and intensified associated storm surge; and
- destruction and loss of mangroves, wetlands, and structural changes in the fishery sector (GOAB, 2009a).

Therefore, the ability of these ecosystems to sustain other biological resources from which livelihoods are derived are reduced.

The establishment of protected areas was one management strategy to ensure resource protection, maintenance of scenic and historic landscapes, recreation, and sustainable development (GENIVAR, 2011). This management strategy can contribute to restoring and maintaining the natural adaptive capacity of Antigua and Barbuda

Protected areas are recognized robust systems of biodiversity conservation and therefore help to manage the unavoidable threat of climate change as these natural ecosystems serve as carbon sinks and resources for adaptation. Protected areas contribute to the composition, structure and functioning of the ecosystem well beyond their own borders and provides ecosystem services for disaster reduction, water supply, food and public health, all of which enable community based adaptation (Dudley et al, 2010).

In addition, the Ridge to Reef Project funded by GEF focused on the rehabilitation of the same areas with the aim of protecting the water drainage system from erosion of mud and silt (GOAB, 2012d). The main aim of the Ridge to Reef Demo Project was to establish an integrated management plan for the south-western region that incorporates both marine and forest reserves and protects the key biodiversity assets and functional habitats within this environmentally sensitive area (Clovis, 2010). The successful implementation Ridge to Reef Project will increase the adaptive capacity of the communities in the south-western region due to the financial benefits and livelihood created (country side tours) which will be obtained from conservation of key habitats, species and cultural land marks.

Antigua and Barbuda has recently established a System Plan for the development and management of protected area and has revised their National Biodiversity Strategy and Action Plan (NBSAP), which served as the long-term plan for sustainable use of biodiversity in Antigua and Barbuda (Gore-Francis, 2013). The NBSAP would foster partnerships between Government, communities, non-governmental organisations and the private sector which would contribute to the greater protections of these essential services and contribute significantly to the natural adaptive capacity. The National Office of Disaster Service (NODS) in collaboration with the GEF, created an Environmental Sensitivity Map, which constituted part of the Environmental Information Management and Advisory System (EIMAS) (Gore-Francis, 2013). The Environmental Sensitivity Index Map is integral to adaptation in Antigua and Barbuda as it would be possible to highlight the locations of ecological resources in the country while at the same time creating spatial maps to assess the vulnerability to hazards. The EIMAS and the Environment Sensitivity Map is essential for monitoring, verification, and reporting, which are critical increasing adaptive capacity. The EIMAS, if effectively implemented can ensure that ecosystems are maintaining a good capacity, possess efficient management, effective and established governance structures and support from local communities.

The Sustainable Island Resource Management Mechanism (SIRMM) Project, which was undertaken in collaboration with the GEF, involved the establishment of demonstration sites, the use of various technologies and the construction of bench terraces as firebreaks and for soil erosion (GOAB, 2012d). The SIRMM Project will contribute significantly to the adaptive capacity because its aim is to develop and implement a comprehensive cross-sectoral ecosystem approach that enhances ecosystem functionality, biodiversity conservation and sustainable livelihoods. The approach that is employed under the SIRMM Project will considers the island's ecosystems and its marine and terrestrial resources as a capital asset, which if properly managed and protected, will continue to yield a flow of vital goods and services such as water, productivity, physical shelter, adaptive capacity and resilience necessary for sustainable economic development. Improving the management and sustainable use of the ecosystem resources and alleviating the multiple stressors on the environment increases the island's natural capacity to combat climate change.

4.1.2 Social Capital

Social capital is an important element of coping with climate change and climate variability as it determines the social network cognitive elements, culture, and relationships between community members and social groups. Despite the fact that a person's adaptive capacity is dependent on their access to resources and ability to use them effectively, the adaptive capacity of a society is highly dependent on the ability to act collectively to address the threats posed by climate change and climate variability. Population size relative to land area, the structure of society, age stratification of the population, employment rate, and access to resources are all factors that influence social capital (Adger et al, 2004).

The existing social networks and social cohesion are critical for coping with adversity and change. Social networks are important to ensuring resilience to climate change that is derived from dependence upon and reciprocity with small social groups of people (Mendis et al, 2003).

Based on the 2011 National Housing Census the national population density was 776.5 people per square miles in Antigua and 29.2 people per square miles in Barbuda, which is significantly higher than it was in 2001 when the population density was 688.0 people per square miles in Antigua and 23.2 per square miles in Barbuda.

Population density is one factor, which determines the outcome of vulnerability to climate change and climate variability. More densely populated areas have increase expose to hydro meteorological hazards, because a larger percentage of people are exposed. Therefore, human and financial resources would have to be allocated for areas with higher population densities. The significant growth in St. John Rural is evidence of the continued de-urbanisation of the population that has been a trend over the past 20 years (Statistics Division, 2012) (Figure 34).

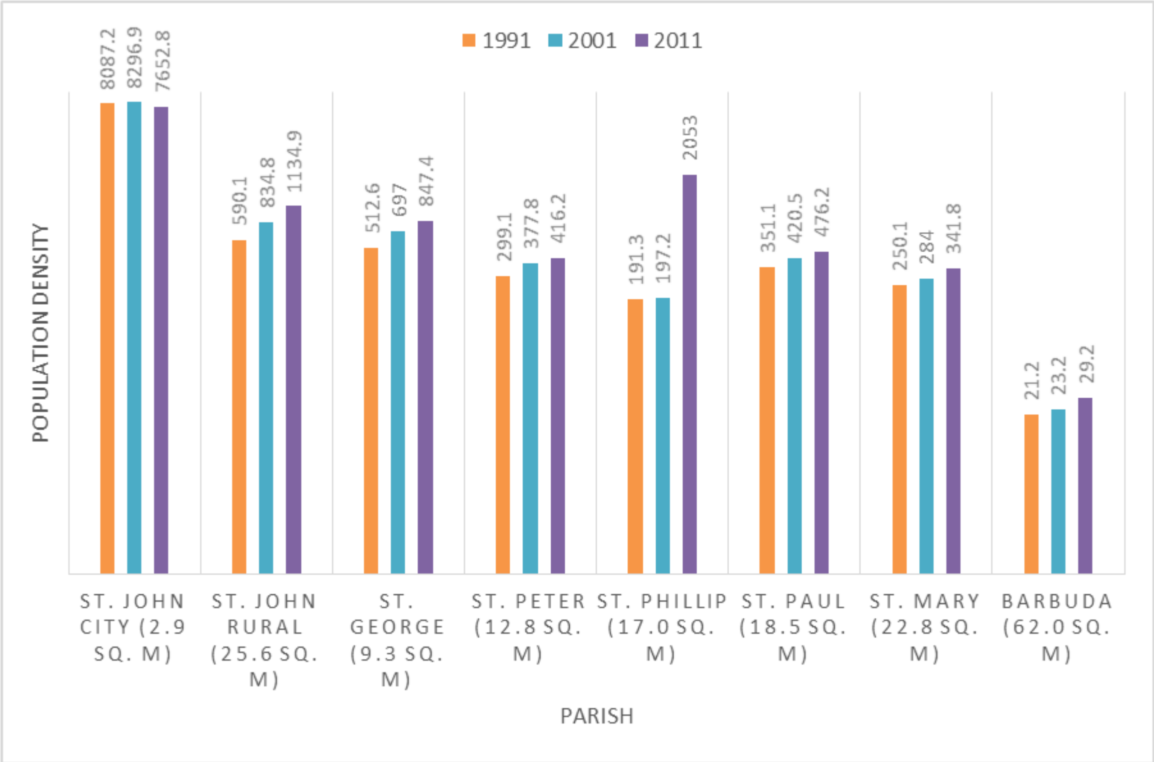

Figure 34: Population Density by Parish for Antigua and Barbuda

The unemployment rate in Antigua and Barbuda based on the 2011 National Census was 10.2%. The indigent population was estimated at 5% of the population, constituting 4.4% of the households in the country. The poverty line was estimated at EC$ 6318.00 (US$ 2366.00) per annum. 18.4% of the population fell below the poverty line, indicating that 18.4% of the population is unable to meet basic needs. Therefore, it is estimated that the cumulative total of 28.3% of the population is estimated to be at risk. The poorest districts are St. John's City (22%) and St. John' s rural (8%); followed by St. Philip (26%); St Paul (16%); St. Peter (15%); St. Mary (14%); St. George (12%) and Barbuda (11%). Poverty and unemployment is directly linked to vulnerability as grater income allows spending on adaptation planning, therefore contributing to a reduction in adaptive capacity. Unemployment and poverty also limits access to resources and social services and increases the difficulty in sustaining a livelihood. Many of these residents within communities with high levels of poverty had to go outside of the communities to access social services. There are few non-governmental organisations and community based organisation that organise programmes to assist residents, but participation in these programmes are not very high.

Social capital is a critical component of adaptive capacity as networks and partnerships between stakeholders and agencies within communities allow for collaboration in developing integrated and built-faceted adaptation strategies. The relationships among the rural communities are relatively good. For example, Ebenezer is a close knit community; Wilikies possess a strong community spirit and the Piggotts community is considered to be a family community as majority of the residents are related. The existing social networks and social cohesion are critical for coping with adversity and change. Social networks are important to ensuring resilience to climate change that is derived from dependence upon and reciprocity with small social groups of people (Mendis et al, 2003).

4.1.3 Economic Capital

Economic capital includes the financial resources of a country along with the built infrastructure and the economic condition of the population. The economic condition of a population is considered a strong determinant of adaptive capacity and as a result, economically disadvantaged individuals and communities are especially vulnerable to environmental change. At the national level, the available financial resources to address climate change can affect most aspects of adaptive capacity. Therefore, the overall economic wealth of a country will determine national level monitoring, adaptation strategies, resources to respond to environmental, and climate changes (Mendis, et al, 2003).

Antigua and Barbuda is categorised as middle-income developing country (Simpson et al, 2012) which has a direct impact on its adaptive capacity. St. John's City is the national urban centre. All Saints and Codrington serve as sub-national centres. Parham, the English Harbour and Flamouth area, Old Read and Bolans serve as special-development settlements where there are various mixed concentrations of tourism, heritage, fishing, agricultural, residential, commercial and recreational activities (UNHABITAT, 2011). The main economic challenge for Antigua and Barbuda which limits its adaptive capacity is limited economic resilience due to dependence on one main economic driver, tourism and increasing national debt as a percentage of GDP which exceeds 100% (GOAB, 2012b).

The financial resources of Antigua and Barbuda, which have a significant impact on adaptive capacity, is evident in the money supply. Between September 2012 and September 2013 the money supply increased by 5.7% to US $2.9 billion. One of the major contributors to this is an 8.8% increase in private sector savings deposits from approximately US $1.1 billion in September 2012 to US $1.1 billion in September 2013.

Private sector demand deposits and private sector foreign currency deposits grew by 22.5% and 14.8% respectively. With the start of the tourist season in 2013 it was anticipated that the money supply would continue to expand as a result of increased foreign currency deposits and currency in circulation associated with enhanced activity in the tourism sector (GOAB, 2014b).

In 2013, Antigua and Barbuda experienced robust growth in construction activity, which had positive spin-off effects on financial services, real estate, and transportation sectors, adding significantly to its economic capital. In addition, there was significant public investment in critical economic infrastructure, including roads and airport expansion (CBD, 2013). The adaptive capacity of the fisheries sector is expected to increase due to the Fisheries Complex Refurbishment Project being undertaken in 2014 in collaboration with the Government of Japan (GOAB, 2014b).

In 2013, the built infrastructure as it relates to education was improved and increased. An amount of US $24.5 million from the Caribbean Development Bank (CDB) was approved for Antigua and Barbuda to enhance instructional effectives and expand opportunities for children to complete primary and secondary school. In addition, US $13.4 million was approved to provide the physical infrastructure required to achieve universal secondary education access, as well as to enhance instructional effectives and leadership of the schools and the education system (CDB, 2013).

Other projects that have benefitted the people of Antigua and Barbuda include US $622,000.00 for fencing and drainage work at the King George V Grounds; US $1.1 million to provide relief to citizens and residents affected by Hurricane Omar and US $1.5 million to support the sweeping and dredging of the Nevis Street pier (GOAB, 2014b).

In order to improve the economic condition of the population in 2008 the GOAB launched the Peoples Senior Citizens Utility Subsidy Programme (SCUSP) and Benefit Programme (PBP) in 2009.

In 2013, there were 1,800 beneficiaries of the PBP, which mainly consisted of single mothers, senior citizens who do not receive and pension and person with disabilities (GOAB, 2013b). In addition, in 2014, the Government of Japan, through its Grants Assistance for Grassroots Human Security Projects, supported local non-governmental organisations or community based organisations in small development projects. Priority sectors for the Grassroots Human Security Projects include education; primary health; vocational training; special education; agriculture; public welfare; and the environment (GOAB, 2014b). The interventions in relation to the Economic Action Plan and the Social Transformation Programme implemented by the government have helped to generate some economic activity and maintained the social safety nets that provide crucial relief to the vulnerable in society.

4.1.4 Human Capital

Human Capital is the skills, education, experiences, and general abilities of individuals within a community or country. The collection and dissemination of relevant and current information and the number of skilled and trained personal also influences adaptive capacity (Mendis et al, 2003).

A capability assessment conducted by Organisation of American States (OAS) in 2001 revealed that 27% (6) of a total of 22 government institutions in Antigua and Barbuda were involved in disaster mitigation activities while 14% (3) were involved in the preparation, response and recovery stages of the disaster management process (OAS, 2001). The study further revealed that 100% of the 22 government agencies interviewed indicated that that institutional capacity for dealing with disaster management was inadequate (OAS, 2001).

The common inadequacies, which were identified by capability assessment as it relates to institutional capacity, included:

- lack of suitable policy framework for disaster management;
- weak institutional and administrative structures;
- lack of capability to plan, implement and monitor a disaster mitigation programme;
- ineffective institutional coordination systems and inadequate financial and human resources for conducting disaster mitigation planning and
- weak implementation capacity and weak linkages between government and the private sector (OAS, 2001).

Currently NODS through the operations of the National Emergency Operations Centre (NEOC) is the organisation in Antigua and Barbuda with the responsibility of addressing disaster issues. NODS is the umbrella body for the disaster services within the various districts, which were headed by district coordinators (UN-HABITAT, 2011). Various organisations and agencies that have a portfolio within the National Disaster Plan include:

- Red Cross,
- Fire Brigade,
- Royal Police Force,
- Defence Force,
- Coast Guard,
- Shipping Agents,
- Central Board of Health and
- Mount St. John's Medical Centre (UN-HABITAT, 2011).

With regards to legal capability, the general enforcement of the Act and Regulations related to addressing environmental issues was weak due to the lack of consideration of mitigation planning in development decision making and inadequate administrative structure and technical human resources involved in enforcement of the Acts and Regulations . There is room for improvement as it related to the political will and support for activities associated with natural hazard mitigation policy and plan.

In 2007 based on the United Nations Development Programme (UNDP) Human Development Index (HDI) Antigua and Barbuda was in 57th position among 182 countries, as result of the substantial investments in education and health over the last quarter of the century and given the relatively high per capita income that was achieved. This position in 2007 placed Antigua and Barbuda as the second highest ranked in the OECS after St. Kitts.

The adult literacy rate was estimated at 98.4% based on the 2001 Census (GOAB, 2012b). Universal primary education in Antigua and Barbuda is free and compulsory (GOAB, 2009a). Education facilities are widely available in Antigua and Barbuda and attempts to improve the existing standard has been undertaken in order to develop human resources.

The position of the population in relation to the poverty line played a significant role in determining their adaptive capacity based on financial resources (UN-HABITAT, 2011). The GOAB (2011) indicated that increasing poverty eroded the ability of poorer people, especially younger people to take advantage of educational and training opportunities. Despite the existence of social service agencies, their interventions have not been well coordinated which affects the ability and success in addressing health issues (GOAB, 2011).

There have been instances of capacity and institutional building. The GEF assisted the Antigua and Barbuda with the development of a Geographical Information System (GIS) based platform in order to map environmental and socio-economic amenities (UN-HABITAT, 2011). Five key government agencies utilise the Environmental Information Management, which included:

- the Environmental Division,
- Development Control Authority,
- Survey Division,
- NODS and
- the National Parks Authority (UN-HABITAT, 2011).

Environmental health already presents significant challenges for health managers and climate change would affect various aspects of the environmental health portfolio. As a result, the GOAB emphasised the need to strengthen the national capabilities for the health managers in order to perform their duties effectively (GOAB, 2009a).

4.1.5 Political and Legislative Capital

Adaptive capacity is dependent on the extent to which institutions are robust enough to attend to the needs of diverse stakeholders and foster their engagement in adaptation decisions and actions (IPCC, 2014). National Scale policies have a significant influence on the well-being of the vulnerable groups within society. Investment in critical areas such as education, healthcare, and physical infrastructure will also affect adaptive capacity by determining opportunities for vulnerability reduction and adaptation (Adger et al, 2004).

The existence of effective legislation, regulation, programmes and plan that address socio-economic and environmental issues have a direct impact on the political adaptive capacity of Antigua and Barbuda. A Draft Integrated Water Resource Management (IWRM) Strategy and Draft Management Plan was prepared in order to reduce the discharge of pollutants and restore watersheds and establish watersheds protection.

However, the implementation of the IWRM Strategy has encountered legal and political issues as well as commitment issues (Simpson et al, 2012) and therefore provides evidence of weak political capital.

The Antigua and Barbuda Drought Management Plan was initiated to provide water restriction implementation procedures. The Drought Management Plan is expected to be enacted objectively and speedily to preserve the health and general welfare of the population of Antigua and Barbuda (Antigua Public Utilities Authority (APUA), 2010). It was proposed that the Water Division of the APUA would be responsible for the management of the Antigua and Barbuda Drought Management Plan. APUA and the Antigua and Barbuda Meteorological Office would monitor the indicators of drought established within the plan. APUA would be guided by the 'Response Plan' developed for response to varying levels of drought (AUPA, 2010).

The drought indicators included:

- Raw Water Availability from the Potworks and other Reservoirs;
- Rainfall and other metrological data;
- El Niño Effect; and
- Water Demand Greater than Normal (AUPA, 2013).

Environmental initiatives within the legislative framework have contributed to increasing the natural adaptive capacity of Antigua and Barbuda. Sustainable Island Resource Management Zoning Plan (SIRMZP) (2012) functioned as the overarching guide for national development (Gore-Francis, 2013). The objectives of SIRMZP included:

- improving the country's socio-economic base;
- reforming the public sector;
- sustaining and conserving the country's biodiversity;
- reducing the national debt to sustainable levels;
- reducing poverty; reducing vulnerability to natural disasters; and
- strengthening community relationships and
- improving private and public sector partnerships (Gore-Francis, 2013).

Antigua and Barbuda has also undertaken the Capacity Building for Environment Management in Antigua and Barbuda Strategy and Action Plan 2007-2012 which included that preparation of a draft Environment Management Act (Simpson et al, 2012). This act established the Department of the Environment as the chief executive agency responsible for the units of climate change and ozone depletion.

The act makes provision for the sustainable management of waste, forestry and water quality (Simpson et al, 2012).

The National Poverty Reduction Strategy (NPRS) in 2010 served as the strategic framework, which would guide the macroeconomic, structural and social policies and programmes that would be pursued from 2011-2015. The idea was that the NPRS would provide the basis for National Economic and Social Transformation (NEST) Plan 2010-2014 by refining key strategies that are in place, identifying the gaps and supplementing the existing intervention with new ones (GOAB, 2012a). NEST is considered a more comprehensive approach to poverty reduction in Antigua and Barbuda, which was developed with the aim of economic rebalancing (GOAB, 2012a).

The Ministry of Agriculture of Antigua and Barbuda in 2009 formulated a National Food Production Plan in order to strengthen the country's capacity for food production to ensure national food security. In 2012 the National Food and Nutrition Security Policy was issued, which focused primarily on availability, accessibility, consumption and stability of supply. The National Food and Nutrition Security Policy highlighted priority areas, which included: capacity building, legislation and the protection and conservation of water and land resources (Gore-Francis, 2013).

In addition, legislation was enacted to make owners more responsible for their livestock through an enforceable system of animal registration. In addition branding and tagging of livestock has been promoted by the Livestock Division to facilitate easy identification of loose livestock, which may be responsible for damaging property and protected vegetation (Mitchell, 2009). The Environmental Awareness Group (EAG) in collaboration with Caribbean Natural Resources Institute (CANARI) implemented a project aimed at increasing public awareness and developing recommendations for managing and controlling the islands' goat population (Mitchell, 2009).

With the assistance of regional partners the Government of Antigua and Barbuda is currently developing a National Sustainable Tourism Plan and Policy, which is designed to address six thematic areas, which include:

- tourism management;
- capacity building;
- marketing;
- transportation;
- environment linkages; and
- health, safety and security (Gore-Francis, 2013).

The Tourism Strategic Policy and Plan promotes increase public and private sector participation and commitment to assist with achieving their objective to maximise the social and economic benefits of the tourism industry (GOAB, 2013a). Through the implementation of donor, funded projects the Government of Antigua and Barbuda is establishing co-management approaches and linkages with community base groups for eco-tourism products (Gore-Francis, 2013).

The Government of Antigua and Barbuda through its 2013 Budget Address provided their support to launch a Green Tourism Initiative Programme with the aim of assisting tourism operators with the assessment and reduction of the environmental issues which affect them (Gore-Francis, 2013). Elements within this programme include:

- the adoption and implementation of energy efficient and renewable technology within buildings;
- application of water conservation strategies; promoting and
- facilitating integrated waste management and the development of 'green' policies and procedures (Gore-Francis, 2013).

Since 2010, Antigua and Barbuda was in the process of developing a National Disaster Management Plan (The World Bank, 2010). There are some issues with enforcing elements of disaster risk within the law, which included:

- limited human resources coupled with inadequate technical expertise;
- ambiguous legal framework; and

- over lapping mandates between various agencies which lead to ineffective use of resources and disunity (UN-HABITAT, 2011).

Antigua and Barbuda has also undertaken the Comprehensive Disaster Management (CDM) strategy of the Caribbean Disaster Management Agency (CDEMA) in their recent policy development and planning has contributed to ensuring that greater emphasis is placed on identifying hazards and have focused increased efforts on community level interventions (Simpson et al, 2012).

As early as 2005 emphasis has been placed on the need for climate change considerations to be integrated into all aspects of natural hazard management and to become a key part of the physical planning process (DFATD, SPREP and CARICOM, 2005). A Policy Framework for Integrated (Adaptation) Planning and Management, which served as guide adaptation to climate change, was initiated (James, 2002, Simpson et al, 2012 and GOAB, 2013a). There are 7 sectors, which are highlighted within this Policy Framework, which include:

- agriculture,
- health,
- tourism,
- energy,
- biodiversity, water, and
- human settlements (Simpson et al, 2012).

In the past Antigua and Barbuda has lacked the ability to comply fully with all the requirements of the United Nations Convention on Climate Change (UNFCCC) and the Barbados' Programme of Action due to:

- the lack of effective institutions and systems;
- ineffective waste management systems to combat the impact of pollution on marine and terrestrial ecosystems and
- lack of available financial resources to development and implement coastal zone management plans (UN-HABITAT, 2011).

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The Environment Division in Antigua and Barbuda is in the process of formulating a draft policy aimed at addressing the adverse impacts of climate change on the coastline and the watersheds (UN-HABITAT, 2011). In addition, the Draft Environment Protection Management Bill, which was initially developed in 2005, was presented before cabinet in September 2013 for enactment (Gore-Francis, 2013).

In the absence of a specific statutory basis of requiring an Environmental Impact Assessment (EIA) in Antigua and Barbuda, a new Physical Planning Act has been prepared and formally established an EIA process (DFATD, SPREP and CARICOM, 2005). For the integration of climate change adaptation into the EIA process in Antigua and Barbuda, some of the recommendations included:

- revision of the definition of EIA under the Physical Planning Act to adequately consider climate change;
- the establishment of a formal EIA process to provide clarity and certainty and also a framework for regulation and management of the EIAs;
- provision of comprehensive criteria for screening and scoping environmental impact ensuring that significant climate change impacts are identified;
- provision of clear guidelines for the preparation of the EIA report confirming that climate change impacts are addressed and
- provision of a clear criteria governing the EIA experts guaranteeing that the individuals possess the required qualification, technical ability and knowledge on climate change and adaptation policies and measures (DFATD, SPREP and CARICOM, 2005).

The Government of Antigua and Barbuda adopted the United Nations International Strategy for Disaster Reduction (UNISRD), which has led to initiatives such as hospital safety. Undertaking hospital safety from disasters as a health and climate change adaptation would involve structural modifications and human resource development, which would in turn require political commitment and financial resources (GOAB, 2009a).

A National Food Production Plan was formulated in 2009, in order to strengthen the country's capacity for food production to ensure national food security (Gore-Francis, 2013). In 2011 the FAO indicated that the poverty estimates for Antigua and Barbuda has decreased to 9% due to the partnership entered into by the Ministry of Agriculture and the FAO to undertake steps to reduce extreme poverty in Antigua and Barbuda (UN-HABITAT, 2011. In 2012 the National Food and Nutrition Security Policy was issued, which focused primarily on availability, accessibility, consumption and stability of supply. The priority areas in the National Food and Nutrition Security Policy included capacity building, legislation and the protection and conservation of water and land resources (Gore-Francis, 2013).

The main economic and political challenges for Antigua and Barbuda which directly affects its adaptive capacity includes limited economic resilience due to dependence on one main economic driver, tourism, and increasing national debt as a percentage of GDP. With regards to legal capability the general enforcement of the policies and regulations related to environment issues mitigation have been weak as mitigation planning was not integrated into development decision making and inadequate administrative structure and technical human resources were involved in enforcement of the policies and regulations. However, the recently formulated and implemented environmental initiatives within the legislative framework have contributed to increasing the natural adaptive capacity of Antigua and Barbuda.

5 National Scale Adaptation Options

Focal Area	Adaptation Option	Key Issues	Necessary Action	Additional Information
Ecosystem Based Adaptation Options	Increase Management Effectiveness of Marine Protected Areas- Sustainable Financing and Management of Eastern Caribbean Marine Ecosystem Project (2011-2016).	One of the national vulnerability and adaptation priorities for 2014-2016 identified at the Inception Workshop for the Third National Communication to the UNFCCC and again reiterated that the National Stakeholder Consultation for this project is the establishment and proper management of marine protected areas in Antigua and Barbuda.	• Efforts and resources should be geared towards committing and successfully completing the Sustainable Financing and Management of Eastern Caribbean Marine Ecosystem Project (2011-2016). • A similar programme should be formulated for woodland and forested areas in Antigua and Barbuda, to increase its resilience to climate change and other human activities.	• The main objective of this project is to improve the management effectiveness of protected area networks across the Eastern Caribbean (OECS, 2009). • The project not only demonstrates synergies with VIAAC project but also with Antigua and Barbuda's Government adaptation agenda. • The project achieves this aim by increasing the resilience of coastal and marine ecosystems to climate change through the creation of effectively managed and protected areas that improve coral health and ecosystem integrity. • Component 3 of the Sustainable Financing and Management of Eastern Caribbean Marine Ecosystem Project is of significant importance to Antigua and Barbuda. • Component 3 consolidates and strengthens the

				management and effectiveness of existing protected marine and coastal protected areas but also ensures that all priority ecosystems in Antigua and Barbuda will be included in the marine protected area network (OECS, 2009).
	- The status of the Protected Systems Area Plan developed in 2010 needs to be determined and effectively implemented	- Effective implementation of the Protected Systems Areas Plan (2010)	• An effective Protected Systems Area Plan will contribute to the operations and effectiveness of the system, measures and capacity needs critical to ensure effective implementation should be established These include: ○ Establish and provide the minimum institutional structure (including staffing) required for effectively implementing the plan ○ Adequately trained staff to effectively implement the articles of the plan ○ Provide adequate monitoring infrastructure, equipment and materials to ensure compliance to the plan ○ Develop partnerships	• The purpose of the Protected Systems Area Plan was to create and clarify mechanisms for improved management of Protected Areas at the national and site levels.

			with other stakeholder for the conduct of monitoring and evaluation of activities as stipulated by the plan ○ Increase awareness of the plan.	
Disaster Risk Reduction	Agriculture Disaster Risk Management (ADRM) Plan	• Natural hazards and climate change have devastating impacts on the agriculture economy in Antigua and Barbuda, • A study conducted by the FAO in 2013 revealed that Antigua and Barbuda reported an absence of an Agriculture Disaster Risk Management (ADRM) Plan (Roberts, 2013).	• The development, establishment and implementation of the ADRM plan. • In order for the effective establishment and implementation of a ADRM plan a focal point or disaster risk manager (DRM) within the Ministry of Agriculture needs to be identified and appointed. The focal point and other stakeholders within the agriculture sector should draft roadmap/action plans while at the same time securing technical and financial assistance to operationalise the roadmap/ action plans in order to eliminate technical and financial constraints previously experienced. • The success of the ADRM plan is highly dependent on its implementation. Therefore, the institutional framework within the Ministry of Agriculture	• Two approaches can be used to develop the ADRM for Antigua and Barbuda, which includes that CDM approach or plans based on the priority areas for the Hyogo Framework of Action (HFA). ○ The CDM approach promoted by the CDEMA encourages the development of distinct action plans for reducing risk at each phase of the disaster cycle. This approach to the development of ADRM has been successful in Jamaica (Roberts, 2013). ○ The other options for the development of the ADRM plan for Antigua and Barbuda is one that developed based on the priority areas of the HFA as was utilised in St. Lucia and Belize (Roberts, 2013).

			should be strengthened to support the implementation of the plan. In addition tools for monitoring and evaluation of the ADRM plan after it has been implemented should be identified and established to determine the impact of the plan on risk management of the agriculture sector. Any identified shortcomings through monitoring and evaluation should be addressed.	Systematic piloting, evaluation, and replication of best practices for Disaster Risk reduction (DRR) suited to the needs of Antigua and Barbuda can be used to determine the most appropriate articles with the ADRM plan.
	Agriculture Early Warning System (AEWS): Prediction and Planning	Many people whose livelihood is dependent on the agriculture and fisheries sector already pay close attention to daily weather but if they could monitor long-term climate information then they could better plan for future climate change and variability to make better-informed on-farm management decisions.	• Of tremendous assistance to the farming, community is the enhancement of climate prediction tools. • In order to build resilience to the recurring threats to the agriculture sector due to climate change and natural disaster a Local Agriculture Early Warning Systems (AEWS) for Antigua and Barbuda should be developed and a network of focal points to disseminate alerts to the agriculture community in the vulnerable area should be set up. • The government agencies and stakeholder within the agriculture sector in Antigua and Barbuda should support Early Warning System for	• The FAO in collaboration with Caribbean Community (CARICOM) Secretariat is in the process of developing a Regional Information and Early Warning System for Food and Nutrition Security (ISFNS) 2012-2016. • The Early Warning System for Food and Nutrition Security (ISFNS) 2012-2016 developed by FAO and CARICOM is expected to construct risk profiles for the region’s main crops in support of the emergency preparedness, agricultural risk management and crop insurance (CARICOM, 2011).

Food and Nutrition Security, by ensuring the effective dissemination of the information provided as well as other available information from other available information from various projects through the establishment of the network of focal points.

- These focal points will succinctly communicate pertinent information to the agriculture and fisheries subsectors, which would inform their response strategies.

- Information from Caribbean Agro-meteorological Initiative (CAMI) (2010), Caribbean Drought and Precipitation Monitoring Network (CDPMN), launched in 2009 under the Caribbean Water Initiative (CARIWIN).and Caribbean Climate Outlook Forum (CariCOF) could be communicated to people whose livelihoods are dependent on the agriculture and fisheries sector.

- Community-centred partnership approach can also be used as the method of information capacities for

		disseminating tailored climate information, early warning, and climate impact analysis in the agriculture and fisheries sectors, offer opportunities for sustainability and is consistent with best practices at both regional and international levels (Roberts, 2013). • In addition, multiple media such as email notification and text messages, bulletins and newsletters could be used to regularly send information to farmers and fisher folk	
	Financial Aid and Financial Risk Sharing Mechanism	Agriculture and fisheries possess residual risk as a result of climate change or natural disasters	• The scope and feasibility of financial back-up and risk transfer mechanisms in the agriculture and fisheries sector in Antigua and Barbuda as a mechanism for removing residual risk as a result of climate change or natural disasters should be assessed. • This can be facilitated through the development and establishment of partnership with the credit union and other financial institutions (Roberts, 2013). • The development of an incentive programme that encourages the productive

			sector to actively participate in implementing practices that adapt and mitigate to climate change should be undertaken. • In the process of developing financial risk-sharing mechanisms Antigua and Barbuda, can seek support from the OECS and CARICOM, which could offer case studies, or models, which Antigua and Barbuda can follow. Insurance however is not a substitute for good production practices. Therefore, careful attention should be paid to crop mixes, financial savings, and price hedging (Wenner, 2005).	
Legislative and Regulatory Framework	Enactment of the Integrated Water Resource Management Policy	• The implementation of the Integrated Water Resource Management Strategy (IWRM) in the Caribbean Region has been little progress toward providing a basis for institutional reform. • No Caribbean country has yet implemented any significant IWRM proposals, other than a few catchment-scale demonstration projects. In addition no key linkages between land and water management had been integrated into policies and	• The working group made up of the technocrats and the government agencies, which formulated the IWRM should be re-established to effectively advocate for the urgent implementation of the IWRM policy. • Denial, delay, or deferral of the implementation of the IWRM Policy is not an option for Antigua and Barbuda, since the impacts of climate change are already being felt.	In 2011, Antigua and Barbuda completed the IWRM road map, which included that IWRM Visions and Policy Statement. The IWRM Policy was submitted to the government for approval. In addition to the policy related IWRM work, a demonstration project addressed the impact of sewage overflows from septic tanks on an important coastal wildlife area (Global Water Partnership (GWP), 2014)

		planning (Cashman, 2013). • Specifically in Antigua and Barbuda, the IWRM Strategy has encounters legal and political issues as well as commitment issues (Simpson et al, 2012). • At present water management in Antigua and Barbuda is still guided by the 1973 Public Utilities Act, under which responsibilities for water management are distributed across a number of agencies within government, including the Water Division in the Antigua Public Utilities Authority (APUA) (IWRM) (GWP, 2014).		
	Revise and update the National Health Policy for Antigua and Barbuda	• The Health Policy for Antigua and Barbuda is outdated and is not adequate to meet the changing health situation due to threat of climate change. • The Health Policy for Antigua and Barbuda was created in 1997 and update in 1984. • The Health Policy was expected to serve as the authority on health issues in Antigua and Barbuda for a five year period until 2001.	• There are significant synergies between climate change adaptation and health care initiatives • The output from draft strategy on Universal Health Coverage for Antigua and Barbuda consultation can be utilised to revise and update the National Health Strategy for Antigua and Barbuda. • Health policies and programmes need to integrate existing and projected climate related risks in order to curb these	In June 2014 a national consultation on Pan American Health Organisation's (PAHO's) draft strategy on Universal Health Coverage for Antigua and Barbuda was convened (Government of Antigua and Barbuda, 2014c).

risks and establish an effective health adaptation strategy for Antigua and Barbuda.

- Human and financial resources should be invested in revising and updating the Health Policy for Antigua and Barbuda in order to integrate climate variability and climate change concerns into health and social plans and programmes.

- The revised and updated National Health policy can serve as an overarching guiding legislation, which would contribute to:

- the elimination of disjointed and weak annual planning process and predetermined budget allocations;

- strengthen decentralised health governance structures;

- strengthen community based health services and health facilities to adequately deal with emerging health concerns including those develop a system of enforcing regulation and

			ensuring quality	
Cross-sectoral Linkages	Agri-tourism initiative and policy	The agriculture sector in Antigua and Barbuda has been experiencing economic decline of the because of sustainability issues, which are exacerbated by climate change.,	• To ensure economic sustainability Antigua and Barbuda need to diversify their agricultural operations, by establishing linkages between the agriculture and tourism sectors in the form of agri-tourism. • The results from the analysis conducted by the agriculture technician appointed to the Ministry of Tourism needs to be applied in the staging of the farming process to create memorable visitor experience in Antigua and Barbuda (Maynard & Dolly, 2011). • The success of this agri-tourism endeavour is highly dependent on capacity building in agri-tourism. Some of the training identified as necessary for capacity building in agri-tourism in Antigua and Barbuda includes: ○ product development and product definition, ○ marketing, ○ customer service, ○ rural tourism, ○ the use of social media in agri-tourism, ○ entrepreneurship,	• Agri-tourism is involves trips to an operational farm or agribusiness operation as a recreational activity or educational field trip. • In 2010, the Government of Antigua and Barbuda appointed an agricultural technician to the Ministry of Tourism to develop agri-tourism. The agricultural technician was responsible for the development for the analysis and development of the agri-tourism value chain, tourism experience creation, and product design (Maynard & Dolly, 2011). The method for developing the agri-tourism product is the 'staging' of the farming processes. • Due to the fact that in Antigua and Barbuda agri-tourism is cross sectoral, involving both the agriculture and tourism economies, modifications to the production function of the farm should be handled carefully to maintain the integrity of the core agriculture production function, to avoid any compromise to either the core or secondary functions.

			○ on-farm visitor safety, ○ costing and pricing, and ○ management of groups (Maynard & Dolly, 2011). • Capacity building for farmers, extension personnel in tourism and agriculture sector and taxi operators is also essential. Agriculture extension officers or rural advisory agents need to be re-trained to guide the agri-tourism farmers through their entrepreneurship undertakings. • Effective farm and tourism management are key principles governing the success of the agri-tourism operation. The development and the implementation of an agri-tourism policy should be undertaken in order to serve as the guiding framework for this endeavour.	
	Initiatives and programmes undertaken as part of the Reduce Risks to Human & Natural Assets Resulting from Climate Change (RRACC) Project (2011-2015)	Climate change will exacerbated the issues affecting the agriculture industry which include: high input cost; crop failure due to pests and other environmental conditions and reduced access to both local and global markets.	• Adoption of technology and technical and capacity building within the agriculture Sector in order to build resilience against climate change impacts should be undertaken. • Efficient and cost-effective	• Specifically the RRACC Project in Antigua and Barbuda seeks to: ○ Build capacity and capability of relevant agencies in the area of greenhouse technology and irrigation

technologies, which address high costs of production and facilitate increases in productivity, should be adopted, maintained and supported.

- The building of a freshwater catchment at the foot of the Highlands in Barbuda under the RRACC project can be used as a pilot to determine the feasibility of establishing other freshwater catchments in drought prone areas in Antigua and Barbuda. Establishing fresh water catchments will have both environmental and economic benefits. The catchment will help to:
    - reduce the threat of drought'
    - reduce soil erosion,
    - minimise turbidity of the sensitive costal ecological wetlands, and
    - increase the resilience of the agriculture sector to climate change (OECS, 2014).
- From an economic perspective, these catchments will help to:
    - enhance the farming potential
    - increase agricultural production,

technologies, which will help to reduce crop failure where these may be vulnerable to changes in rainfall patterns;
- Promote the effective use of water in agricultural greenhouse practices;
- Increase the availability of relevant food products for the local market;
- Promote economic growth, employment for the youth and reduce import expenditure (OECS, 2011);
- Promote sanitary rain water harvesting techniques;
- Promote aquaponics;
- Promote the building of more robust and resilient housing for livestock;
- Promote agriculture biodiversity management; and
- Encourage more research on pest and disease management (OECS, 2013)

- re-establish markets, and
- improve the sustainability of livelihoods within the of livelihoods within the agricultural sector (OECS, 2014).

- The areas in which technical and capacity building should be provided to agro-processors include:
    - new processing techniques;
    - sourcing of packaging and
    - labelling materials;
    - access to information
    - and promotion (Government of Antigua and Barbuda, 2012a).
    - new processing techniques;
    - sourcing of packaging and labelling materials;
    - packaging and labelling materials;
    - access to information on food safety standards; and product development and promotion (Government of Antigua and Barbuda, 2012a)

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