COUNTRY PAPER

ON

NATIONAL CLIMATE CHANGE ISSUES

Towards the Implementation of CPACC Component 4: Formulation of a Policy Framework for Integrated

(Adaptation) Planning and Management

Prepared By

Philmore James

For

Caribbean Planning for Adaptation to Climate Change (CPACC)

ANTIGUA AND BARBUDA COUNTRY PAPER

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LIST OF ABBREVIATIONS & ACRONYMS

ACS	-	Association of Caribbean States
APUA	-	Antigua Public Utilities Authority
CBD	-	Convention on Biological Diversity
CCA	-	Caribbean Conservation Association
CEP	-	Caribbean Environmental Programme
CITES	-	Convention on International Trade of Endangered Species
CPACC	-	Caribbean Planning for Adaptation to Climate Change
DCA	-	Development Control Authority
EAG	-	Environment Awareness Group
EEZ	-	Exclusive economic Zone
ECLAC	-	Economic Commission for Latin America and the Caribbean
GHG	-	Greenhouse Gas
IPCC	-	Inter-governmental Panel on Climate Change
IRF	-	Island Resource Foundation
IUCN	-	World Conservation Union
LBSMP	-	Land-Based Sources of Marine Pollution
MAB	-	Man and the Biosphere
MALF	-	Ministry of Agriculture, Lands and Fisheries
MARPOL	-	Marine Pollution (Convention)
MOH	-	Ministry of Health
MOL	-	Ministry of Labour
MOP	-	Ministry of Planning
NDF	-	National Development Foundation
NODS	-	National Office of Disaster Services
NPA	-	National Parks Authority
NSWMA	-	National Solid Waste Management Authority
OECS-NRMU	-	Organization of Eastern Caribbean States-Natural Resource Management Unit
POA	-	Programme of Action
SIDS	-	Small Island Developing State(s)
SPAW	-	Specially Protected Area and Wildlife
TFAP	-	Tropical Forestry Action Plan
UNCLOS	-	United Nations Convention on the Law of the Seas
UNEP	-	United Nations Environmental Programme
UNESCO	-	United Nation Educational Scientific and Cultural Organization
UNFCCC	-	United Nations Framework Convention on C

Executive Summary

Antigua and Barbuda is a Small Island Developing State (SIDS) characterized by its limitation in size, availability of human and economic resources to address adverse hazard impacts and its high vulnerability to climate change and sea level rise. The climate of Antigua and Barbuda is changing as is directly evident from the increase in the number and intensity of tropical weather systems over the last decade. In addition there is an anticipated rise in sea level and an increase in the severity of storm surges, and drastic changes in rainfall distribution as manifested by extreme conditions of flood or drought.

Climate Change and Sea-Level Rise as manifested directly in the changes in weather phenomena show major impacts on the different sectors or specific resources. These include:

- Physical damage to crops and animals. There are also significant social and economic and structural changes to the agriculture sector.
- Increased pressure on the already limited water supplies. There is greater dependence on expensive desalinated water.
- Destruction and loss of property and infrastructure especially in low-lying coastal areas. This could lead to changes in the employment structure of the country.
- Increased incidence of vectors, increased risk of various infectious diseases, and increased mental and physical stress and disorders arising from hurricane activity; In addition there is a wide range of public health consequences, particularly in terms of environmental health and nutrition.
- Increased destruction and loss of critical coastal/marine ecosystems such as coral reefs, sea grass beds, beaches and mangroves.
- Destruction of hotels and other tourism facilities. There are also psychological effects on potential visitors.
- Increased damage and losses to fishery equipment, vessels and infrastructure from storm and hurricane activity. There is added pressure on the fishery resources by persons displaced from other sectors.
- General loss of biodiversity.

The key issues with respect to climate change on Antigua and Barbuda

- ***Physical Planning and Development Control.***
- ***Coastal and Marine Resource Management and Development.***
- ***Natural Disaster Response and Management.***
- ***Fresh Water Resource Management and Development.***
- ***Appropriate Agricultural Development.***
- ***Economic Initiatives and Incentives.***
- ***Fisheries Management and Development***
- ***Strategic Environmental and Public Health Management:***

In order to effectively deal with major issues, there is a need for extensive public education and awareness. Existing institutional and legislative frameworks particularly the distribution or arrangements of government ministries require special review and changes to reflect current concerns of climate change and sea level rise. While there are inadequate facilities and insufficient human resources available within agencies to effectively undertake their mandate serious overlaps and gaps still occur in the responsibilities and functions of various organizations.

Antigua and Barbuda has signed on to several international agreements relating to coastal/marine management. The process for appropriate implementation of related obligations tend to be relatively weak. There is still a direct need for developing relevant legislations to deal with the issues of climate change and sea level rise.

The specific policy options re: the National Climate Change issues for Antigua and Barbuda focus on the following strategies or actions:

- Developing and strengthening of the country's natural disaster response capability.
- Establishing a National Climate Change Center;
- Building national capacity and strengthening institutions at all levels.
- Strengthening the Physical Planning Management capability.
- The development and implementation of a comprehensive National Physical Development Plan.
- Formulation of economic and regulatory proposals for natural resource usage.

It is anticipated that once the relevant policy documents are developed, with the necessary implementation Antigua and Barbuda will be able to use the adaptation strategies to deal with climate change and sea level rise in the future.

1.0 INTRODUCTION

Global climate change and climate variability are likely to have adverse and lasting impacts on the physical, social and economic systems of small island developing states like Antigua and Barbuda, which lack adequate resources for adaptation. An analysis of the impacts caused by increased hurricane/tropical storm activity, sea level rise and more intense droughts has shown that climate change will have significant impacts on the physical environment of Antigua and Barbuda. There will also be an equally significant influence on the economy (B.Challanger, 1997).

Antigua and Barbuda is an extremely low-lying country. About 70% of the land in Antigua is less than 100 feet (30 meters) above sea level. Most of Barbuda is 10 feet (3 meters) above sea level, except in the highlands near the northern end where heights reach up to 124 feet (37.9 meters). More than 60% of the population live within the coastal zone. In addition, reclamation of land, sand mining and the lack of comprehensive natural system engineering approaches to control flooding and sedimentation has increased the country's vulnerability to erosion, coastal flooding and storm damage. Sea level rise will exacerbate the existing problems and impact the total land area.

The climate of Antigua and Barbuda is punctuated by the occurrence of a range of extreme climatic events such as tropical storms, hurricanes, sea surges, floods and drought along with their disastrous human, environmental, social and economic impacts. The Scientific Community has concluded that climatic change caused by the emissions of Green House Gasses will result in increased frequency and severity of climatic events. In addition, there do exist stresses, non-climatic factors, which are likely to increase the country's risk and vulnerability to extreme climatic events.

It is anticipated that Antigua and Barbuda, as is the case with most of the islands in the Lesser Antilles Island chain, will be affected by more and more hurricanes and tropical storms. Since Hurricane Luis in 1995 storm occurrence has become an annual event with four hurricanes directly hitting Antigua and Barbuda over the last five years. Storms have caused extensive damage to the coastline of Antigua and Barbuda. There was widespread damage to beaches, mangroves, coral reefs and sea grass beds during recent storms. Coastal structures and infrastructure were also badly damaged.

Apart from damages done by passing storms, the coastal ecosystems have been severely affected and in some cases totally destroyed as a result of anthropogenic factors. These already stressed areas were severely battered by hurricane Hugo in 1989, and before they had time to fully recover were impacted by hurricane Luis of 1995 and subsequently by other hurricanes.

During Hurricane Luis in 1995, most of the coastal hotels were damaged by flooding as hurricane waves reached extensively inland. No real estimates exist as to the total impact of hurricanes throughout Antigua/Barbuda over the past decades. The effects are however cumulative as is generally evident throughout the state. The size of the islands makes them even more vulnerable to the impacts of storms.

This paper is done with an understanding that there are critical information and knowledge gaps and needs for Antigua and Barbuda. There is need for the following:

- Detailed accurate data especially for coastal and marine areas;
- Economic valuation of ecosystems in order to quantify benefits;
- Studies to get more precise understanding of various processes, which operate, over the physical landscape and important interrelationships that exist between socio-economic development and environmental management.
- Continuous documentation of information regarding the frequency, intensity and impacts of hurricanes, droughts, floods and other natural disasters with a view of monitoring and re-evaluating projections of future climate change and sea level rise.

1.1 Physical Characteristics

Antigua is a low-lying island located in the north-centre of the Lesser Antilles island arc system (Lat 17^o -17^o 10' N, Long 61^o 40' - 61^o 55' W). The island is 108 square miles (280 km^2) in area and roughly 14 x 11 miles (22 x 17 km) in size. The coastal zone shows marked variations in its topography, geology, socio-economic and ecological characteristics. Antigua's topography varies from a southwestern hilly volcanic region, to a low rolling (mainly clay) central plain, to the flat, low elevated, limestone upland area in the northeast. The volcanic region is highest in elevation and includes several peaks above 1000 feet. The coastline is very indented with numerous bays and offshore islands. A marked feature of the low-lying coastal areas in both Antigua and Barbuda is the wide distribution of sandy beaches and mangroves. Sea grass beds and coral reefs predominate in the shallow waters. The coastline is also fringed with reefs and shoals. Figure 1.1.1 illustrates the main physical features of Antigua.

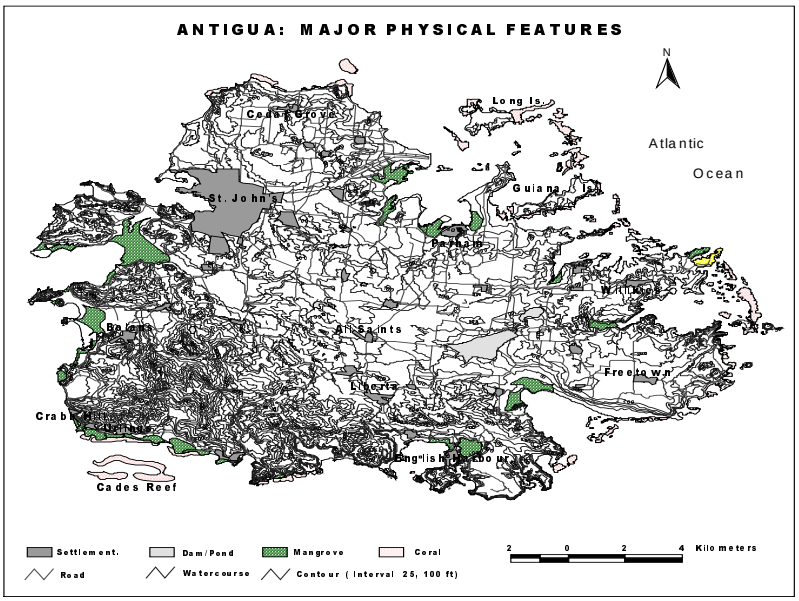
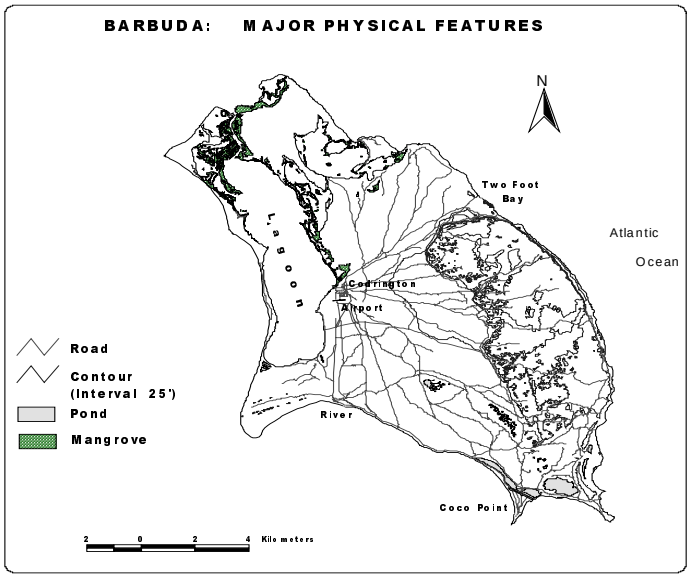


Figure 1.1 Main Physical Features of Antigua

Barbuda is a low limestone island located 40 km north of Antigua. Figure 1.1.2 shows the main physical features of Barbuda. The topography is relatively uniform, rising only a few feet above sea level. The Highland, located in the northeast reach elevation of about 100 feet (30 m). A lagoon, averaging about 2.5 km wide, runs along most of the western side of the island separated from the sea by a narrow sand bar. The coastline is fairly straight and is backed by extensive sand dunes. Like Antigua, the coastline is fringed with numerous coral reefs.

According to Atkins (1983), 5 percent of Antigua is sloped less than 2 degrees; 65 percent is sloped 3-10 degrees: 20 percent is sloped 11-20 degrees; 9 percent is sloped 21-30 degrees; and 1 percent sloped more than 30 degrees. These figures are in marked contrast to neighboring islands

Figure 1.2 Main Physical Features of Barbuda



such as Dominica where two thirds of the islands land area exceeds a 30-degree slope. The slopes in Barbuda are even more gentle.

The presence of different wave-cut platforms along the coast of Antigua and Barbuda is evidence of changing sea levels during geological time. There is no conclusive evidence of whether there is emergence or subsidence of the land.

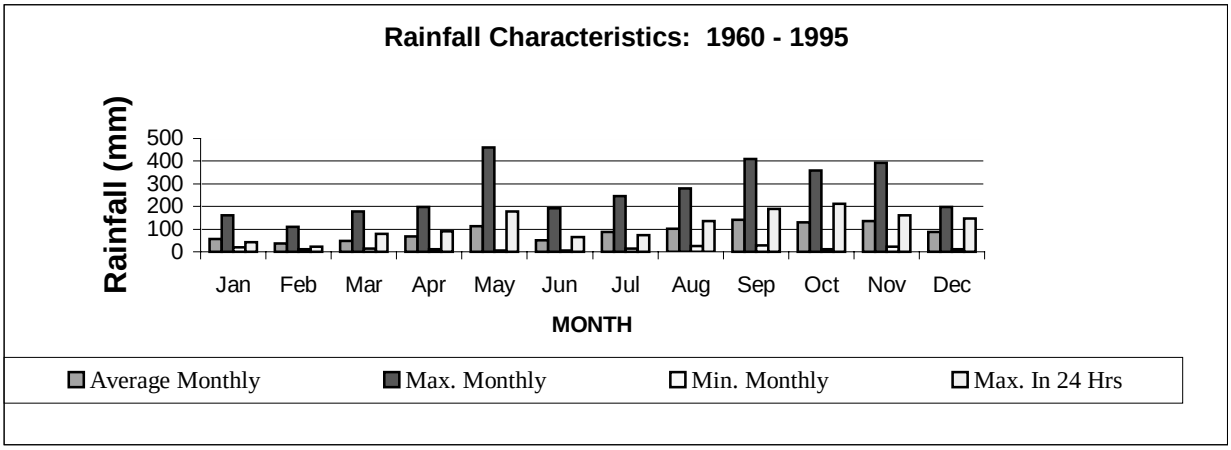
1.2 Regional/Local Climatology and Related Phenomena

The climate of Antigua and Barbuda may be classified as tropical marine with average annual temperature and rainfall being 28 ^{o} C (81 ^{o} F) and 40 inches (100 cm), respectively.

The main rainfall characteristics are shown in Figure 1.2.1. Generally, there are marked wet and dry periods for any given year, with a dry season from January to April and the wet season from August to November coinciding with the hurricane season. During the dry season less than 20%

of the rainfall occurs. May is usually a wetter month averaging about 4 inches of rainfall, followed by a drop in June and July before the start of the true wet season in August. Almost half of Antigua's yearly rainfall is a result of storms that individually produce more than one inch of rain (OAS, 1990). The relative humidity of Antigua is high compared to the other islands in the region; the heavy dews deposited at night are believed to contribute to water availability in the drier regions. As indicated in Table 1.2.1, the average relative humidity is generally slightly higher during the earlier part of the day when the mean sea level pressure is higher (Table 1.2.2).

Figure 1.3 Rainfall Characteristics of Antigua 1960 – 1995



Barbuda is drier than Antigua and, in fact, is one of the driest islands in the Caribbean. Estimates of average annual rainfall are between 30 inches (Hill, 1966) and 39 inches (OAS, 1990). Dry and wet seasons are the same as in Antigua.

Table 1.1 Average Relative Humidity: 1960 - 1995

Average. R. H.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
07 LST	81	81	81	81	82	82	83	83	84	85	85	83
15 LST	72	72	72	72	74	75	77	76	77	78	77	75

Table 1.2 Mean Sea Level Pressure: 1970 - 1995

M.S.L. Pressure (mb)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
07 LST	1016.3	1016.4	1015.9	1015.3	1015.4	1016.5	1016.7	1015.5	1014.2	1011.7	1013.7	1005.2
15 LST	1015.3	1015.4	1015.1	1014.2	1014.5	1014.1	1016.1	1013.1	1011.4	1012.2	1012.5	1014.1

Temperatures average 29^{o}C (84.2^{o}F) during the hotter months and 24^{o}C (75.2^{o}F) during the cooler months, but temperatures as high as 34^{o}C (93.2^{o}F) and lows of 15^{o}C (59^{o}F) have been

recorded. The major temperature characteristics for Antigua between 1969 – 1995 are given in Table 1.2.3.

Table 1.3 Major Temperature Characteristics 1969 – 1995: Antigua

Temperature (0C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NORMAL DAILY MAX.	28.2	28.3	28.6	29.2	29.8	30.5	30.7	30.9	30.7	30.4	29.5	28.6
NORMAL DAILY MIN.	22.3	22.1	22.5	23.3	24.3	25.3	25.4	25.4	24.8	24.3	23.7	22.8
EXTREME MAX.	31.0	31.0	33.0	32.0	33.0	33.0	34.0	33.0	33.0	33.0	32.0	31.0
EXTREME MIN.	17.0	17.0	18.0	18.0	20.0	22.0	21.0	22.0	21.0	20.0	19.0	16.0
AVERAGE	25.3	25.2	25.6	26.3	27.1	27.9	28.1	28.2	27.8	27.4	26.6	25.7
Mean No. Days Temp. >32^0 C				0.04	0.70	1.30	2.80	4.30	4.20	1.50		

Antigua and Barbuda ranks high in terms of vulnerability to tropical storms and hurricanes. Table 1.2.4 shows the major tropical systems that affected Antigua and Barbuda between 1995 and 1999. Four of the systems made landfall. Apart from the direct effects of hurricane winds there is also the effects of storm surge along the coastline. For the beaches monitored, the changes in beach area and width result from a combination of factors including hurricanes impacts.

Table 1.4 Tropical Systems which affected Antigua and Barbuda Between 1995 and 1999

Name	Category	Wind Speed	Track Location	Date
Iris	TS	93	South	27-Jul-95
Luis	4	222	Landfall	09-Sep-95
Marilyn	1	148	North	15-Sep-95
Bertha	1	139	South	07-Aug-96
Hortense	1	130	North	09-Oct-96
Erika	1	130	North	09-Jun-97
Georges	3	185	Landfall	21-Sep-98
Jose	2	157	Landfall	20-Oct-99
Lenny	TS	102	Landfall	20-Nov-99

Wind Speeds are for the direct time of passage

Available data have shown that the number and intensity of tropical storms is on the increase. Table 1.2.5 clearly shows that the number of named storms increase over the last five year period (55 %) and the number of hurricanes per year by 78 %. For the same period the number of

hurricane days per year tripled while the number of category 3, 4 or 5 hurricanes quadrupled. Antigua and Barbuda experienced four major tropical systems during the past five years. Antigua and Barbuda have received severe impacts both physically and economically. In addition there are some strong sea swells between November and February. Flooding particularly in low-lying areas is quite common around Antigua and Barbuda during periods of storms or hurricanes.

Table 1.5 Hurricane Frequency Between 1990 and 1999

Five Year Period	No. Named Storms	No. Hurricanes Per Year	No. Hurricane Days Per Year	No. Category 3, 4, 5 Hurricanes Per Year
1990 – 1994	8.4	4.6	13.6	1
1995 – 1999	13.0	8.2	41.4	4.0

Source: Various Internet Sites.

On the other hand the islands are also prone to severe drought conditions. It is quite common to experience wet conditions for some months and very dry conditions for the rest of the year.

1.3 Important Ecological/Biological Attributes

Antigua and Barbuda's coastal areas contain some of the most diverse and productive habitats. They include specialized ecosystems such as mangroves, coral reefs, sea grasses and beaches. These ecosystems support a variety of economic activities including tourism, fisheries, recreation and transportation. More recently, intensive tourism development has resulted in severe biophysical alterations to the coastline and destruction of coastal and marine habitats.

1.3.1 Mangroves

In 1997 there were 36 major wetland sites around Antigua and 9 sites around Barbuda. The dominant species in both islands are the *Rhizophora* (red mangrove), *Avincenia* (black mangrove), *Languncularia* (white mangrove), and *Conrcarpus* (buttonwood mangrove) occasional at a few sites. The mangroves support a wide variety of terrestrial and aquatic species and play several other important roles within the context of an integrated coastal system.

Growing in close proximity to the sea renders mangrove swamps particularly vulnerable to disruption by sea level rise. Ellison predicted that mangrove systems will be disrupted by a rise of 0.3 meters, and will retreat landward with a sea level rise of 1 meter.

Within a mangrove ecosystem, the various species shows preferences to elevation, salinity, and frequency of inundation, resulting in species zones. As sedimentation occurs, either by land erosion or by material brought in by the sea, elevations increases, and there is usually a seaward shifting of the species zone. However, if the rate of sea level rise exceeds the rate of sedimentation, then mangroves species zone will migrate landward, and the seaward margins will change. To adequately assess the response of mangroves to sea level rise, the rate of sedimentation must be established from past studies. However, none of this data is available for Antigua and Barbuda.

It is expected that climate change will significantly disrupt the mangrove ecosystems around Antigua and Barbuda, especially since many of these areas are presently under stress from natural and anthropogenic factors. It is anticipated that as mangroves retreat inland with sea level rise some areas may be completely lost. If given an opportunity, however, other vegetation types may succeed in their place.

It is generally agreed that mangroves on low islands are more susceptible to disruption by sea level rise because the only sediment available is produced by the trees themselves, giving relatively low rates of sediment accumulation. The fringing mangroves, which accounts for the greater portion of mangrove around Antigua, will suffer significantly.

Most of the mangrove sites around Antigua have been destroyed or severely damaged. The major cause of the damage is due to coastal development, particularly those associated with hotel development. Hurricanes have also caused widespread physical damage to mangrove systems in the past.

1.3.2 Coral Reefs & Sea Grass Beds

Ideal conditions for the existence of coral reefs and sea grass beds are provided around Antigua/Barbuda. Antigua and Barbuda sits on a shallow rock-floored platform or shelf, which in turn is covered by sediment (sand and mud) and a wide variety of reefs. The edge of the shelf is at depths of 50 - 100 fathoms (90 - 180 m) where it drops rapidly to oceanic depths. The shelf is quite narrow however, along the south coast of Antigua, where it drops off to depths of over 1000 feet (305 m) within a mile (1.6 km) from shore**.** Coral reefs flourish on this shelf and are therefore fairly common to the coasts of Antigua and Barbuda; collectively their area is estimated at 25.45 sq. km (Bacon, *et al*., 1984). Fringing reefs are quite common although other types such as bank and patch are found around Antigua and Barbuda. The reefs are better developed on the Windward (east) side than the Leeward (west) side where an abundance of fine sediments in some areas provide a difficult environment for reef life to develop. The species of coral around Antigua and Barbuda include *Acrcopora palmata, Monastera annularis* (star coral), *Diploria* spp. (brain coral), *Millipora* ("stinging coal"), *A.Cervicornis* (branching coral).

The two major sea grasses in Antigua and Barbuda are the dominant flat-bladed turtle grass (*Thalassia testudinum)* and the less common, thin rod shaped leaves of Manatee grass (*Syringodium fillilorme),* which occurs commonly in association with turtle grass. Both grasses grow best in loose sediments at relatively shallow depths (0.5 - 10m), and where water circulation by currents is persistent.

Coral reefs give protection to the shoreline, provide sediments for the beaches and supports recreational uses for tourism. It is also a habitat for many reef species. Most of the fishery around Antigua and Barbuda is associated with reefs. In general, the reefs around Barbuda are more healthier than those around Antigua.

Coral reefs become stressed as a result of both natural and anthropogenic activities. Stresses occur as a result of high sedimentation due to inappropriate land development and poor agricultural practices, increase nutrient loading, direct destruction and over exploitation of the reef. High nutrients /sediments levels can smother corals or encourage the growth of green algae which prevents light reaching the reef and can kill both coral and algae.

Indiscriminate and destructive fishing habits can lead to over-fishing, and hence over exploitation of reefs. One effect of over-exploitation is that it can result in the take over by green algae as a result of the reduction of population of algal-feeding fish.

Coral reefs and sea grass beds are regularly damaged by a variety of natural causes. The most dramatic of these are the devastating effects of large tropical storms and hurricanes. Powerful waves generated by such storms may topple large colonies, hundred of years old. Sediments raise and swept violently across reefs and sea grass areas by waves and currents may scour and scrape the bases of colonies, be deposited among the living polyps, or bury sea grasses. Even after, the danger yet remains, for injured areas may now be highly vulnerable to infection by bacteria or colonization by rapid growing algae.

Alevizon (1993) decribe the reefs on Antigua as being in very poor condition. Many of the reefs have suffered extensive damage. Later studies have concluded that conditions have worsened in several areas. (Goreau ; Bounce ; IRF ,). Information available on the current status of the reefs and marine environment indicate reef deterioration. It was reported in 1989 that there were no sign of White or Black Band diseases or of bleaching and no examples of bleaching, however in 1996, Multer reports the presence of Black and White band disease while Goreau emphasized widespread bleaching. It is not conclusive if these were due to climate change or sea level rise.

1.3.3 Beaches

Sandy beaches form the dominant coastal landscape of Antigua and Barbuda. There are however minor areas bordered by rocky outcrops, sheer cliffs, stony beach or mangroves. Unlike Barbuda, whose coastline is dominated by almost smooth continuous coralline sandy beaches, Antigua is characterized by numerous sheltered pocket beaches. The relatively narrow shelf and an increase in dead or nearly dead corals restrict the constant supply of sediments to the coast.

The major beaches around Antigua/Barbuda provide recreational purposes for both tourists and locals, are used as fish landing sites and also forms a source of fine aggregates used in building construction. The beach is also a habitat for nesting turtles and other animals and plants.

Beaches are affected by both natural processes and anthropogenic factors. Anthropogenic factors affecting beaches include sand mining, dredging and building of hard structures too close to the shoreline, and poorly designed sea defenses.

Analysis of the erosion rates along the monitored beaches of Antigua and Barbuda indicate that although the average erosion rates for specific periods may appear positive (indicating accretion), erosion is still the dominant process on nine beaches while another nine show accretion to be dominant (James 2001). Seven beaches show marked variations in the dominant process in that different processes dominate on the different segments of the beach. The rate of erosion appears to be independent of the location on the island. Significantly, where there is variation between the different beach segments erosion tend to dominate along the northern end of the beach. It was also demonstrated that when classified most of the beaches on Antigua were categorized as having medium to high beach erosion hazard. The average annual beach erosion rate for monitored beaches on Antigua are shown in Table 1.3.1.

Table 1.6 Antigua – Mean Annual Beach Erosion Rates 1992 – 1999

Beach	Mean Annual Beach Erosion Rate (m/yr)
Dickenson Bay	-2.01
Runaway Bay	0.17
Fort James	-0.50
Deep Bay	-0.55
Yorks Bay	0.59
Stony Horn Bay	0.21
Mosquito Cove	-1.47
Lignumvitae Bay	2.16
Ffryes Bay	0.65
Darkwood Bay	-0.08
Crabhill Bay	1.49
Morris Bay	-0.71
Falmouth	0.90
Mamora Bay	-0.14
Pigeon Point	0.30
Halfmoon Bay	-0.26
Long Bay	-0.47
Dutchman Bay	0.16
Jabberwock	0.02
Average	0.02

For both Antigua and Barbuda, the impact of storms on the beaches vary depending on several factors including:

- *The presence or absence of bordering coral reef systems*
- *The degree of shelter including the relief of surrounding areas*
- *The size (Extent) and orientation of the beach*
- *The width of shelf which determines the nearness of deep water conditions*
- *. The amount of man-related activities, including sand mining, dredging and coastal development including the building of coastal structures.*

In the case of Barbuda with its flat, low-lying landscape there is even greater contrast in the erosion rates. Of the five beaches monitored on Barbuda two (Two Foot Bay and Dulcina) clearly show accretion as the dominant process while erosion is more significant for two others (Palm Beach and Palmetto Point). The different sectors of Coco Point tend to vary with accretion dominant in the north whereas the peninsular in the south is eroding. Table 1.3.2 shows the mean annual rates of coastal change in Barbuda between 1995 and 1999. The beach erosion hazard categories for Barbuda range from the extreme of very low (Dulcina) to very high (Palmetto Point).

Table 1.7 Barbuda – Mean Annual Beach Erosion Rate 1995 - 1999

BEACH	Mean Annual Beach Erosion Rate (m/yr)
Gravenor Bay	0.19
Coco Point	0.28
Dulcina	5.28
Palmetto Point	-4.25
Palm Bay	-1.82
Two Foot Bay	2.69
Average	0.40

Table 1.3.3 shows the effects of Hurricane Luis in 1995. According to COSALC 1996, the average change in beach profile width in Antigua (-4.9m) was greater than that for Barbuda (-1.1m). Beaches in Barbuda are usually backed by extensive sand dunes which act as a reservoir for beach nourishment along coastal areas eroded during the storm. This contributed to the

small change in profile width for Barbuda. However, the average dune/land edge retreat after the hurricane was further inland for Barbuda (17.7m) than for Antigua (4.9m). Generally, there

Table 1.8 Average Beach Changes in Antigua-Barbuda Following Hurricane Luis in 1995

AVERAGE CHANGE IN PROFILE AREA (%)	-23
AVERAGE CHANGE IN PROFILE WIDTH (m)	-3.3
AVERAGE CHANGE IN DUNE/LAND EDGE (m)	-7.6

Recalculations based on COSALC (1996)

may be variations between the rate of erosion/accretion along a particular beach but the dominant trend appears to be erosion. In both Antigua and Barbuda, the beaches located on the west and south coasts show the greatest erosion rates.

Beach erosion steepens the beach profile and in excessive conditions may lead to exposure of the rocky substratum. Beach-nesting species, such as turtles, may be completely lost. In addition, infrastructure near eroded beaches are subject to greater flooding risk. In general, the downgrading of a beach may discourage tourists and tourism development along the coast. Conditions for beach recovery varies throughout the coastal region of Antigua-Barbuda.

It is expected that sea level rise will expose higher levels of shore face to wave and current action (Hendry, 1993.) The shoreline will be expected to erode, with sediments moving offshore, and the shoreline retreating landwards.

An increase in the frequency and intensity of hurricanes will expose shorelines to greater impacts. It is anticipated that although in few areas there may be some accretion, erosion will dominate along most of the coast of Antigua/Barbuda. Erosion along with sea level rise will produce a net effect of reducing the size (land area) of Antigua/Barbuda.

1.3.4 Biodiversity

In spite of the harsh climatic conditions experienced by Antigua and Barbuda, it is still rich in biodiversity. According to Lindsay and Horwith, the following are the main characteristics of the biodiversity of Antigua and Barbuda:

Flora

1158 Species of Plants
45 Species of ferns and fern allies (43 Antigua, 2 Barbuda)
4 Species of Gymnosperms
1109 Species of angiosperms

Of the flowering Plants, 197 species merit special conservation. There is special concern for 22 endemic species of which 5 occur only in Barbuda. Some 73 species are classified as rare or have become extirpated.

Fauna:

Fresh water fish:	71 species endemic to the Antilles although Fish base lists only 11fresh water species for Antigua and Barbuda. There are 5 known native species.
Marine fish:	Fish base lists 291 species for Antigua and Barbuda.
Amphibians:	2 species known for Antigua
Reptiles:	20 species or subspecies recorded, 4 of which are extinct
Birds:	182 species recorded for Antigua and Barbuda

The vegetation of Antigua and Barbuda is dominated by secondary formations. About 20% of the land area of Antigua is covered by woodlands, 35% under scrub growth, 5% in agricultural production and about 30% is unimproved pastures. The dry scrub forest is dominated by Acacia spp. and in some areas there are large tracts of lemon grass (citronella spp.). About 66% of Barbuda is under woodland, 22% under mangrove and 9% under scrub vegetation. Table 1.3.4 show the woodland composition of Antigua and Barbuda.

Table 1.9 Vegetation Composition of Antigua and Barbuda

	Category	**Area (Ha)**
Antigua	Moist Forest	2200
	Dry Woodland	5654
	Cactus Scrub	1100
	Mangrove	300
	Sub-total	9254
Barbuda	Wooded Area	10 619
	Mangrove	3533
	Scrub/Rough Grazing	1285
	Sub-total	15 437
	TOTAL	24 691

Source: TFAP, 1993

Many of the offshore islands provide homes for sea birds, ground-nesting birds and other animal species. The Barbuda Lagoon is home for a nesting colony of Frigate Birds (Fregata magnificent) while there is the rare Antiguan Racer snake (Alsophis antillensis antiguae) on Great Bird Island.

Turtle nesting sites can be found on several of the beaches of Antigua and Barbuda. Marine turtles represent some of Antigua and Barbuda's most important threatened and endangered species. The main species are the hawksbill (Eretmochelys imbricata), the loggerhead (Caretta caretta), leatherback (Dermochelys careacea) and the green (Chelonia mydas).

1.4 Hydrological Characteristics and Water Resources

Antigua is divided into 86 watersheds six of which are identified as major catchments based on socio-economic and agro-ecological conditions (Benjamin and Fernandez, 2000). Because of unreliable rainfall several dams and reservoirs have been built to increase the amount of storage especially during dry periods. In addition there are 50 active wells which together with the desalination plants (2.8 million gallons/day capacity) supplies most of the water for domestic and industrial purposes. In addition, rainwater is harvested by householders mainly for drinking purposes.

Unlike Antigua, Barbuda depends heavily on its ground water resources. Rising sea level will threaten the viability of fresh water aquifers and other sources of ground water. Most of the aquifers are located relatively near the coast. In addition, the thin subsurface soil and extensive sand mining in some coastal areas can produce significant impacts on the already scarce water resources.

Stewart Environmental Systems Inc. (1980) indicated that the depth of the water table is generally less than 5 feet in the lowlands. Water also flows through available joints and fractures in the rocks. Any slight increase in sea level can affect the level and salinity of ground water supplies. Already, the salinity range from 200ppm-2480ppm in Barbuda. With the predicted future sea level rise the main aquifers and wells may be fully or partially inundated and the ground water supplies could become permanently lost. Although the Palmetto Sands (600ha) has a potential yield of 14.3 million gallons of fresh water annually, (Mather, 1971), and an estimated recharge 6 times greater, (Mc Millan, 1985), its location and relief puts it at considerable risk to the effects of sea level rise.

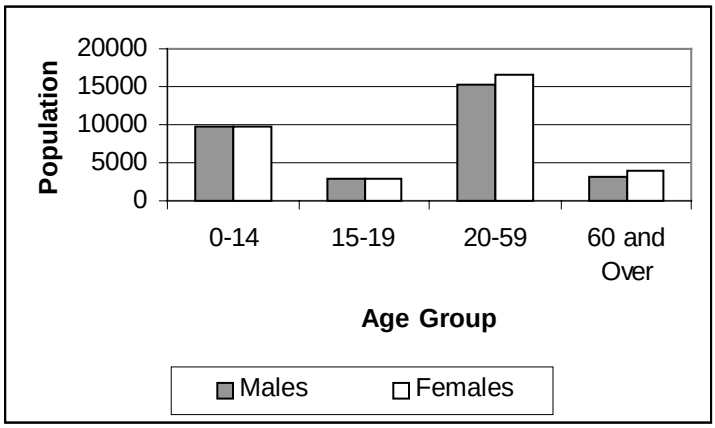
With minimal sea level rise, Barbuda is expected to suffer from inundation, fresh water shortages and increased salt damage. The whole island's economy will be threatened.

1.5 ***Socio-Economic Characteristics***

According to the 1991 census of Antigua and Barbuda the population was 63 878. The estimated average growth rate increased by approximately 1.5% during each succeeding year since 1992. Figure 1.3.1 illustrate the age/sex structure of the population of Antigua and Barbuda in 1991. A World Bank report indicated that the annual population growth rate between 1993 and 1999 was 0.7 percent. Life expectancy was 75 years while the infant mortality was 17 per thousand live births. Between 1975 and 1995 there was very little change in the crude birth and death rates and the rate of natural increase. However, there were slight decreases in infant mortality rate and

the overall population growth rate. This is illustrated in Table 1.3.5. The estimated labour force represented 61 percent of the population.

Figure 1.4 Age/Sex Structure of the Population of Antigua and Barbuda in 1991



Source: Statistics Office

Table 1.10 Demographic Indicators for Selected Years

INDICATOR	1975	1985	1991	1995
Population (Estimated mid-year)	62 067	63 605	63880	64 353
Population Density /km^2	157.8	178.5	135	146
Crude Birth Rate (per'000)	19.2	14.1	18.4	20.9
Crude Death Rate (per'000)	6.9	6.4	6.9	7.1
Rate of Natural Increase (%)	1.24	0.93	1.2	1.3
Infant Mortality Rate	38.2	24.4	21.1	
Population Growth Rate (% per annum)	0.5	0.12	0.1	0.2

Source: Statistics Office

The population of Barbuda is estimated at 1200 (DCA 1997). The labor force was estimated to be 30 000, of which 11% were in agriculture, 82% in commerce and services and 7% in industry. It was estimated that only 3.3% labor force was involved in fishing in 1995. Addition social and economic indicators are given in Tables 1.3.6 and 1.3.7 below.

Economically, Antigua/Barbuda is highly dependent on tourism and other service industries. However, primary industries such as agriculture and fishing are relatively important contributors to the national economy. About 40% of the population of Antigua and Barbuda live within the coastal zone. There is therefore a high concentration of people and structures relatively close to the coastline. In addition the vast majority of tourism developments occur within this zone. Most of the activities are concentrated in St. John's, the main town, as is the population. In fact most of St.John's occur at levels below 50 feet while the entire area on Codrington, Barbuda is below 25 feet (C.Jeffery, P. James 1997). Major settlements are scattered throughout Antigua,

including coastal regions, but settlement in Barbuda is confined to one main area, Codrington. These have serious implications for climate change and sea level rise throughout the country.

Table 1.3.6 gives some indication of the structure of the economy of Antigua and Barbuda. The high percentage of the GDP attributed to Services reflects the importance of the tourism sector. Of considerable significance is the low contribution from primary production, particularly agriculture, against the high proportion of imports of goods and services.

Table 1.11 The structure of the Economy of Antigua and Barbuda

STRUCTURE of the ECONOMY				
	1979	**1989**	**1998**	**1999**
(% of GDP)				
Agriculture	8.2	4.0	4.0	3.9
Industry	15.8	22.0	18.9	19.2
Manufacturing	4.9	3.1	2.3	2.2
Services	76.0	74.0	77.1	76.8
Private consumption	51.0	49.5	57.6	62.9
General government consumption	18.4	19.0	21.7	23.4
Imports of goods and services	75.5	90.8	83.5	87.2
	1979-89	**1989-99**	**1998**	**1999**
(average annual growth)				
Agriculture	-2.3	0.9	4.2	3.3
Industry	10.0	2.9	7.7	6.2
Manufacturing	5.0	-0.3	5.5	4.0
Services	6.4	3.2	2.9	4.2
Private consumption	5.5	5.7	24.6	14.3
General government consumption	6.5	5.7	9.3	12.7
Gross domestic investment	10.4	2.2	-18.7	-3.2
Imports of goods and services	8.4	2.5	2.9	9.3
Gross national product	5.5	4.0	4.5	5.4

Note: 1999 data are preliminary estimates.
Source: World Bank

Manufacturing in Antigua is small scale, in the early stages of development and, characterized by modest and fluctuating growth. The existing mix of industries serves domestic and foreign markets and, relies heavily on imported inputs for processing and assembly by local labor.

In accordance to the United Nations Framework Convention on Climate Change (UNFCCC) a study have shown that the principle sources of Green House Gases (GHGs) in Antigua and Barbuda are electricity generation and transportation sectors, which account for more than 90% of emissions.

Table 1.12 Key Social and Economic Aspects of Antigua and Barbuda

POVERTY and SOCIAL	Antigua and Barbuda	Latin America & Carib.	Upper-middle-income
1999			
Population, mid-year *(millions)*	0.07	509	573
GNP per capita *(Atlas method, US$)*	8,990	3,840	4,900
GNP *(Atlas method, US$ billions)*	0.61	1,955	2,811
Average annual growth, 1993-99			
Population *(%)*	0.7	1.6	1.4
Labor force *(%)*	..	2.5	2.1
Most recent estimate (latest year available, 1993-99)			
Poverty *(% of population below national poverty line)*	..	..	..
Urban population *(% of total population)*	37	75	76
Life expectancy at birth *(years)*	75	70	70
Infant mortality *(per 1,000 live births)*	17	31	27
Child malnutrition *(% of children under 5)*	10	8	7
Access to improved water source *(% of population)*	95	75	78
Illiteracy *(% of population age 15+)*	5	12	10
Gross primary enrollment *(% of school-age population)*	105	113	109
Male	..	..	..
Female	..	..	..

KEY ECONOMIC RATIOS and LONG-TERM TRENDS	1979	1989	1998	1999
GDP *(US$ billions)*	0.09	0.37	0.62	0.64
Gross domestic investment/GDP	24.3	41.2	32.2	29.8
Exports of goods and services/GDP	81.8	81.0	72.0	71.1
Gross domestic savings/GDP	30.6	31.5	20.8	13.7
Gross national savings/GDP	39.6	23.1	20.7	14.5
Current account balance/GDP	-21.1	-21.2	-11.5	-15.3
Interest payments/GDP	2.2	2.4	..	..
Total debt/GDP	33.6	55.9	..	..
Total debt service/exports	5.9	4.5	..	..
Present value of debt/GDP	..	..	..	..
Present value of debt/exports	..	..	..	..

(average annual growth)	1979-89	1989-99	1998	1999	1999-03
GDP	6.9	3.1	4.4	4.6	..
GNP per capita	5.0	3.4	3.6	4.5	..
Exports of goods and services	8.4	0.6	0.3	3.3	..

Source: World Bank

1.6 Other Factors/*Phenomena:*

The Eastern Caribbean island arc system by nature an area vulnerable to both earthquake and volcanoes by virtue of its geological structure and tectonic history. The earthquakes, which have affected Antigua and Barbuda, have recorded damages particular to structures only within specific areas. There are no records of widespread earthquake damage throughout Antigua and Barbuda especially in recent times. . Both islands have recorded major earthquakes in 1843 and as late as 1974.

Volcanic activity on Antigua and Barbuda is almost non-existent. On the other hand volcanic activity in nearby Montserrat has caused an increase in population and the related stresses on the natural resources of Antigua and Barbuda.

Drought is a serious problem in Antigua and Barbuda, although its effects have been overshadowed by the more frequent hurricanes and tropical storms. There were severe droughts affecting both islands between 1964 and 1968 and in 1983 –1984. Droughts may occur independent of climate change however, in most there is direct evidence to indicate that a correlation exists.

2.0 IMPACTS OF POTENTIAL CLIMATE CHANGES AND SEA-LEVEL RISE:

Climate Change and Sea-Level Rise are manifested directly in the changes in weather phenomena. These include hurricane characteristics such as increased intensity and occurrences which directly result in increased magnitude and intensity of storm surges, changes in rainfall and temperature patterns as manifested in more extreme conditions. The impacts that may be produced on the different sectors or specific resources are listed below:

2.1 Agriculture

- loss of crops and livestock from both storm and drought activity;
- reduced availability of water for agriculture, particularly during times of competition with domestic and tourism demands;
- increased evapo-transpiration as a result of higher temperatures;
- heat stress, particularly on poultry and livestock;
- reduction of rough pastures available for livestock;
- greater post-harvest losses arising from increased temperature and/or humidity;
- erosion of hillsides and loss of top soil due to increased flash flooding and heavy precipitation; and
- enhanced vulnerability to pests and weeds through changed hydrologic and atmospheric conditions.

2.2 Fresh Water Resources

- Additional pressure on limited available water supplies during the annual dry season;
- Saline intrusion into freshwater aquifers in coastal areas;
- Increased evaporation from surface water storage;
- Increased damage to drains and pipes from flash flooding;
- Greater vulnerability of water sheds arising from drought (including fire damage) and hurricanes (particularly wind damage); and
- Greater dependence on expensive desalinated water to supply expanding domestic water demand.

2.3 Human Settlement

Climate change/sea level rise impacts on human settlements in Antigua and Barbuda are likely to include:

- Destruction and loss of infrastructure in low-lying coastal areas arising from sea-level rise;
- Greater property damage and loss from increased hurricane activity;
- Flooding of low-lying areas from storm run-off and storm surge;
- Increased costs for sea defense mechanisms;
- Increased costs and reduced availability of insurance coverage for property; and
- Heightened vulnerability of tourism properties in the coastal zone
- Changes in the employment structure of the country.

2.4 Human Health

Anticipated climate change impacts on human health include:

- Increased incidence of vectors can enhance opportunities for breeding of dengue bearing mosquitoes;
- Damaged water supply systems could cause a shortage of potable water. This in turn could impact negatively on hygiene and sanitation standards, resulting in the outbreak of disease such as cholera, gastro-enteritis and increase the risk for other diseases like malaria and yellow fever;
- increased cardio-respiratory and allergic disorders due to climate-enhanced increases in air pollutants;
- Injuries, increased risk of various infectious diseases, and increased mental and physical stress and disorders arising from hurricane activity;
- wide range of public health consequences, particularly in terms of environmental health and nutrition.
- Increased rainfall patterns may produce greater contamination of coastal and fresh water supplies leading to a greater incidence of skin, eye and ear diseases.
- Drought conditions can affect food production and daily nutrition. Flooding and drought can affect the economic and ultimately psychological well-being of farmers, especially those involved in marginal or subsistence agriculture.

2.5 Coastal Zone

The Principal impacts of climate change and sea level rise on the coastal zones of Antigua and Barbuda are likely to include:

- Submergence and inundation of beaches and coastal lands:
- Coastal erosion;
- Salinization of aquifers;
- Submergence, silting and loss of sea-grass beds;
- Coral reef degradation and loss due to submergence and bleaching as well as physical damage;
- Destruction to human settlements and infrastructure along the coast from intensified storm surge and coastal flooding; and
- Destruction and loss of mangroves and wetlands.
- Structural changes in the Fishery Sector.

2.6 Tourism

The impacts of climate change/sea level rise on the tourism are linked to its' effects on the natural and man made resources which make up the total tourism product. Tourism in Antigua and Barbuda is beach oriented with the majority of the hotels built along the coastal zone with inadequate setbacks. Therefore some of the climate change impacts on tourism will be a reflection of those mentioned above. These will include:

- Destruction of hotels and other beach front properties due to the effects of sea level rise, storm surge and hurricanes.
- Destruction of the natural habitats including bleaching of reefs, the submergence of beaches and inundation of coastal lands which are the prime tourism resources.
- Water shortages due to additional pressures on limited available supplies during the dry season;
- Psycological effects on potential visitors.

2.7 Fisheries

The impacts of climate change and sea level rise on the Fisheries sector of Antigua and Barbuda may be difficult to determine since there are other factors such as over-fishing and man-induced stresses on the habitats and other fisheries resources which are likely to produce some effects. The following impacts may be identified:

- Increased stress on breeding grounds and habitats from sea level rise and altered hydrological cycles.
- Longer and more intense periods of rough seas affecting the availability of fishery resources.
- Increased damage and losses to fishery equipment, vessels and infrastructure from storm and hurricane activity.
- Increased pressure on the fishery resources by persons displaced from other sectors.

2.8 Biodiversity

Sea level rise, increased temperatures and altered precipitation patterns could make marginal areas unsuitable for certain species resulting loss of biodiversity. Increased rainfall can cause increased soil erosion and landslides in vegetated areas resulting in further loss. On the other hand, drought conditions can produce drastic changes in biodiversity in that there may be changes in the type and amount of animal and plant life over considerable areas. Anthropogenic forces such as clearing and burning of vegetation will further compound the problem.

Anthropogenic factors combined with increased hurricane frequency and intensity can also subject natural habitats to increased stress and damage and place certain plant and animal species at risk.

2.9 Major Implications For Impacts

The major implications for the impacts of climate change and sea level rise are shown in table 2.1.

Table 2.1 Major Implications for Sea Level Rise and Climate Change

CHANGE FACTOR	IMPLICATIONS FOR		
	Fisheries	**Coastal Zone**	**Tourism**
Sea-Level Rise	Changes in coastal habitat; Possible loss of habitat	Habitat loss, including beach, mangrove, sea grass and corals. Possible migration of habitat/ shifting of plant communities; Inundation of coastal lands; Loss of coastal structures; Dislocation of population; Change of livelihoods	Loss of beach and facilities on or near the coastline.
Increased Number and Intensity of Tropical Storms	Damage and loss of gear and vessels; habitat loss	Temporary or permanent damage and loss of mangroves, beaches, sea grass, coral reefs; Decreased Fish production.	Loss of coastal property and infrastructure. Increased cost of coastal protection.
Storm Surge	Damage and loss of gear and vessels; habitat loss	May affect life-cycles of marine life.	Possible loss of lives and property.
Extreme Rainfall Conditions: **Floods /Droughts**	Increased siltation and pollution of coastal waters Drying of some wetland areas thus affecting fish breeding grounds	Landslides, increased sedimentation and erosion Siltation and salinity changes can cause habitat loss or degradation. Reduced productivity of coastal vegetation; Increased soil salinisation	Increased cost of providing clean water for general use.
Temperature Increase	Possible habitat changes	Coral bleaching; death of some reefs; Salinization of some wetland areas Minor changes can cause a reduction in biodiversity. Can produce algal blooms and associated conditions.	Health implications especially for tourists. More vector borne diseases, etc.

Table 2.1 Major Implications for Sea Level Rise and Climate Change (Cont'd)

CHANGE FACTOR	IMPLICATIONS FOR			
	Agriculture	**Fresh Water Resources**	**Human Settlement**	**Human Health**
Sea-Level Rise	Loss of land Increased cost of protection	Possible rise in the water table and increased salinization in coastal areas	Loss of land Increased cost of protection, building and insurance	Changes in coastal habitat; Possible loss of habitat
Increased Number and Intensity of Tropical Storms	Loss of crops and animals. Damage to access roads; Reduced output Increased cost of production	Possible contamination of water supplies;	Loss of lives, damage to property and infrastructure. Increased building costs. Loss of earnings.	Damage and loss of gear and vessels; habitat loss
Storm Surge	Animal and crop loss		Temporary loss of land and damage to people and property.	Damage and loss of gear and vessels; habitat loss
Extreme Rainfall Conditions: **Floods /Droughts**	Reduced crop and animal quality and yields; Soil loss, Excessive leaching; Possible animal loss Low agricultural water supply; Slow and stunted growth of animals and plants Reduced fruit size Reduced soil fertility.	Reduction in water quality; Damage to water storage systems; Insufficient water supplies for household use;	Damage to people and property. Increased cost of providing basic facilities.	Increased siltation and pollution of coastal waters Drying of some wetland areas thus affecting fish breeding grounds
Temperature Increase	Reduced animal and crop yields. Increased cost of production. Increased use of fertilizers and pesticides. Animals suffer heat stress	Greater rate of evaporation could lead to less water storage.	Increased risk of disease. Increased cost of personal health .	Possible habitat changes

3.0 KEY ISSUES WITH RESPECT TO CLIMATE CHANGE

The key issues that require urgent attention if meaningful strategies for adaptation to climate change and sea level rise are to be designed and implemented were identified in a report prepared by Brian Challenger on Adaptation to Climate Change in Antigua and Barbuda.

- ***Physical Planning and Development Control.***

In general the land use development control and physical planning functions of Antigua and Barbuda are extremely weak and under developed. There are a number of reasons for this including limited technical expertise and an underlying political suspicion of the physical planning process.

In Antigua and Barbuda the weaknesses in the physical planning process have resulted in a number of problems including urban sprawl; soil erosion; inadequate liquid and solid waste disposal in certain areas; steady alienation of agricultural land to residential and other purposes; and the costly provision of public infrastructure and utilities. From the point of view of the projected climate change scenarios these have enhanced vulnerability to flooding, drought and sea level rise. Coordination in planning is essential to the overall process of development. In addition improved public and private sector collaboration will ensure better coordination in the planning and implementation of development policies and strategies.

- ***Coastal and Marine Resource Management and Development.***

Frequently identified concerns affecting coastal and marine resources of Antigua and Barbuda include habitat loss, reduction in water quality and coastal erosion (CEP, 1991). In many instances uncontrolled tourism and residential development in coastal areas have contributed to these problems. While the quantitative extent of coastal resources in Antigua and Barbuda as well as the causes of destruction are not precisely known, climate change and accompanying sea level rise will have potentially severe ecological and socio-economic impacts, specially in the view of the central role which the islands' coastal and marine resources play in the country's tourism product.

Antigua and Barbuda coastal and marine areas are among the most sought after for development, though the siting of facilities along the coast invariably increases risk exposure to coastal storm damage. Despite these difficulties public policy does little at present to restrict development in hazardous areas and may inadvertently encourage such practices (Burton, 1996). Integrated coastal and marine areas management should be promoted.

- ***Natural Disaster Response and Management.***

Antigua and Barbuda like other small developing countries, is highly vulnerable to natural disasters arising out of its small geographical area, its location in the Atlantic 'belt", and its dependence on a single economic sector. Changes in the global climate accompanied by greater

climate variability are likely to be the source of increased extreme weather events and particularly hurricanes, droughts and storm surges. Not withstanding the considerable achievements made in disaster preparedness and response it is likely that disaster risks levels in Antigua and Barbuda have increased in recent decades as development has intensified. Factors which have contributed to this increase in vulnerability include the shifts away from traditional Caribbean architectural practices and materials to more vulnerable forms of construction, extensive deforestation, the development of coastal and beach front sites for tourism and residential property, and the historical absence of strict implementation of Land Use Development plans and Building Codes which factor in risk consideration.

- ***Fresh Water Resource Management and Development.***

Antigua and Barbuda is characterized by low rainfall; a situation aggravated by marked seasonal distribution. Important sources of freshwater are desalinization, ground water extraction, and surface water.

Existing water management problems include saline intrusion of ground water sources, dependence of expensive desalinized water and variability of surface water supplies. Demand is projected to continue to grow in line with economic growth and increasing urbanization, intensifying competition for available supplies. This is of particular significance to the agricultural sector, which is generally provided lower priority, than the municipal and tourism sectors. Desalinization already accounts for more than sixty percent of portable water production and its use is generally on the increase. With the constant threat to fresh water supplies, there is need for a comprehensive water resource management programme.

- ***Appropriate Agricultural Development.***

Historically the main adaptation required for agriculture in Antigua and Barbuda has been to drought. Although the historical record also shows the major impacts which hurricanes have had on social and economic life during the plantation era (NODS, undated). Despite increased availability of water in other sectors as a result of desalinization, the agricultural sector remains disadvantaged in receiving water supplies during periods of drought. This will need to be addressed if agricultural production is to be sustained in this scenario of more intense drought conditions. Additionally, agricultural land loss is occurring at a rapid rate.

Other projected climate change impacts will also require attention. In general there is much less recent agricultural sector experience of adapting to some of the consequences of heat stress and hurricane damages associated with climate change scenarios than to drought.

- ***Economic Initiatives and Incentives.***

The instrument of insurance is closely related to perceptions of vulnerability and risk. In Antigua and Barbuda and other Caribbean countries access to insurance is increasingly being restricted as

global reinsurance reduce the level of coverage available, particularly to vulnerable coastal habitats (pers, comm. M. Gomez, 1997)

Among the problems confronting the insurance sector are its weak capital structure, the existence of a large number of entities providing insurance and a weak regulatory and supervisory capability (UWICED, 1996). While internationally concerns about global warming have promoted increased awareness, on the part of insurance and reinsurance companies, of the need to promote disaster mitigation measures in order to reduce the rapidly increasing volume of insurance claims in the future, insurance companies in Antigua and Barbuda and the Caribbean have been relatively slow to move in this direction.

- ***Fisheries Management and Development***

One of the principal difficulties in assessing climate change impacts on the fisheries sector involves distinguishing the impacts already being experienced as a result of habitat loss and over exploitation. The small scale of operations of most fishers enhances the vulnerability of many of the fisheries sector operations: many fishing communities are also among human settlements most vulnerable to long term sea level rise and storm surge.

Plans for the development of the fisheries sector in Antigua and Barbuda include upgrading of fish landing and marketing facilities as well as targeting of pelagic resources in the country's extensive Exclusive Economic Zone (EEZ).

- ***Strategic Environmental and Public Health Management:***

Disturbances to Earth's life support systems as a result of climate change will result in increased risk to the health of human populations in many ways. Vulnerability of specific populations will be dependent on a number of variables including quality of available health care services and related support infrastructure. In Antigua and Barbuda the health sector is already the second largest recipient of public funds as efforts are being made to deliver health services to all at primary, secondary and to a lesser extent tertiary levels. The anticipated impacts of climate change could place additional strain on already overstretched resources.

3.1 Ranking of Issues by Magnitude and Significance

The magnitude and significance of the impacts of climate change on the various issues are shown in Table 3.1. Some attempt is made at ranking the issues based on their relative situations. The extent of activities and structures within the coastal zone indicate that it will be an area of high impact. There will be direct impacts on fisheries, tourism, human settlements, water resources

and biodiversity. In the long run major adjustments may be necessary. The rate of adjustment could determine the extent to which the impact of climate change and sea level rise affect Antigua and Barbuda.

Table 3.1 Ranking of Issues according to Sector of Influence

Issues/Concerns	**Magnitude**			**Significance**		
	High	***Medium***	***Low***	***High***	***Medium***	***Low***
Agriculture		✔			✔	
Coastal Zone	✔			✔		
Fisheries	✔				✔	
Fresh Water resources	✔			✔		
Human Health		✔		✔		
Human Settlement		✔			✔	
Tourism	✔			✔		
Biodiversity	✔			✔		

3.2 Institutional and Legal Arrangements for Responding to Issues

Existing institutional and legal arrangements for environmental management in general and coastal management in particular may be characterized as multi-agency and interdisciplinary. Table 3.2 lists primary coastal resources management activities, indicating the agency to which responsibility is assigned.

Table 3.2 Allocation of Coastal Management Responsibilities

COASTAL MANAGEMENT FUNCTION	**AGENCY RESPONSIBLE**	**GOVERNMENT MINISTRY**
Building Development Control Within Coastal Area	Development Control Authority (DCA)	Prime Minister's Office
Regulation/Design/Construction of Civil Works	Public Works / DCA	Public Works (MOPW)
Development and Management of National Parks	National Parks Authority (NPA)	Tourism and Environment (MOTE)
Planning and Allocation of	Land Division	Agriculture, Lands, Fisheries

Government Lands	/Central Housing and Planning Authority (CHAPA)	(MOALF) / Housing and Urban Development (MOHUD)
Planning and Allocation of Lands in Barbuda	Barbuda Local Council	Barbuda Local Government (BLGC)
Protection/Management of Coral Reefs, Sea grasses and Mangroves	Fisheries Division (FD)	Agriculture, Lands, Fisheries (MOALF)
Sand Mining and Mineral Extraction	Public Works	Public Works (MOPW)
Water Quality Monitoring; Setting of Coastal Water Quality Standards	Central Board of Health (CBH)	Health (MOH)
Enforcement/Marine Surveillance	Coast Guard (ABDFCG) / FD Royal Antigua and Barbuda Police Force (RABPF)	Defense and Security MOALF , Ministry of Legal Affairs, Home Affairs and Labour
Legal support and advise	Attorney General Chambers,	Ministry of Legal Affairs, Home Affairs and Labour (MOLA)
Control of imports/exports	Customs and Excise Department	Finance (MOF)
Development and maintenance of coastal infrastructure	PWD, Antigua Public Utilities Authority (APUA)	Ministry of Communications, Works, Transport and Public Utilities
Pollution monitoring, including water quality control	Central Board of Health (CBH)	MOH
Management of leisure Ports, some legislation base regarding oil pollution, establishing of infrastructure in the marine environment	Antigua Port Authority	MOF
Financing agricultural and fishing enterprises	Antigua Barbuda Development Bank (ABDB	

3.3 Key Legislation Relating to Coastal Management

Table 3.3 provides the main legislations that are supportive of coastal adaptation activities. The wide variety of agencies responsible for coastal management present serious implications for implementation.

Table 3.3 Coastal Management Legislation

TITLE	OBJECTIVE	AGENCY
The Fisheries Act (1983) and Fisheries Legislation (1990)	Fisheries Management and Development	Fisheries Division
National Parks Act (1984)	Designation, Management (including Development Control) and Development of National Parks	National Parks Authority (NPA)
The Marine Areas (Preservation and Enhancement) Act (1972) and The Marine Areas (Preservation and Enhancement) Regulations (1973)	Declaration and Management of Marine Protected Areas	Fisheries Division
Beach Control Ordinance (1991)	Control of sand mining	Public Works Department (PWD)
The Barbuda By-Law (1934, 1959)	Management and Development of Marine and some Forest Resources	Barbuda Council
Land Development and Control Act (1977)	Land Development and Control including application review and approval and development surveillance.	Development Control Authority (DCA)
Forestry Act (1941) and Forestry Regulations (1941,1952)	Forestry Management and Development	Forestry Division
Crown Lands Act (1917) and Crown Lands Regulations (1926, 1930, 1939)	Renting, Sales and Settlement of Crown Lands. Planning and allocation of government lands for residential, agricultural and other land use purposes.	Lands Division

Marine Areas Act (1982)	Regulates maritime activities and uses of the marine areas.	Marine Services, Antigua Port Authority (APA)
Antigua and Barbuda Building Code and Guidelines (1995)	Prescribe Guidelines for Building Structures.	Development Control Authority (DCA)
Litter Act	Control of litter in public or private places	MOH National Solid Waste Management Authority (NSWMA)
Merchant Shipping Act (1981)	Regulates laws governing Merchant Shipping	Marine Services (APA)
Pesticides Control Act	Regulates imports, use, labeling and storage of pesticides.	MALF Ministry of Trade (MOT)
Public Health Act	Regulates oversight for sewage, industrial and solid waste disposal	MOH (CBH and NSWMA)
Plant Protection Act (1988)	Regulates control of pests and diseases and prevents the introduction of exotic species.	MALF

Key:

APA : Antigua Port Authority
DCA : Development Control Authority
MALF : Ministry of Agriculture, Lands and Fisheries
MOPI : Ministry of Planning and Implementation
MOL : Ministry of Labour
MOT : Ministry of Trade
MOTE : Ministry of Tourism and Environment
MOH : Ministry of Health
NPA : National Parks Authority
NSWMA : National Solid Waste Management Authority
PWD : Public Works Department

3.4 Non-government Agencies in Antigua and Barbuda and their Respective Association with Coastal and marine Management.

Several non-government organizations provide important inputs in the management of coastal and marine areas. The interventions range from participation in consultations to the provision of essential goods and services. Table 3.4 identifies the main agencies involved.

Table 3.4 NGOs with Responsibility for Coastal/Marine Management

AGENCY	RESPONSIBILITY
Antigua Fishermen's Cooperative Society/ Antigua and Barbuda Fishermen's Alliance/ Barbuda Fishermen's Association	Facilitate arrangements for the general operations of commercial fishermen around Antigua and Barbuda.
National Development Foundation (NDF) Antigua and Barbuda Development Bank	Provide loans and general finance to fishermen and farmers.
Antigua and Barbuda Sports Fishing Association	Coordination of activities of recreational fishermen.
Environment Awareness Group (EAG)	Various independent coastal inventories and surveys and biodiversity projects including the monitoring of the Antiguan racer snake.

3.5 International Agreements Relating to Marine Management in Antigua and Barbuda

Antigua and Barbuda is a signatory/party to many regional and international conventions and agreements. The country also participates in most of the regional programmes and organizations. These are listed below.

Conventions and Agreements

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 1973)
International Convention for the prevention of pollution from ships (MARPOL 73/78)
Basel Convention on the Control of trans-boundary Movements of hazardous wastes and their disposal
United Nations Convention on the Law of the Sea (UNCLOS, 1982)

Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena Convention, 1983) and its protocol concerning Specially Protected Areas and wildlife (SPAW, 1990)
Convention on Biological Diversity (CDB, 1992)
United Nations Convention to Combat Desertification (1992)
United Nations Framework Convention on Climate Change (UNFCCC, 1992) and its Kyoto Protocol 1997.
Montreal Protocol on substances that deplete the Ozone Layer
Convention concerning the Protection of the World Cultural and Natural heritage

Regional Programmes and Organization

Caribbean Conservation Association (CCA, 1967)
Central American and Caribbean Programmes of the World Conservation Union (IUCN)
UNESCO's Man and the Biosphere Programme (MAB, 1972)
Caribbean Environment Programme of UNEP (CEP, 1981)
Organization of Eastern Caribbean States (OECS, 1981) and its Natural Resources Management Unit (OECS-NRMU)
Tropical Forestry Action Plan (TFAP, 1985)
Caribbean Development and Cooperation Committee of the Economic Commission for Latin America and the Caribbean (ECLAC)
Programme of Action for Small Islands Developing States (SIDS – POA, 1994)
The Association of Caribbean States (ACS, 1996)

3.6 Other Issues

In addition to the main issues discussed above, the following should also be considered when looking at issues related to climate change and sea level rise in Antigua and Barbuda:

- Existing institutional and legislative frameworks particularly the distribution or arrangements of government ministries.

- Inadequate facilities and insufficient human resources available within agencies to effectively undertake their mandate. In addition, there may be different levels of political interference in the decision-making machinery.

- Overlaps and gaps in the responsibilities and functions of various organizations.

4.0 TOWARDS AN ADAPTATION POLICY

Once the impacts of climate change and sea level rise are identified appropriate adaptation strategies should be established. Generally, there is a need for increased capacity for climate change at a national level. This should involve consultation of all stakeholders, starting at the sector level. This could be co-ordinated by a functional National Climate Change Committee.

4.1 Adaptation Options

Considering the three basic options for adapting to climate change: retreat, accommodation and protection the broad goals of promoting sustainable development and vulnerability reduction to climate change and sea level rise should always be satisfied. The following objectives should therefore be achieved:

- Economic Development
- Environmental protection
- Equity
- Risk minimization
- Minimizing of economic losses
- Increase institutional response.

The strategies for adapting to climate change are categorically given below. Possible measures or actions that could be implemented take into consideration the broad approaches to adaptation as outlined in the UNEP Handbook on the Methods for Climate Change Impacts and Adaptation, including:

- Bearing Losses
- Sharing Losses
- Modifying the Threat
- Preventing Effects
- Changing Use
- Changing Location.

Agriculture

- Increased education and public awareness.
- Improved Research on crops and animals adapting to climate change and sea level rise. Consideration should be given to varieties of crops and animals that can withstand conditions of drought, flooding, higher temperatures and increased salinity and the maintenance of viable populations of local crop and livestock races.
- Establishing an integrated Disaster Management Plan for agriculture. This should give consideration to integrated watershed management including appropriate water storage devices and an effective Drought and Flood Management plan.
- Introduction of effective agronomic practices and the use of appropriate technology including a suitable irrigation system, soil and water conservation practices and the reduction of pesticide use making its application safer.

Human Settlement and Infrastructure

- Public Education and Awareness
- Improved Physical Planning and Development Control. Strict measures should be taken to avoid further development in vulnerable areas especially along the coastal zone. The updated National Physical Development Plan should be implemented.
- Implementation and strengthening of existing legislations dealing with setbacks and the general building codes.
- Resiting of some structures including critical facilities and utilities.
- Strengthening community level disaster management.

Human Health

- Public Education: This should focus on promoting awareness programmes towards reducing health risks associated with diseases such as malaria, dengue and cholera.
- Strengthening of health service delivery capacity in Antigua and Barbuda.
- Increased medical supplies and improving the quality of health services in Antigua and Barbuda.
- Increase efficiency in solid waste management systems including the monitoring of waste (both solid and liquid) with appropriate adaptation and relocation of landfill sites;
- Increased enforcement of health legislation;

Tourism

- Public education and Awareness;
- Public participation in tourism development and planning; A precautionary approach is recommended.
- Strengthen legislative frameworks for coastal development including EIA legislation/regulations and the establishment and enforcement of land use policy and regulations/legislation;
- Decentralise coastal tourism development and the promotion of eco-tourism and other forms of non-consumptive uses.
- Establish environmental guidelines for tourism and other forms of development.

Fisheries

- Increased education and public awareness;
- Improved data collection and management system for the fishery resources;
- Formulation of a Coastal Zone Management Plan, including the monitoring of critical coastal habitats.
- Construct and reinforce infrastructure at appropriate fish landing sites.
- Develop appropriate technology to design and build new and improved fishing gear and vessels;
- Develop possible alternatives including aquaculture development and a shift towards targeting the pelagic species.
- Develop a system of Marine Protected Areas (MPA's);
- Develop the legislative capacity to manage the fisheries, including updating of existing legislations.

Water Resources

- Protection and maintenance of critical watersheds;
- Develop and implement an integrated Water Resource Management Plan including improved management of the water distribution system and the construction of more water production and storage facilities. Special consideration should be given to the water situation in Barbuda. Desalination and selective siting of wells are possible options.
- Public education and awareness.

Coastal Zone

- Public education and awareness;
- Public participation in development and planning;
- Establishment and/or expansion of the monitoring programmes for mangroves, sea grass beds, coral reefs and beaches;
- Formulation of a Coastal Zone Management Plan,
- Updating and enforcement of existing legislations including the implementation of appropriate setbacks.
- Increase the capacity of Antigua and Barbuda to monitor the dumping of toxic waste at sea.

Biodiversity

- Implement national strategies for conservation and sustainable use of biological diversity. This should include the identification and monitoring of the major components of biodiversity, the protection of rare and endangered species, the protection and preservation of critical bird-nesting sites and bat-roosting sites and the stabilizing and rebuilding of populations of specific turtle species.
- Strengthen institutional framework and training of human resources including an intensive programme for environmental education, information exchange and public awareness;
- Identification and protection of Forest Reserves. Some reforestation may be necessary especially within major watersheds.
- Coordination of the Biodiversity Strategy and Action Plan.

4.2 Policy Considerations

In order to adapt to climate change and sea level rise the outlined adaptation proposals should be implemented. These should form part of a National Development Policy Framework for Antigua and Barbuda, which gives due consideration to addressing issues related to climate change and sea level rise. The formulation of a National Climate Change Policy is essential for the coordination of any comprehensive climate change adaptation strategy and action plan. This should involve all the major sectors of the country on the basis that appropriate legal and institutional structures are developed to deal with climate change within an integrated framework.

In formulating a national strategy/ action plan in relation to climate change/sea level rise, key priorities to be addressed will include:

- Institutional and legislative review; the legal process of introducing new legislation and accelerating modification of existing laws and regulations should be simplified.

- Strengthening institutional frameworks and training of human resources; Scarce resources should be allocated and shared for the benefit of the country.

- Incorporation of Climate change issues into national planning; Sound future policy planning should be based on sound research

- Establish national systems for data collection, monitoring, enforcement and evaluation; Information collected should be fed back into the management and decision making process.

- Technical and scientific cooperation and coordination both nationally and regionally;

- Intensive public awareness and education;

- Stakeholder consultation, participation and involvement at all levels;

- Financial and other resources considerations.

The priority options should be fed into important sector and national management and/or development plans such as:

- A National Disaster Management Plan;
- A comprehensive Agricultural Development Plan
- An integrated Water Resources Management Plan
- A Fisheries Management and Development Plan
- The Biodiversity Strategy and Action Plan
- An Integrated Coastal Zone Management and Development Plan
- The National Physical Development Plan
- The National Strategic Development Plan.

The specific policy options re: the National Climate Change issues for Antigua and Barbuda should include the following recommendations:

- Develop and strengthen the country's natural disaster response capability. The policy should strengthen the relevant agencies, particularly NODS, and incorporate the establishment of a comprehensive plan for national disaster management.
- Establish a National Climate Change Center; National climate change issues need to be fully documented and further researched so as to produce vulnerability and adaptation analyses. The National Climate Change Center would feed directly into the Caribbean Climate Change Center. In addition, information could be provided to feed directly into

the national education system and a structured programme of public education and awareness re: climate change and sea level rise.

- Build national capacity and strengthen institutions at all levels. Human resources and institutional capabilities should be strengthened to cope with the adverse effects of climate change and sea level rise.
- Strengthen the Physical Planning Management capability. The framework for environmental, social and economic planning should be revitalized. The integration of all sectors of the society in the planning process should be emphasized.
- Develop and implement a comprehensive National Physical Development Plan. Related legislations should reflect current issues of climate change and sea level rise.
- Formulate economic and regulatory proposals for natural resource and energy usage. Critical resources should be valued as national treasures. As a result of economic valuation, the use and abuse of resources may be regulated through the use of incentives/disincentives. A national energy policy should also be formulated.

There are other initiatives, which could contribute significantly to the success of establishing of a national climate change policy. Antigua and Barbuda benefited from the UNEP sector assessment of vulnerability and adaptation to climate change and sea level rise. In addition, the formulation of economic regulatory proposals is the pilot component undertaken by Antigua and Barbuda under the CPACC project. These can form the basis for future projects related to Climate change and sea level rise.

5.0 SUMMARY AND CONCLUSIONS

Climate change is a reality for Antigua and Barbuda. Vulnerability to natural hazards such as hurricanes and drought is very high for Antigua and Barbuda as seen over the last decade where the country experienced several major hurricanes.

Given existing physical, socio-cultural and economic conditions various adaptations strategies must be considered in order to reduce the effects of climate change and sea level rise on Antigua and Barbuda. Adaptation options are presented for major sectors including: agriculture, human settlement and health, water resources, coastal zone, fisheries, tourism and biodiversity.

The following issues should form the basis for the formulation of a National Climate Change Policy document for Antigua and Barbuda:

- ***Strengthening Physical Planning and Development Control.***
- ***Coastal and Marine Resource Management and Development.***
- ***Improving Natural Disaster Response and Management.***
- ***Fresh Water Resource Management and Development.***
- ***Appropriate Agricultural Development.***
- ***Establishing Economic Initiatives and Incentives.***
- ***Fisheries Management and Development***
- ***Strategic Environmental Health Management:***

With an integrated approach to planning and extensive stakeholder participation in the decision making process national climate change policies for Antigua and Barbuda should embrace the following:

- Developing and strengthening of the country's natural disaster response capability.
- Establishing a National Climate Change Center;
- Building national capacity and strengthening institutions and linkages.
- Strengthening the Physical Planning Management capability.
- The development and implementation of a comprehensive National Physical Development Plan.
- Formulation of economic and regulatory proposals for natural resource usage.

Where possible, new policies should be based on scientific evidence. Once developed they can be used to model impact assessment within other SIDS which experience similar conditions to Antigua and Barbuda.

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