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FOREWORD

The Government of Grenada is pleased to submit its First National Communication to the United Nations Framework Convention on Climate Change (UNFCCC).

This Initial Communication is indicative of our commitment to fulfill our obligations under the Convention, a commitment that is evidenced by the Action Plan which has been developed to address the key issues identified in the process of preparing this Initial Communication.

This Action Plan is aimed at initiating processes to mitigate our greenhouse gas emissions and at formulating a national response to the adverse impacts of climate change on our country.

We wish to emphasise in this regard, that while we will take action to mitigate our greenhouse gas emissions, we see this as primarily a responsibility of the Annex I Parties, given that our emissions are insignificant within the global context. We want to stress the need for these Annex I Parties to initiate action within their countries that will make significant contributions to reducing the global level of greenhouse gas emissions, as quickly as possible.

Of more concern to us however, is the reality that the more significant effects of climate change will affect the very lives of our people. This will come from the adverse impacts created by sea level rise, increased temperatures and extreme events on our coastal zones, our water supply systems, our key economic sectors of agriculture and tourism, our water supply systems and the health of our people.

We have detailed the results of our initial analysis of these potential impacts and, through this Initial Communication, we want to highlight the urgent need to address these impacts with the design and implementation of appropriate response measures. These response measures will include more in-depth analyses in a number of areas, analyses for which we do not at present have the technical capabilities, or resources, to initiate action.

Our Initial Communication has detailed our needs in these areas and we hope that it will become the vehicle through which we can mobilise the support needed to ensure the sustainable development of our people, our communities and our country.

This support is necessary, as we are a vulnerable Small Island Developing State, with limited financial and technical resources at our disposal. We note the provisions of the UNFCCC to provide "new and additional" resources to States like ours to address the adverse impacts of climate change. We urge that the process for implementing these provisions is speeded up, so that we can expedite the development and implementation of the appropriate response measures.

It would be remiss of me not to recognize the contributions of the Global Environment Facility, The United Nations Development Program and the National Communications Program in the preparation of this Initial Communication.

It is our wish that the support received from these agencies will be expanded in the future, as we work together to ensure that our activities today do not compromise the ability of future generations to enjoy the high quality of life that this planet is capable of providing.

Hon. Clarice Modeste-Curwen (Dr.)
Minister of Health and the Environment

ACKNOWLEDGEMENTS

This First National Communication represents the input of a large number of people during the eighteen-month period over which it was prepared.

The contribution of the Global Environment Facility (GEF), which financed the enabling activity, was instrumental in getting the project off the ground and the technical support received from the National Communications Support Program (NCSP) was instrumental in providing technical guidance to the process.

Special mention must be made of the local consultants who led the process on the various specialised sections, namely:

John Auguste - Greenhouse Gas Inventory, Energy Sector and Mitigation Analysis
Christopher Joseph - Greenhouse Gas Inventory, Non-Energy Sector
Dr. Everson Peters – Vulnerability and Adaptation Analysis
Dr. Linus Spencer-Thomas – Socio-Economic Analysis and Scenario

They were ably supported by the other members of the technical team, in the persons of:

Robert Alexis – Ministry of Legal Affairs
Michael Mason – Land Use Division, Ministry of Agriculture
Fabian Purcell – Physical Planning Unit, Ministry of Finance
Trevor Thompson – Land Use Division, Ministry of Agriculture
Terrence Smith – TP Engineering

The participation of the numerous stakeholders from the various economic sectors, government ministries, non-governmental agencies, community-based organisations and funding agencies, was critical to the success of the process. These stakeholders contributed documentation and data when requested and participated in the many initiation, validation and review workshops that were an integral part of the process. The role of the Sustainable Development Committee in monitoring progress on a monthly basis is worthy of special mention.

The support of the Permanent Secretary and Staff of the Ministry of Finance was highly appreciated throughout the process, especially that of Joslyn Paul, Climate Change Focal Point. Special credit must be given to the contribution of the Administrative Officer, Ivy Bain. She was the thread that held the process together over the entire period.

Notwithstanding the wide range of inputs into the process, the responsibility for this final output rests with the National Coordinator and any errors and omissions thereof is not to be attributed to the other participants in the process.

Leon Charles
National Coordinator
Initial Communication Project, Grenada

ACRONYMS AND ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
ART	Agency of Rural Transformation
CC	Climate Change
CET	Common External Tariff
CFC	Chlorofluorocarbon
CH_4	Methane
CMI	Caribbean Meteorological Institute
CO	Carbon Monoxide
CO^2	Carbon Dioxide
CPACC	Caribbean Planning for Adaptation to Global Climate Change
EC$	Eastern Caribbean dollar
GAC	Grenada Agricultural Census
GCM	General Circulation Model
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GHG	Greenhouse Gases
Gg	Gigagrams
GIS	Geographic Information System
GOG	Government of Grenada
GRENCODA	Grenada Community Development Agency
GRENLEC	Grenada Electricity Services Limited
Ha	Hectares
HFC	Hydroflourocarbon
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IPCC-IS92a-c	Intergovernmental Panel on Climate Change Climate Scenarios
IPM	Integrated Pest Management
Km	Kilometre
Lbs	pounds
MOA	Ministry of Agriculture
MOH	Ministry of Health
MOF	Ministry of Finance
MTESP	Medium Term Economic Strategy Paper
NAWASA	National Water and Sewage Authority
NO_X	Nitrogen Oxides
N_2O	Nitrous Oxide
NMVOC	Non-methane Volatile Organic Compounds
OECS	Organisation of Eastern Caribbean States
OTH	OTH International
PSIA	Point Salines International Airport
PFC	Perflourocarbon
SF_6	Sulphurhexaflouride
SIDS	Small Island Developing States
SLR	Sea Level Rise
SO_X	Sulphur Oxides
SST	Sea Surface Temperature

UNESCO	United Nations Educational Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
V&A	Vulnerability and Adaptation
US$	United States dollars
WHO	World Health Organisation

EXECUTIVE SUMMARY

This Initial Communication was prepared in fulfillment of Grenada's commitments under the United Nations Framework Convention on Climate Change (UNFCCC). The preparatory process involved a series of consultation meetings and peer reviews by a wide range of stakeholders, aimed at validating the results of the technical analyses and providing inputs into the recommended strategies and actions.

The Initial Communication consists of:

- A description of National Circumstances;
- An Inventory of emissions of greenhouse gases by sources;
- A initial analysis of Grenada's vulnerability to the adverse impacts of climate change;
- Proposed national measures aimed at fulfilling Grenada's commitments under the UNFCCC. Some of these measures will be eligible for financing under the Global Environment Facility (GEF).

1. NATIONAL CIRCUMSTANCES

The independent State of Grenada consists of the islands of Grenada, Carriacou and Petit Martinique is located at 11° 58′ North latitude and 61° 20′ west longitude and lies between Trinidad and Tobago to the south and St. Vincent and the Grenadines to the north. It is the southernmost of the Windward Islands.

Fig 1: The Tri-Island State

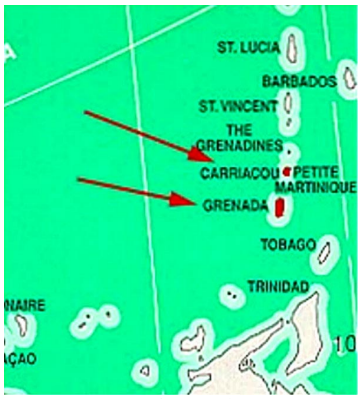


Fig 2. Location of Grenada

The island is internationally renowned as the Isle of Spice and as the home of the world famous Grand Anse beach.

It was a British colony until 1974, when it became an independent state. It has retained a parliamentary democracy system of government within the Commonwealth, with the British monarch as head of state represented by a Governor General.

1.1. GEOMORPHOLOGY

The Island of Grenada is 34 km (21 miles) long and 18km (12 miles) wide and the three islands taken together have a land area of 345 sq. km (133 sq. miles).

Generally, the country is characterised by mountainous terrain ringed by extensive coral reefs. The highest point, Mt. St. Catherine lies 833 meters above sea level. The other main peaks are Fedon Camp 767 meters, Mount Qua Qua 735 meters, Mount Lebanon 715 meters and Mount Sinai 701 meters. The highest points in Carriacou, High North and Mount Carre are both 291 meters.

The mountains rise steeply from the West Coast and descend more gently to the East Coast. Carriacou is characterized by a north to southwest mountain ridge.

On the islands of Grenada and Carriacou, approximately 77% and over 54% respectively of the land area has slopes exceeding 20°. Approximately 3% of the land area is at sea level and these include the main towns and many of the key socio-economic facilities.

1.2. COASTAL ECOSYSTEMS

There are a variety of coastal and marine resources in Grenada - coral reefs, sea grass beds and mangrove swamps, which have proven to be of crucial importance in the formation and sustenance of other resources as well as near-shore fisheries. The sea grass beds and mangrove wetlands are highly dependent on the presence of coral reefs (hydrodynamic barriers that dissipate wave energy) as it enhances the structure of the sea grass and mangrove communities.

1.3. CLIMATE

The country is characterized by humid tropical climate, with relatively constant temperatures throughout the year averaging 26 degrees centigrade. The mean maximum temperature is 31.4 degrees centigrade while the mean minimum is 24.0 degrees centigrade.

Over the last decade the annual rainfall ranged from 750 to 1400 mm. Two distinct rainfall patterns are evidenced. The dry season typically runs from January to May and the rainy season from June to December. Carriacou and Petit Martinique generally receive lower levels of rainfall and during the dry season can experience severe drought conditions.

Grenada lies in the path of the North East Trade Winds and although located south of the hurricane belt, the country is vulnerable to tropical storms, occasional hurricanes and storm surges. The hurricane season runs from June to November and Grenada was last hit by a major hurricane in 1955 (Hurricane Janet), which brought very extensive damage and resulted in the loss of over one hundred (100) lives.

In 1999, the first major storm surge, as a consequence of Hurricane Lenny, caused severe infrastructural damage to the West Coast of the Islands and to Carriacou and Petit Martinique. In the intervening years, occasional storm damage has been experienced.

Photo 1: Hurricane Lenny Storm Surge

1.4. THE ECONOMY

In 1994, the Grenadian economy was based on agriculture and tourism. This began to change in the 1995 – 1998 period, as the Government pursued a strategy of economic diversification, based on consolidation of the existing sectors and the development of new ones – financial services and informatics.

Grenada's gross domestic product was US$189.2M, with the main contributors being Transport, Wholesale and Retail trade, Agriculture, Communications, Hotels and Restaurants, Banks and Insurance and Construction.

This represented a GDP growth of 3.33% and followed two years of poor growth – 1.10% in 1992 and -1.22% in 1993.

Table 1 – National Circumstances

CRITERIA	1994
Population	97,793
Relevant areas (square kilometers)	345
GDP (1994 US$)	189.2M
GDP per capita (1994 US$)	1,935
Estimated share of the informal sector in the economy in GDP (percentage)	not applicable
Share of industry in GDP (percentage)	7
Share of services in GDP (percentage)	50
Share of agriculture in GDP (percentage)	11
Land area used for agricultural purposes	30,365 ac.
Urban population as percentage of total population	11
Livestock population - **Cattle** - **Sheep** - **Goats** - **Pigs** - **Chickens**	 4368 13,052 7,004 5,338 81,688
Forest area	7,300 ac.
Population in absolute poverty	n.a.
Life expectancy at birth (years) - **Male** - **Female**	 69 72
Literacy rate	95%

1.5. SOCIO-ECONOMIC CONTEXT

1.5.1. Population

The last population census conducted in 1991 reported that 95,945 persons were resident in the country. Estimates by the Central Statistical Office (CSO) put the 1994 population at 97,793.

The population was fairly evenly distributed along gender lines, with 50 percent being males and 50 percent females in 1991.

The age distribution showed that 47 percent were less than 20 years old and 16 percent were 50 years and over.

The geographical distribution showed areas of dense population concentrations within the various parishes. 11 percent of the population lived in the five main towns, while 89 percent lived in villages and rural communities. 5.1 percent lived in the capital city, St. George's and 1.8 percent lived in the second largest town, Grenville.

1.5.2. Poverty

There was no official poverty data available for 1994. The per capita income was US$1,935.

1.5.3. Health

The main health indicators for 1994 are listed in **Table 2** and shows that Grenada has made progress in most of the critical areas.

1.5.4. Life Expectancy

The life expectancy was 69 years among males and 72 years among females.

Table 2 – Key Health Indicators

CRITERIA	
Immunization Coverage (%):	
▪ DPT	91
▪ Polio	84
▪ Measles/MMR	87
Infant Mortality Rate (per 1000 live births)	14.6
Neonatal Mortality (per 1000 live births)	9.8
Perinatal Mortality (per 1000 live births)	8.9
<5 Mortality Rate (per 1000 live births)	0.6
% Pregnant Women (15 – 49) with anemia	14.5
% Births attended by trained persons	99.5
% Low Birth Weight Infants	10
Maternal mortality per 1000 deliveries	Nil
Incidence of malaria per 1000 population	Nil
Incidence of dengue per 1000 population	0.11
Incidence of TB per 1000 population	0.01
Incidence of AIDS per 1000 population	0.07

Source: Ministry of Health

1.5.5. Education

Grenada's education system provides services for children from six months onwards. Compulsory education begins at age five and ends at age sixteen, but both private and government facilities provide day care services for children from six months, pre-school services for children from 3 years, primary school services for children from age 5 and secondary school services for children from ten years.

Despite the provision of services, there are insufficient school places for the entire age cohorts in each grouping and in 1994, the gross enrolment ratios[1] at the various educational levels were:

- Day Care – 3%
- Pre-school – 79%
- Primary – 129%

1.5.6. Literacy - The official literacy rate is 95% (Central Statistical Office).

[1] Number of children enrolled as a percentage of applicable age cohort in country

2. GREENHOUSE GAS INVENTORY

The ultimate objective of the United Nations Framework Convention on Climate Change (UNFCCC) is the *"... stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."*[2] To this end, all Parties to the Convention have undertaken to *"develop, periodically update, publish and make available to the Conference of Parties ... national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies agreed upon by the Conference of Parties"*[3]

The Grenada inventory of greenhouse gas emissions and removals by sinks have been calculated for the base year 1994 using the Revised Intergovernmental Panel on Climate Change (IPCC) Guidelines (1996) for National Greenhouse Gas Inventories.

Table 3 provides a national summary of the Greenhouse Gas Inventory, with the data disaggregated on a sectoral basis.

Table 3 - Initial National Greenhouse Gas Inventories Of Anthropogenic Emissions By Sources And Removals By Sinks Of All Greenhouse Gases Not Controlled By The Montreal Protocol - 1994

Greenhouse Gas Source and Sink Categories	**CO_2**	**CH_4**	**N_2O**
Total (Net) National Emission (Gigagram per year)			
1. All Energy			
Fuel combustion	135	0.02	0.002
Energy and transformation industries	62		
Industry	4		
Transport	52		
Commercial-institutional	6		
Residential	10		
Other (Agriculture, Forestry and Fisheries)	1		
Biomass burned for energy	n.e.		
Fugitive Fuel Emission			
Oil and natural gas systems	n.a		
Coal mining	n.a		
2. Industrial Processes			
3. Agriculture			
Enteric Fermentation		0.00324	
Manure Management		0.00106	
Solid Waste Disposal		70	
Agricultural Soils			0.00108
4. Land Use Change and Forestry			
Changes in Forest and other woody biomass stock	(92)		
Forest and Grassland Conversion			
Abandonment of Managed Lands			
5. Other Sources as appropriate and to the extent possible (please specify)			

Notes: n.a. – not applicable; n.e – not estimated

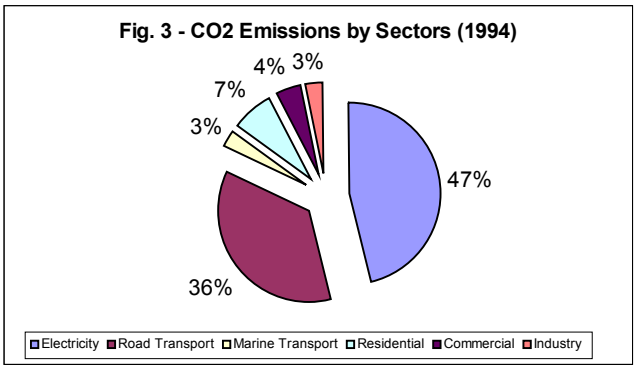
[2] UNFCCC, Article 1

[3] UNFCCC, Article 4.1 (a)

2.1. PRIMARY EMISSION SOURCES

2.1.1. Carbon Dioxide

The analyses showed that Grenada emitted 135 Gg of carbon dioxide in 1994. This is equivalent to 1.38 tonnes of carbon dioxide per capita.



The key sources of these carbon dioxide emissions from the energy sector were from the combustion of liquid fossil fuel type, consisting of gasoline, jet kerosene, diesel oil, liquefied petroleum products (LPG), and lubricants. CO2 emissions from fossil fuel, account for 100% of total emissions of carbon dioxide and 95.2 % of all greenhouse gases.

On a sectoral basis, the main emissions sources, highlighted in **Fig. 3,** were as follows:

- **Power/Electricity Sector -** Grenada has one national electricity company, *Grenada Electricity Services Limited* (referred to as **GRENLEC**), which supplies electricity throughout the State of Grenada. **GRENLEC** is presently a privately owned company. Electricity generation accounts for approximately 47% of the total domestic supply of secondary energy. The resulting CO_2 emissions from this activity were 62 Gg, and represented 47% of total CO_2 emissions.

- **Road Transport** - This sector was responsible for 47.86Gg of CO_2 emissions, which represented 35.8% of total CO_2 emissions, and 34 % of total GHG emissions. This sector is privately owned and operated.

- **Marine Transport -** The Marine transportation sub-sector represented 4.6% of the total sectoral energy consumption, and produced 4.23Gg of CO_2 or 3.2% of total CO_2 emissions.

- **Manufacturing And Construction Industries -** CO_2 emissions from this sector accounted for 2.8% of the total emissions and were estimated at 4 Gg.

- **Residential, Institutional And Commercial Sectors -** The emissions from the above-mentioned sectors were estimated at 16.21Gg and accounted for 11 % of total CO_2 emissions.

- **Forest Reserves** – These emissions of carbon dioxide are mitigated by a 92 Gg carbon dioxide sink, composed mainly of a forest reserve of 7,300 ac. It must be noted that the acreage of forests used did not include non-forest trees, as the growth rate data necessary for the calculations were not available.

2.1.2. Other Greenhouse Gases

The only other significant emission of GHG in Grenada comes from the solid waste disposal landfill, which was estimated to emit 70 Gg of *methane* in 1994. The total emissions of methane were 71 Gg – 0.72 tonnes per capita.

Emissions of *non-methane volatile organic compounds (NMVOC's)* were estimated at 1 Gg, generated mainly by asphalt use and the production of rum, spirits, alcoholic beverages and other food production.

There were also small quantities of nitrous oxide emissions from the use of artificial fertilizers and the cultivation of leguminous crops.

Emission estimates for Oxides of Nitrogen (NO_x), Carbon Monoxide (CO), Sulphur Dioxide (SO_2), Sulphurhexafluoride (SF_6), Hydrofluorocarbons (HFC^s), and Perfluorocarbons (PFC^s) were not calculated for the following reasons:

- The emitting activities addressed in the 1996 Revised IPCC guidelines, are not relevant to Grenada.

- For SF_6, HFC^s, and PFC^s, imports of products containing these have only recently started.

- Chlorofluorocarbons (CFC^s) are still being used, but calculations for such were not considered in this exercise, since these substances are being addressed by the Montreal Protocol.

2.1.3 ACTIONS FOR IMPROVING COMPILATION OF GHG INVENTORIES

In order to improve the quality of future GHG inventories, Grenada intends to take the following actions:

- Initiate appropriate measures to ensure that the information gaps identified are filled with the relevant and updated information/data. This could be achieved by the improvement of existing databases at the Customs & Excise Department, the Central Statistical Office and the Inland & Revenue Departments.

- Assess the options for capturing annual production and consumption data on primary fuels (firewood, charcoal, coconut and nutmeg shells, sugar cane products, and the like).

  This assessment can be done by the Energy Unit, Ministry of Communications, Works & Public Utilities, working along with the Ministry of Finance (Central Statistics Department) and the Ministry of Agriculture. This can include a survey to determine with greater accuracy the levels of fuel wood and charcoal consumption, and the impact that this is having on Grenada's natural forest reserves.

- Collaborate with other regional countries in the development of emissions factors for activities that emit greenhouse gases, which will more accurately reflect the practices in the region. This will include a review of emissions factors for activities

already reported in this initial inventory, as well as the development of emissions factors for activities not included in this initial inventory.

3. VULNERABILITY ANALYSIS

The National Vulnerability Statement assesses what is currently known about Grenada's vulnerability to the effects of climate change (rising temperatures, sea level rise and increase in extreme events), identifies existing gaps in the available information and makes recommendations on how such information gaps can be addressed.

As Vulnerability and Adaptation (V&A) analysis is a continuous process, it is anticipated that the quality of data would improve with time and that this statement would be complemented in the future by more informed analysis.

3.1. CLIMATE CHANGE SCENARIOS FOR GRENADA

Climate change is a threat to mankind. Although no one is certain about the future effects or severity of climate change, there is conclusive evidence of four (4) changes, viz:

- an increase in temperature,
- an increase in CO_2 concentration,
- a rise in sea level, and
- an increase in the frequency and severity of extreme events.

There are no specific climate change scenarios available for Grenada and pending more accurate regional data on variation in climate, and a consensus on a regional climate change scenario, the scenarios adopted for temperature changes and sea level rise are based on the IPCC (1995) accepted and recommended scenarios i.e. temperature rise of 1.0°C to 3.5°C and sea level rise of 15 cm to 95cm by 2100.

In addition, mean global precipitation is predicted to increase by 3% to 7% by the year 2100 using 8 GCMs with IS92a forcing scenarios. This synthetic scenario is used in the absence of more data being available.

In the case of Grenada, a positive or negative variation of 5% to 20% in total precipitation by the year 2100 may be considered. Shrivastava (1997) reported that annual precipitation would increase by approximately 6% in the Western Caribbean and decrease by 4% in the Eastern Caribbean. Wetter wet seasons and severer and longer droughts during the dry seasons are predicted.

An increase in the frequency of extreme events may also be experienced. It is predicted that by the year 2100, there will be a 5 to 10 percent increase in the wind speeds of tropical storms worldwide for a Sea Surface Temperature increase of 2.2 °C (Knutson et al. 1998)

These projected changes are expected to be updated in time, with improvements in models and increased understanding of the science.

3.2. POTENTIAL EFFECTS OF CLIMATE CHANGE (CC)

This analysis of the potential impact of Climate Change in Grenada is constrained by two factors, viz:

- Firstly, there is uncertainty about the interaction of all the global processes - natural and man-made - and the socioeconomic dynamics.

- Secondly, the data sets necessary for rigorous analysis, through simulations of the natural processes are incomplete and therefore restricts how the extent to which the results from initial analyses may be interpreted.

This means that efforts would be needed to begin the collection of as much of the baseline data as possible, in order to improve future analyses to guide national planning and development.

3.2.1. Impact on Water Resources

(a) Water Availability

Shrivastava (1997) reported that *annual precipitation would increase by approximately 6% in the Western Caribbean and decrease by 4% in the Eastern Caribbean. Wetter wet seasons and severer and longer droughts during the dry seasons are predicted.*

Increased temperatures and reduced precipitation would lead to enhanced evapotranspiration and lower surface runoff, reduced mean available soil-water, reduced rates of groundwater recharge and reduced opportunities for filling of rainwater cisterns in Carriacou. To sustain adequate soil-water and groundwater recharge water conservation techniques would have to be strengthened.

(b) Water Quality

Saltwater intrusion from sea level rise would reduce the available groundwater on the main island Grenada. In Carriacou and Petit Martinique, where the 27 major open wells are within 100m of the shoreline, high salinity would lead to abandonment of such traditional wells.

3.2.2. Impact on Agriculture and Fisheries

(a) Agriculture

The impact of global climate change on agriculture has been studied extensively for various crops at many different scales. However, studies on the major crops of Grenada - nutmeg, cocoa, bananas and spices are not available.

The impact of the combined elements of climate change on agriculture, especially tropical crops is not quite clear but would be complicated by other socioeconomic activities such as commodity prices, labour availability and labour cost.

(i) Crop production

Agricultural crop production would be influenced by changes in soil moisture for bananas, cocoa and nutmeg. Higher temperatures would increase evapotranspiration, while CO_2 enrichment could boost productivity in C3 plants. This includes tree-crops (nutmegs and

cocoa), cassava, maize, yams, bananas, coconut, sweet potatoes, pigeon peas, and beans (Wittwer 1992). Greenhouse-grown type vegetables can produce large fruit size, and larger fruit numbers and can show yield increases of 10 to 70% (Wittwer 1992).

Nonetheless, the impact of climate change with reduced annual rainfall by itself would be negative on crop yield. For example, both nutmeg and banana production are positively correlated to annual precipitation.

In the case of a 10% to 20% reduction in precipitation, banana production - now mostly rainfed - would require irrigation schemes for sustainability. The effect of increased temperatures would further exacerbate the situation through increased evapotranspiration and reduced soil water.

The extent to which carbon dioxide enhancement and natural plant adaptation would dampen these effects are not known and should be researched.

(ii) Livestock

Carriacou accounts for 30% of the total livestock population of Grenada. Livestock production in Carriacou is most vulnerable to weather conditions since it experiences less rainfall than anywhere else in Grenada during drought conditions. Past experiences have demonstrated this susceptibility, as losses in some extreme events like the droughts of 1984 and 1992 caused stock losses of 20% to 40% respectively. Recovery from these losses can take many years.

(iii) Fisheries

There are no available studies, published or unpublished, on fish production and climate in Grenada. However the breeding ground of 17 of the main species of demersals, which provides about 43% of the total fish catch in Grenada, may be negatively affected where mangroves, reefs and other mud banks are affected by climate change and sea level rise.

Preliminary analysis of data provided by the Fisheries Division, Ministry of Agriculture showed a relationship between fish production and the El Nino phenomenon. In the year preceding El Nino (the 4 strongest El Ninos since 1980 were 1982/83, 1986/87, 1991/92 and 1997/98) fish production was reduced by 25% to 60% of the average. Similarly at the onset of La Nina production was 30% to 50% higher.

During 1999, algae bloom caused significant demersal "fish kill" creating a scarcity of the domestic supply of fish. This algae bloom was associated with environmental changes, including warmer sea temperatures and turbidity and enhanced eutrification from continental flushout due to heavy rainfall. During the 3 months of the "fish kill", fisher-folk who fall into the lower socioeconomic strata were unemployed for 3 to 4 months. The overall lost earnings for these people and the cost to government in the form of financial support are unpublished but are expected to be significant.

3.2.3. Impact on the Coastal Zone

Grenada has been selected as one of the pilot sites for the Coastal Zone Vulnerability and Adaptation Component of the CPACC Project. The results of this pilot project are not yet available and, when available, will further inform the analysis in this section.

The preliminary results however indicate that there could be serious adverse impacts on coastal communities and infrastructure, from flooding and inundation, especially during storm surges. The experience of Hurricane Lenny in 1999 is instructive in this respect. There is also significant potential for salt water intrusion into the water supply in Carriacou.

Some parts of the main commercial center of St. George's (e.g. the Carenage, Melville Street) and the tourist areas in the southwest peninsula are also susceptible to flooding during periods of high seas and heavy precipitation. Serious disruption of social and economic life in these areas could be expected to occur as a result of sea level rise.

Coastal erosion from sea level rise and extreme events would also disrupt coastal villages like Gouyave, Grand Mal, Duquesne, Soubise and Marquis.

Roads through these communities and other unsettled areas (e.g. Airport road, Carriacou, and a number of sections of roads on the Western Coast) are practically at sea level and below sea level in some cases. These roads could experience flooding, become impassable during high tides and experience severe damage during storm surges.

(b) Beach Erosion

The earliest *Beach Monitoring* in Grenada dates back to 1985 with a coastal monitoring programme in response to severe erosion problems identified in Grand Anse and other beaches (Cambers 1996). Early studies showed that the erosion had greater seasonal variation (up to 34% beach profile area) than long-term variation (up to 10.5% beach profile area), particularly in the West Coast. For Grand Anse, annual erosion was about 11% during 1984 to 1986.

Application of the Bruun rule to beach erosion analysis shows that for a 50 cm rise in sea level, up to 60% of Grenada's beaches would disappear in some areas (Peters, 2000). These beaches include Grand Anse, Morne Rouge, Harvey Vale and Paradise all of which are important tourist attractions.

(c) Sandy Islands And Reefs

Sandy Island, White Island and a number of Keys, which are one to two meters above sea level, could be wiped out as a result of submergence during storm surges**.** In the past 25 years, Sandy Island on the west coast of Carriacou, has lost about 60% of its area, while small sand banks that existed for hundreds of years between Carriacou and Petite Martinique have disappeared completely.

3.2.4. Tourism

The impact of climate change and sea level rise on tourism would be mostly indirect. As climate in the higher latitudes would be milder, Grenada could be a less desirable climate-influenced destination.

Another possible negative impact on tourism could be the loss of beaches, or the deterioration of the beaches due to erosion from natural phenomena and/or climate change. Water sports, which is currently a rapidly growing sub-sector of tourism, would become less attractive in the absence of quality beaches.

Higher temperatures would increase the operating costs of hotels, as there would be greater per capita water consumption and power consumption for air conditioning. A good analogue of the impact of temperature rise on power consumption can be seen in the annual variation of mean temperature and power usage.

An analysis of the historic power and temperature data for a small tourism plant shows that for a 1.1°C variation in average monthly temperature, there is 25% variation in power consumption. July to September 1999, was one such period on record, with a 0.9°C above average temperature causing an 11% increase in power consumption.

3.2.5. Human Health

The major effects of climate change on global human health are caused by heat stress, air pollution, alterations in the incidence of communicable diseases, under-nutrition and inundation. (WHO 1990). The ability to assess the human health impacts of climate change is at a very early stage of development (Balbus et al, 1998), with the impact being more complex than on other sectors.

In Grenada the main effect is likely to be caused by the increased incidence of vector-borne communicable diseases for which the vectors are currently resident, or are likely to be imported. Respiratory diseases associated with regional dust storms during the hurricane seasons are also likely.

Preliminary analysis of the three most common diseases, influenza, viral conjunctivitis and gastro enteritis shows correlation between annual and July precipitation and these diseases. Significant positive correlations are observed for the incidence of viral conjunctivitis and influenza and August precipitation - R=0.70 and R=0.62 respectively. **This is an area where further research is required.**

4. INSTITUTIONAL ARRANGEMENTS

4.1. ENVIRONMENTAL MANAGEMENT

The current approach to Environmental management in Grenada is sectoral in nature. The Ministry of Health and the Environment has the primary responsibility for the environment along with some twenty agencies, inclusive of Government departments, non-governmental organisations (NGOs) and statutory bodies (Physical Planning Unit – Draft Sectoral Report on the Environment, 2000).

4.2. LEGISLATIVE FRAMEWORK

The legislative framework for environmental management reflects the fragmentation of the institutional framework. A review of the environmental legislation in Grenada (Alexis, 2000) concluded that "… most of the laws … are sectoral and decentralized … while they have environmental application, they were not legislated to address those concerns and are mainly incidental to environmental management."

The review cites forty-nine (49) separate pieces of legislation that are applicable to one or more of the issues related to Climate Change and that can be applied in the context of climate change.

4.3. POLICY FRAMEWORK

There is no coordinated policy framework for the management of the environment in Grenada. Even in cases where there is clear sectoral responsibility, clear-cut policy frameworks are few and far apart.

A small number of initiatives to remedy this situation has been initiated since 1994, the most significant being the institutionalization of the Grenada Solid Waste Management Authority in 1996 and the development of a Forestry Policy and Strategic Plan in the 1997 – 2000 Period. The elaboration of a Biodiversity Strategy and Action Plan in 2000 has also been a significant development in this regard.

4.4. INITIAL COMMUNICATIONS PROJECT

The Initial Communications Project is managed at the local level by the same Steering Committee that is responsible for the CPACC Project. The day-to-day project activities are managed by a National Coordinator and Administrative Officer, specifically contracted by the Project. Consultants were subcontracted for the Sectoral analyses required by the Project and these were supervised and coordinated by the National Coordinator.

5. NATIONAL RESPONSE MEASURES

The national response measures described in this section are based on the foregoing analyses of greenhouse emissions and vulnerability to climate change impacts, in the context of the projections for the socio-economic development of Grenada into the medium term.

The measures recognise the critical need for Grenada to expedite the analysis and implementation of its options to adapt to the adverse impacts of climate change, while fulfilling its obligations under the Convention to reduce greenhouse gas emissions.

They represent a mix of strategies and actions that will be kept under constant review and will be revised and adapted based on evolving circumstances in each of the relevant sectors and in the overall scenario of climate change.

A wide range of policies and measures are proposed in the Initial Communication, a number of which have been prioritized for immediate action. The focus of the short list is to establish the institutional framework for a sustainable approach to addressing climate

change at the national level. It is not a restrictive listing, but rather, an indicative outline of the approach that Grenada intends to pursue.

5.1. PRIORITY ACTIONS

The proposed short list of priorities is:

1. *Strengthening of the Institutional Framework*. This will include:

    - the establishment of a coordination mechanism for environmental management, including climate change;
    - the strengthening of the legal frameworks, including the Building Code to provide for management of climate change issues;
    - the development of a policy framework on climate change with full stakeholder participation; and
    - the strengthening of the technical capacity within the country to address climate change issues, through training of appropriate personnel.

2. *Strengthening of the data collection and monitoring systems to facilitate the collection and analysis of data relevant to climate change*. This will be applicable to all sectors of the economy that are sensitive to the impacts of climate change.

3. *The development and implementation of a National Energy Plan*, with emphasis on increased *energy efficiency* and the use of *renewable technologies*.

4. The provision of *tariff and fiscal incentives* for the use of *renewable technologies*.

5. The development of *national standards for vehicle and industrial emissions*, minimum efficiency ratings on domestic appliances and industrial equipment, as well as a mechanism for ensuring the implementation of these standards.

6. The implementation of the Solid Waste Authority's plans aimed at *reducing the volume of waste* that has to be accommodated in the landfill.

7. The elaboration and implementation of a *Land Use Policy*.

8. The implementation of the *Forestry Policy*.

9. Initiation of *research into flood control technologies* that can be used in the flood prone areas.

10. *Compulsory inclusion of climate change considerations into all national projects being developed in the sensitive sectors*. The climate change considerations will be a component of the Environmental Impact Assessments which will be required for these projects.

11. *Public Awareness and Education on the climate change in general and the role of the individual in mitigating and adapting to climate change*. These programs will be done in conjunction with all the sensitive sectors – water, health, energy use, coastal zone management. The activities will include:

- General public education programs
- In-community education and mobilization
- Inclusion of Climate Change into the social studies and science curricula at the primary and secondary levels.

12. *Continuation of the analysis of Grenada's vulnerability to the adverse impacts of climate change with the objective of informing policy response measures*. This will include:

    - completion of the coastal vulnerability analysis being conducted under the regional CPACC project and implementation of the recommendations;

    - strengthening of systematic monitoring and observation systems e.g. monitoring the actual sea level rise that is being experienced;

    - participation in the development of climate change scenarios, impact models and methodologies relevant to Grenada and the Caribbean, that will facilitate better understanding of the potential impacts of climate change;

    - data collection and analysis aimed at closing the information gaps and improving the understanding of the identified impacts of climate change;

    - improving the accuracy of Grenada's greenhouse gas inventories through the development of local emission factors for activities that are generic to Grenada and the Caribbean.

13. *Strengthen Grenada's participation in the UNFCCC negotiation process*, in order to strengthen the developing country lobby for the provision of resources to cope with the adverse impacts of climate change.

5.2. FINANCING

The small size of Grenada's economy makes it impossible to generate the necessary financing from internal resources in order to respond to the threat of climate change.

The Convention on Climate Change in Article 4.3. specifies that *"The developed country parties and other developed Parties included in Annex II shall provide new and additional financial resources to meet the agreed full costs incurred by developing country Parties in complying with their obligations under Article 12, paragraph 1*[4]*. They shall also provide such financial resources, including for the transfer of technology, needed by the developing country Parties to meet the agreed full incremental costs of implementing measures …".*

Grenada will therefore rely heavily on this commitment by its international partners in order to access financing to meet the costs of responding to climate change. In this regard, it must be noted that the Conference of Parties has made various decisions regarding the provision of resources to developing countries.

[4] This Article refers to the preparation of National Communications

Grenada intends to access these resources as a matter of priority in order to commence the development and implementation of its climate change action plan.

1. NATIONAL CIRCUMSTANCES (1994)

The independent State of Grenada consisting of the islands of Grenada, Carriacou and Petite Martinique, is located at 11° 58′ north latitude and 61° 20′ west longitude and lies between Trinidad and Tobago to the south and St. Vincent and the Grenadines to the north. It is the southernmost of the Windward Islands.

Fig 1: The Tri-Island State

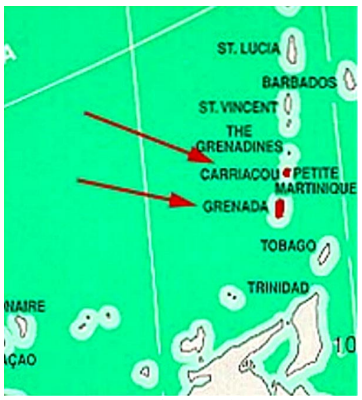


Fig 2: Location of Grenada

The island is internationally renowned as the Isle of Spice and as the home of the world famous Grand Anse beach.

It was a British colony until 1974, when it became an independent state. It has retained a parliamentary democracy system of government within the Commonwealth, with the British monarch as head of state represented by a Governor General.

1.1. GEOMORPHOLOGY

The Island of Grenada is 34 km (21 miles) long and 18km (12 miles) wide and the three islands taken together have a land area of 345 sq. km (133 sq. miles).

A notable feature of Grenada's geography is a well-defined system of watersheds which dissects the landscape resulting in steep hilly topography almost everywhere except in the southwest and north east where it grades in low hills. In the remainder of the country, these slopes end in cliffs of truncated headlands along an almost straight coastline.

Generally, the country is characterised by mountainous terrain ringed by extensive coral reefs. The highest point, Mt. St. Catherine lies 833 meters above sea level. The other main peaks are Fedon Camp 767 meters; Mount Qua Qua 735 meters; Mount Lebanon 715 meters and Mount Sinai 701 meters. The highest points in Carriacou, High North and Mount Carre are both 291 meters.

The mountains rise steeply from the West Coast and descend more gently to the East Coast. Carriacou is characterized by a north to southwest mountain ridge.

On the islands of Grenada and Carriacou, approximately 77% and over 54% respectively of the land area have slopes exceeding 20°. Approximately 3% of the land area is at sea level and these include the main towns and many of the key socio-economic facilities.

The country is of volcanic origin as is evidenced by its pyroclastic rocks, soils and the presence of extinct volcanic craters. The Grand Etang Lake located in the Central Forest Reserve, Lake Antoine and Levera Pond located in the north of the main island are the best known examples of crater lakes on the island. The St. George's harbor and the adjacent lagoon have been reported to have responded violently to volcanic activity from neighboring islands.

There is an active underwater volcano Kick 'em Jenny located within 10 km of the north coast of Grenada and between the islands of Grenada and Carriacou. An eruption of the volcano can seriously threaten the islands with tsunamis and ash fall. Kick 'em Jenny is reported to be the most active underwater volcano in the region.

The island of Grenada has a total land mass of 65,463 acres. Of this, only 1,648 acres (2.5%) is suitable for agricultural utilisation with no limitations, although some of these acreages are already being utilised for other purposes – real estate and commercial. Another 1,470 acres (2.2%) is suitable with moderate limitations and a further 13,361 acres is suitable with strong limitations. The remaining 31,662 acres (74.9%) are not deemed suitable for agricultural use.

The 1995 Agricultural Census concluded that the acreage being cultivated in 1995 was 30,360 acres - 46% of the land acreage – with an additional 7,300 acres under permanent forest.

1.2. COASTAL ECOSYSTEMS

The coastal ecosystems protect the terrestrial communities from natural disasters. They are of significant economic importance especially for the fisheries and tourism sectors, which are highly dependent on the coastal marine resources.

Although there are a variety of coastal and marine resources in Grenada, coral reefs, sea grass beds and mangrove swamps have proven to be of crucial importance in the formation and sustenance of other resources as well as near-shore fisheries. The reduction of water energy, sediment relationships and flow regulation are all important for the sustainability of these ecosystems. The sea grass beds and mangrove wetlands are highly dependent on the presence of coral reefs (hydrodynamic barriers that dissipate wave energy) as it enhances the structure of the sea grass and mangrove communities.

1.2.1. Mangrove and Other Wetlands

Mangrove and other wetlands develop in low energy areas. They are found along coastal areas and lagoons (transition between the river and the sea). Mangroves thrive in tropical and sub-tropical conditions and favour areas where there is a high deposition of silt (river mouth), sheltered lagoons, estuaries, and behind barriers such as coral reefs and cays, facing the open sea.

Photo 1: Wetlands at Conference Bay

In Grenada, mangrove wetland occurs mostly along the coast and occupies one hundred and ninety hectares (Bacon, 1991) of land space. Fringing forests mangrove occur in sheltered areas and in steeper shores along the coastline such as the southern coast of Grenada (e.g. Woburn, Mt. Hartman) while Riverine stands occur along river banks, being more successful where there is saline water. Areas where these types of mangroves occur are mostly on the east coast of the island.

The mangroves in Grenada are located in Levera Pond, Conference Bay, La Sagesse, Woburn Bay, Westerhall Bay, Watering Bay, Petit Carenage, Tyrell Bay and Saline Island. The dominant species are the red mangrove, the black mangrove, white mangrove and the button wood mangrove.

Mangrove wetlands have various functions. These include:

- Filtering and cleaning surface runoff prior to release in the coastal environment;
- The timely release of fresh water into the marine environment (important for coral reefs);
- Serving as a nursery for marine species;
- Being a habitat for local and migrant wildlife and fish population;
- Protecting and stabilising the shoreline;
- Providing materials for a variety of uses - for example, fish pots, jetty, red mangroves provide dye;
- A source of livelihood for rural poor;
- Essential sustenance system for people who depend on charcoal;
- Eco-tourism.

1.2.2. Coral Reefs

Coral reefs are one of the most productive ecosystems in the world, and grow at a rate of 20 – 40 cm / 100 years. It is a very complex ecosystem and has a high biodiversity. Its main structure, calcium carbonate ($CaCo_2$) is the largest of its kind, but covers only a tiny portion of the ocean floors – 0.2 percent, while accommodating up to three thousand (3000) marine species.

Photo 2: Northern Beach Protected by Coral Reef

There are three types of coral reefs in Grenada.

These occur primarily on the northern, eastern and southern seacoast of the island of Grenada and on the east coast of Carriacou and Petit Martinique. The fringing reefs are located on the east coast. They are usually an extension of the land and are found mostly in shallow water. The barrier reefs are also found along the east coast, but are mostly offshore while the patch reefs are found in patches in the sea.

The reefs in Carriacou and Petit Martinique are strongly dominated by Elkhorn coral in shallow and well-developed bridles coral in the deeper floor (ECNAMP, 1980).

Coral reefs have diverse functions that include:

- The production of sand for sandy beaches
- Protection of the shoreline
- A habitat for a variety of species such as lobsters, fishes and shrimps
- Eco-tourism

The last two decades have shown significant degradation of the coral reefs due to diseases, sedimentation from inland erosion and coastal development, pollution, bleaching and the loss of sea grazers.

1.2.3. Sea Grass Beds

Sea grass beds are areas of high productivity that thrive in low energy areas in shallow waters. In this area there is silt deposition, and this resource also produces sediments (sand). There are basically two types of sea grass – the turtle grass and the manatee grass.

The sea grass beds in Grenada are in abundance and are healthy. They are very important as a:

- Nursery for a variety of small fishes;
- Feeding ground for various species;
- Source of oxygen; and
- Habitat for most small sea creatures.

1.2.4. Beaches

Beaches are dynamic ecosystems. In Grenada there are the Stony (Pearls and Victoria beaches at certain times of the year) and the Sandy beaches, the latter being the more aesthetically pleasing.

Beaches perform a number of other functions, *inter alia*:

- Protection of the coastal areas from wave action, especially during hurricanes;
- Provision of habitats for animals and nesting sites for sea turtles;
- A location for social and recreational activities;
- An attraction for tourists.

A number of beaches e.g. Telescope and Pearls on the east coast, have also been used as a source of fine aggregate for construction.

1.3. CLIMATE

The country is characterized by a humid tropical climate, with relatively constant temperatures throughout the year averaging 26 degrees centigrade. The mean maximum temperature is 31.4 degrees centigrade while the mean minimum is 24.0 degrees centigrade.

Over the last decade the annual rainfall ranged from 750 to 1400 mm. Two distinct rainfall patterns are evidenced. The dry season typically runs from January to May and the rainy season from June to December. Carriacou and Petit Martinique generally receive lower levels of rainfall and during the dry season can experience severe drought conditions.

Grenada lies in the path of the North East Trade Winds and although located south of the hurricane belt, the country is vulnerable to tropical storms, occasional hurricanes and storm surges. The hurricane season runs from June to November and Grenada was last hit by a major hurricane in 1955 (Hurricane Janet), which brought very extensive damage and resulted in the loss of over one hundred (100) lives.

In 1999, the first major storm surge, as a consequence of Hurricane Lenny, caused severe infrastructural damage to the West Coast of the Islands and to Carriacou and Petit Martinique. In the intervening years, occasional storm damage has been experienced.

Photo 3: Hurricane Lenny Storm Surge

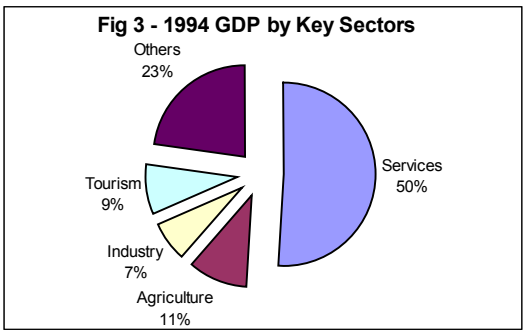
1.4. THE ECONOMY

In 1994, the Grenadian economy was based on agriculture and tourism.

This began to change in the 1995 – 1998 period, as the Government pursued a strategy of economic diversification, based on consolidation of the existing sectors and the development of new ones – financial services and informatics.

1.4.1. Gross Domestic Product

Grenada's gross domestic product was US$189.2M, with the main contributors being Transport, Wholesale and Retail trade, Agriculture, Communications, Hotels and Restaurants, Banks and Insurance and Construction – **Fig 3.**

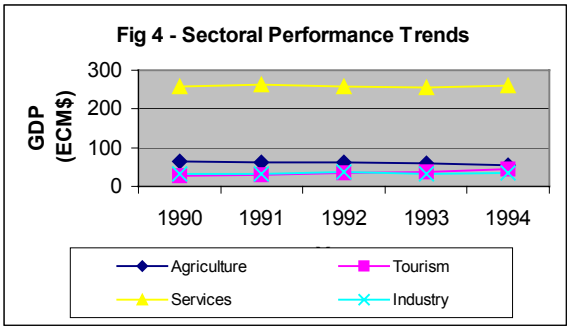


This represented a GDP growth of 3.33% and followed two years of poor growth – 1.10% in 1992 and -1.22% in 1993.

1.4.2. Sectoral Performance (Fig. 4)

(a) Agriculture

The Agricultural sector contributed 11% to GDP. The sector is dominated by tree crop agriculture geared to the export market with the principal crops being nutmegs and mace, cocoa and bananas.



The sector was in decline in 1994, having experienced consecutive years of negative growth since 1990. This decline was the largest for the decade of the nineties (– 6.16%).

Agriculture has historically been the base of the economy and although in decline, was still the second largest generator of foreign exchange to Grenada, as well as a significant source of employment and food for the local population.

(b) Tourism

Tourism, measured by the contribution of hotels and restaurants, contributed 9% to GDP. This was a rapidly growing sector, with positive growth rates of 9.21%, 17.29% and 2.25% for each of 1991, 1992 and 1993 respectively. The growth rate in 1994 was 25.5%.

(c) Services

This sector, comprised of government services, wholesale and retail trade, transportation services and financial services contributed 50% of GDP. With the exception of government services, which recorded negative growth rates for each of the preceding three years (-1.35% in 1991, -5.26% in 1992 and - 5.90% in 1993), all the other components of the service sector recorded positive growth for the preceding three years.

(d) Industry

The manufacturing sector contributed 7% of GDP. This sector grew by 7.5% , following a decline of 12.46% in 1993.

(e) Construction

The construction sector contributed 7% of GDP. It recorded a growth rate of 1.1% in that year, following a decline of 6.11% in 1992 and a positive growth of 4.5% in 1993.

(f) Communications

This sector contributed 10% of GDP. It recorded a growth rate of 7.36% in 1994, following three years of positive growth in the preceding three years – 21.94% (1991), 8.11% (1992) and 3.52% (1993).

Table 1 – National Circumstances

CRITERIA	1994
Population	97,793
Relevant areas (square kilometres)	345
GDP (1994 US$)	189.2M
GDP per capita (1994 US$)	1,935
Estimated share of the informal sector in the economy in GDP (percentage)	not applicable
Share of industry in GDP (percentage)	7
Share of services in GDP (percentage)	50
Share of agriculture in GDP (percentage)	11
Land area used for agricultural purposes	30,365 ac.
Urban population as percentage of total population	11
Livestock population - **Cattle** - **Sheep** - **Goats** - **Pigs** - **Chickens**	 4368 13,052 7,004 5,338 81,688
Forest area	7,300 ac.
Population in absolute poverty	n.a.
Life expectancy at birth (years) - **Male** - **Female**	 69 72
Literacy rate	95%

1.4.3. Macro-economic Indicators

(a) Employment

A Labour Force Survey conducted by the Central Statistical Office of the Ministry of Finance in 1994 reported an unemployment rate of 26.7%. Unemployment was highest among young people between the ages 16 - 24 and was proportionally higher among females.

(b) Inflation

The inflation rate, as measured by changes in the consumer price index, was 2.6%.

(c) Fiscal Operations

The fiscal outturn reflected a current revenue of US$170.3M and a current expenditure of US$169.5M, for a current balance of US$0.9M.

This was offset by capital expenditure of US$58.7, which was financed primarily by US$21.9M of grants, resulting in an overall public finance deficit if US$35.9M.

(d) Exchange Rates

Grenada shares a common currency with the rest of the Organisation of Eastern Caribbean States (OECS) - the Eastern Caribbean dollar (EC$). The EC exchange rate is set by the Eastern Caribbean Central Bank (ECCB) and has been pegged to the United States dollar (US$) at a rate of US$1.00 to EC$2.70, since 1983.

(e) Public Debt

The public debt outstanding was US$84.3M. The outstanding debt was 32.2% of the GDP, with the debt servicing obligations being 5.3% of the value of exports of goods and non-factor services.

1.5. THE SOCIO-ECONOMIC CONTEXT

1.5.1. Population

The last population census conducted in 1991 reported that 95,945 persons were resident in the country. Estimates by the Central Statistical Office (CSO) put the 1994 population at 97,793.

The population was fairly evenly distributed along gender lines, with 50 percent being males and 50 percent females in 1991.

The age distribution showed that 47 percent were less than 20 years old and 16 percent were 50 years and over.

The geographical distribution showed areas of dense population concentrations within the various parishes. The majority of the population was located in the parishes of St. George

and St. Andrew with over 30 percent of the population living in St. George and another 25 percent in St. Andrew. 11 percent of the population lived in the five main towns, while 89 percent lived in villages and rural communities. 5.1 percent lived in the capital city, St. George's and 1.8 percent lived in the second largest town, Grenville.

1.5.2. Social Indicators

(a) Poverty

There was no official poverty data available for 1994. The per capita income was US$1,935.

(b) Health

The main health indicators for 1994 are listed in **Table 2** and shows that Grenada has made progress in most of the critical areas.

(c) Life Expectancy

The life expectancy was 69 years among males and 72 years among females.

(d) Education

Grenada's education system provides services for children from six months onwards. Compulsory education begins at age five and ends at age sixteen, but both private and government facilities provide day care services for children from six months, pre-school services for children from 3 years, primary school services for children from age 5 and secondary school services for children from ten years.

Table 2 – Key Health Indicators

CRITERIA	
Immunization Coverage (%):	
▪ DPT	91
▪ Polio	84
▪ Measles/MMR	87
Infant Mortality Rate per 1000 live births	14.6
Neonatal Mortality per 1000 live births	9.8
Prenatal Mortality per 1000 live births	8.9
<5 Mortality Rate per 1000 Live Birth	0.6
% Pregnant Women (15 – 49) with anemia	14.5
% Births attended by trained persons	99.5
% Low Birth Weight Infants	10
Maternal mortality per 1000 deliveries	Nil
Incidence of malaria per 1000 population	Nil
Incidence of dengue per 1000 population	0.11
Incidence of TB per 1000 population	0.01
Incidence of AIDS per 1000 population	0.07

Source: Ministry of Health

Despite the provision of services, there are insufficient school places for the entire age cohorts in each grouping and in 1994, the gross enrolment ratios[1] at the various educational levels were:

- Day Care – 3%
- Pre-school – 79%
- Primary – 129%

(e) Literacy - The official literacy rate is 95% (Central Statistical Office).

[1] Number of children enrolled as a percentage of applicable age cohort in country

2. GREENHOUSE GAS INVENTORY

The ultimate objective of the United Nations Framework Convention on Climate Change (UNFCCC) is the *"... stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."*[2]

To this end, all Parties to the Convention have undertaken to *"develop, periodically update, publish and make available to the Conference of Parties ... national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies agreed upon by the Conference of Parties"*[3]

To this end, greenhouse gas emissions and removals by sinks have been calculated for the base year 1994 using the Revised Intergovernmental Panel on Climate Change (IPCC) Guidelines (1996) for National Greenhouse Gas Inventories.

2.1. METHODOLOGY

The greenhouse gas inventory (GHG) is a count of gas and particulate emissions affecting the composition of the atmosphere due to the relative increase of emissions such as CO_2, CO, SOx, NOx, and CH_4, due to human activities.

The methodology used in the calculation of the GHG inventories recognised the fact that some greenhouse gases are predominantly emitted by the energy sector e.g. carbon dioxide, and some primarily by the non-energy sector e.g. methane and nitrous oxide.

For the energy sector, two different methodologies were used in the calculation of the GHG inventories in order to check the consistency of the results:

- The first method, called the ***reference approach*** *(top-down method),* is applied to estimate carbon dioxide emissions, quantified as a whole.

- The second method is known as the detailed ***technology-based calculation*** *(bottom-up method or sectoral approach) and focuses on both Carbon dioxide (CO_2)* and the emission of other gases and particulates. These calculations are conducted at the level of energy production, transformation, and end-use activities. The methods have, in general, been applied at a detailed activity/technology level.

For the non-energy sector, a sectoral approach was also used based on the 1996 Intergovernmental Panel on Climate Change (IPCC) Revised Guidelines for National Inventory of Greenhouse Gases (GHG).

[2] UNFCCC, Article 1
[3] UNFCCC, Article 4.1 (a)

2.1.1. Energy Sector

(a) The Reference Approach

The reference approach to estimate the CO_2 emissions emanating from energy activities consists principally of calculating the volume of fuels consumed and the carbon content of each one of the fuels. It is assumed that CO_2 emissions are basically dependent on fuel characteristics and not on the technology used, as in the case for other gases.

The use of biomass is not be included in CO_2 emissions because it is assumed that biomass reproduces at the same rate as it is used, and therefore the net flow of CO_2 is zero. Nevertheless, in this methodology the emissions stemming from biomass are counted and presented as additional information.

The reference approach for estimating CO_2 emissions is based on the notion of apparent consumption of fuels. This concept focuses on the balance of primary energy produced in Grenada, plus imports of primary and secondary energy, less exports, less bunkers (fuels used for supplying international sea-going ships and aircrafts) and stock changes. Hence, carbon is transferred to Grenada by means of energy production and imports (adjusted by stock changes) and transferred outside of Grenada by means of international exports and bunkers.

The calculation of apparent consumption of fuels is defined as follows:

APPARENT CONSUMPTION (TJ) = PEP+IM-EX-BK-VI **[2]**

Where;

PEP = Primary energy production
IM = Import of primary and secondary energy
EX = Export of primary and secondary energy
BK = Sales to sea-going ships and aircrafts on international travel
VI = Variation in inventories (stock changes)

The production of secondary energy is not taken into account because the carbon contained in this energy has already been accounted for in the primary energy from which this energy is derived.

In some cases, the apparent consumption of secondary energy can lead to negative values. For the purposes of accounting for CO_2 emissions, this result is perfectly acceptable because it indicates a net export since national production is not accounted for.

The IPCC Reference Approach for the computation of CO_2 emissions is a simple, accurate and internationally transparent approach. This methodology breaks the calculation of carbon dioxide emissions from fuel combustion into six (6) steps:

Step 1: Estimate the consumption of fuels by product type.

Step 2: Convert the fuel data to a common energy unit BOE (Barrels of Oil Equivalent)

Step 3: Select carbon emission factors for each fuel/product type and estimate the total carbon content of the fuels.

Step 4: Compute carbon stored.

Step 5: Correct for carbon not oxidized during combustion.

Step 6: Convert carbon oxidized to CO_2 emissions

(b) Detailed Technology-Based Calculation

This method consists of estimating the emissions of CO_2 and other gases (carbon monoxide, nitrogen oxides, hydrocarbons, sulphur oxides, and particulates) on the basis of the technology that is applied to extract energy. It is aimed at quantifying emissions that are produced throughout the energy chains, ranging from the development of primary energy, passing through transformation processes, the losses due to transport and distribution, up to end-use of the energy.

Gas emissions are calculated on the basis of the following:

$$\sum \textbf{Emissions} = \sum (\textbf{FE}_{ijk} * \textbf{Activity}_{ijk})$$

where:

FE =	emission factor
Activity =	energy consumption
I =	type of fuel
J =	sector of activity
K =	type of technology

The emissions of gas other than carbon dioxide requires more detailed information. Accurate estimation of their emissions depends on knowledge of several interrelated factors, including combustion conditions, technology, and emission control policies, as well as fuel characteristics. In the absence of local factors, IPCC default emission factors were used for all fuels.

(c) Data Requirements And Sources

(i) Data Requirements

To calculate the supply of fuels to the Grenadian economy, the following data were required for each fuel and the inventory year:

- The amounts of primary fuels produced;
- The amounts of primary and secondary fuels and fuel products imported;
- The amounts of primary and secondary fuels and fuel products exported;
- The amounts of primary and secondary fuels used in international bunkers;
- The net increases or decreases in stocks of fuels.

(ii) Data Sources

The data for energy production and consumption activities were obtained from the following sources:

- Texaco West Indies Limited
- Shell Antilles & Guianas Limited
- The Grenada Electricity Services Limited
- The Grenada Co-operative Nutmeg Association
- The Central Statistical Office, Ministry of Finance
- The Customs & Excise Department, Ministry of Finance
- The Energy Unit, Ministry of Communications, Works & Public Utilities

(iii) Data Acquisition Problems

The national energy database within the Energy Unit, Ministry of Communications, Works and Public Utilities constituted the main source of entry data for the calculation of Grenada's Greenhouse Gas Inventory. During the preparatory work for the computation of Grenada's GHG inventory the under-mentioned data gaps were identified:

- Data pertaining to the variation in the inventory of petroleum products were not readily available, (*little attention was given to compiling/preparing same by the Energy Unit)*.
- Charcoal production *(lack of data/need for more credible estimates).*
- Variation in the stock of fuels *(data exists, but not readily retrievable).*
- Marine Bunkers *(existing data needs disaggregating).*
- Biomass *(lack of fuel wood, sugar cane, and other primary fuel data).*

The required information was obtained through site visits to the Petroleum Marketing Companies, the Customs Department, and the Central Statistical Department.

(d) Assumptions

The following key assumptions underlie the calculation of Grenada's initial GHG inventory for the energy sector:

- It is assumed that CO_2 emissions are basically dependent on fuel characteristics and not on the technology used, as is the case for other gases.

- Abatement technologies are not in use.

- The majority of the motor vehicle fleet is without emission control devices.

- There are no significant increases in fuel wood and charcoal production/consumption.

- That emission factors represent closely operating cycles or regional conditions.

2.1.2. Non-Energy Sector

(a) Data Requirements

To calculate the emissions from the non-energy sector, the following information was required from the various sectors:

(i) Carbon Dioxide (CO_2) from non-energy sources

- Change in forest and other woody biomass stocks
  - Area of stocks
  - Number of non-forest trees
  - Annual growth rate for types of forest and non-forest trees
  - Biomass consumed through commercial harvest
  - Total fuel wood consumed
  - Forest/grassland converted to cropland and pasture (last 10 yrs.)

- Abandonment of managed lands
  - Lands abandoned during 1974 – 1994
  - Lands abandoned during 1874 – 1974

- Chemical Production

(ii) Non-methane Volatile Organic Compound (NMVOC)

- Quantity of asphalt used for road paving

- Production of alcoholic beverages
  - wine
  - beer
  - spirits/rum

- Quantity of food produced by food types
  - bread making
  - production of animal feed
  - production of meat, fish, and poultry.

(iii) Methane (CH_4)

- Number of head of different livestock – non-dairy cattle, poultry, swine, sheep, goat, asses, rabbits, horse

- Total municipal solid waste generated

- Proportion disposed to solid waste sites

- Total national industrial output

- Waste water produced per unit by industry

(iv) Nitrous Oxide (N_2O)

- Total synthetic fertilizer used
- Production of dry pulses
- Production of other crops

(b) Data Sources

The data were acquired through site visits, interviews with heads of departments and general managers from the relevant stakeholder institutions/organisations and reviews of relevant reports. The key organizations involved were:

- Grenada Solid Waste Management Authority
- National Water and Sewerage Authority
- Livestock Division (MOA)
- Grenada Sugar Factory Limited
- Grenada Breweries Limited
- River Antoine Estate
- Shell Antilles and Guianas
- Caribbean Agro Industries
- Ministry of Communication and Works
- Ideal Bakery, Blue Danube Bakery, Imagination Bakery
- Local Wine makers
- Land Use Division (MOA)
- Ministry of Health
- Fisheries Division (MOA)
- Forestry Department (MOA)
- Physical Planning Unit (MOF)
- Lands and Survey Division (MOA)

(c) Data Acquisition Problems

In this initial inventory of emission/uptake estimates, a number of data gaps exist due to:

- Lack of data
- Ambiguousness of data
- Lack of relevance of much of the IPCC Guidelines data, to the nation of Grenada. This occurred at two levels - many of the indicators were not relevant to Grenada on the one hand, and the emission factors that were proposed were not developed in comparable circumstances.

(d) Assumptions

In the absence of country specific data, available default values as prescribed in the revised 1996 IPCC workbook were used. In using these values, consistency was adhered to through selecting default factors for regions that are geographically similar to Grenada, or have similar practices. In the calculation of bread production figures, data were obtained from one bakery, which holds 50% market share. This was multiplied by two (2), to account for production by its two competitors, and a dispersed number of small bakers.

2.2. INVENTORY RESULTS

2.2.1. Sectoral Emissions

Table 3 provides a national summary of the Greenhouse Gas Inventory, with the data disaggregated on a sectoral basis.

Table 3 - Initial National Greenhouse Gas Inventories Of Anthropogenic Emissions By Sources And Removals By Sinks Of All Greenhouse Gases Not Controlled By The Montreal Protocol - 1994

Greenhouse Gas Source and Sink Categories	CO_2	CH_4	N_2O
Total (Net) National Emission (Gigagram per year)			
1. All Energy			
Fuel combustion	135	0.02	0.002
Energy and transformation industries	62		
Industry	4		
Transport	52		
Commercial-institutional	6		
Residential	10		
Other (Agriculture, Forestry and Fisheries)	1		
Biomass burned for energy	n.e.		
Fugitive Fuel Emission			
Oil and natural gas systems	n.a		
Coal mining	n.a		
2. Industrial Processes			
3. Agriculture			
Enteric Fermentation		0.00324	
Manure Management		0.00106	
Solid Waste Disposal		70	
Agricultural Soils			0.00108
4. Land Use Change and Forestry			
Changes in Forest and other woody biomass stock	(92)		
Forest and Grassland Conversion			
Abandonment of Managed Lands			
5. Other Sources as appropriate and to the extent possible (please specify)			

Notes:

1. n.a. – not applicable
2. n.e – not estimated

2.2.2. Reference Approach

The application of the reference approach to determine carbon dioxide (CO_2) emissions can be summarized as follows:

CO_2 emissions (Gg) = AEC ∗ CEF ∗ FCO ∗ CF [3]

where:
AEC = Apparent Energy Consumption (TJ)
CEF = Carbon Emission Factor (t C/TJ)
FCO = Fraction of Carbon Oxidized
CF = Conversion Factor (44/12)

Table 4 provides a statistical summary of the process described above**.**

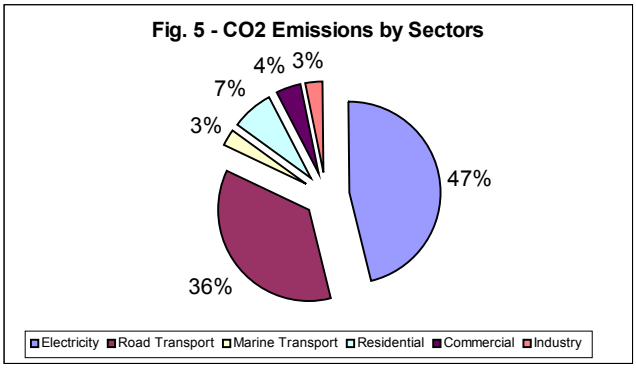
Table 4 - CO_2 Emissions From Fuel Types/Sources (Reference Approach)

Fuel Types	Apparent Consumption (TJ)	Emission Factor (t C/TJ)	Fraction of Carbon Stored (Gg C)	Fraction of Carbon Oxidized	Emissions of CO_2 (Gg)
Gasoline	747.41	18.9	-	0.99	51.28
Jet Kerosene	17.63	19.5	-	0.99	1.25
Other Kerosene	16.49	19.6	-	0.99	1.17
Diesel Oil	885.44	20.2	-	0.99	64.93
LPG	202.19	17.2	-	0.99	12.62
Bitumen	11.61	22	0.01	-	0.89
Lubricants	23.57	20	0.01	-	1.68
	-	-	-	-	-
Wood	n.a	-	-	-	-
Sugar cane Product	n.a	-	-	-	-
Other Primary	n.a	-	-	-	-
TOTAL	**1,904.36**	**-**	**-**	**-**	**133.82**
Total Biomass	n.a	-	-	-	-

2.2.3. Primary Emission Sources

(a) Carbon Dioxide

The analyses showed that Grenada emitted 135 Gg of carbon dioxide in 1994. This is equivalent to 1.38 tonnes of carbon dioxide per capita.



The key sources of these carbon dioxide emissions from the energy sector were from the combustion of liquid fossil fuel type, consisting of gasoline, jet kerosene, diesel oil, liquefied petroleum products (LPG), and lubricants. CO2 emissions from fossil fuel, account for 100% of total emissions of carbon dioxide and 95.2 % of all greenhouse gases.

On a sectoral basis, the main emissions sources are highlighted in **Fig. 5** and are as follows:

- **Power/Electricity Sector:** Grenada has one national electricity company, *Grenada Electricity Services Limited* (referred to as **GRENLEC**), which supplies electricity throughout the State of Grenada. **GRENLEC** is presently a privately owned company. Electricity generation accounts for approximately 47% of the total domestic supply of secondary energy. The resulting CO_2 emissions from this activity was totaled 62 Gg, and represented 47% of total CO_2 emissions.

Photo4: Electricity Power Plant

- **Road Transport:** In 1994, this sector was responsible for 47.86Gg of CO_2 emissions, which represented 35.8% of total CO_2 emissions, and 34 % of total GHG emissions. The road transport sector is private sector owned and operated.

Photo 5: Traffic in St. George's

- **Marine Transport:** The Marine transportation sub-sector represented 4.6% of the total sectoral energy consumption, and produced 4.23Gg of CO_2 or 3.2% of total CO_2 emissions.

- **Manufacturing And Construction Industries:** CO_2 emissions from this sector accounted for 2.8% of the total emissions and were estimated at 4 Gg.

Photo 6: Grenada Breweries Limited

- **Residential, Institutional And Commercial Sectors:** The emissions from the above-mentioned sectors were estimated at 16.21Gg and accounted for 11 % of total CO_2 emissions.

It must be noted however, that the Energy demands in the residential, institutional and commercial sectors are satisfied principally from the following sources:

- Kerosene
- LPG
- Charcoal
- Fuel Wood and
- Electricity

Both the residential and commercial sectors relied heavily on electricity for lighting, refrigeration and air-conditioning purposes.

An analysis of the consumption of petroleum products by products shows that LPG continues to displace kerosene as the preferred cooking fuel.

- **Forest Reserves** – These emissions of carbon dioxide are mitigated by a 92 Gg carbon dioxide sink, composed mainly of a forest reserve of 7,300 ac. It must be noted that the acreage of forests used did not include non-forest trees as the growth rate data necessary for the calculations were not available.

Photo 7: Grand Etang Forest Reserve

(b) Other Greenhouse Gases

The only other significant emission of GHG in Grenada comes from the solid waste disposal landfill which was estimated to emit 70 Gg of *methane* in 1994. The total emissions of methane were 71 Gg – 0.72 tonnes per capita.

Photo 8: Solid Waste Disposal at Perseverance

Emissions of *non-methane volatile organic compounds (NMVOC's)* were estimated at 1 Gg, generated mainly by asphalt use and the production of rum, spirits, alcoholic beverages and other food production.

There were also small quantities of nitrous oxide emissions from the use of artificial fertilizers and the cultivation of leguminous crops.

Emission estimates for Oxides of Nitrogen (NO_x), Carbon Monoxide (CO), Sulphur Dioxide (SO_2), Sulphurhexafluoride (SF_6), Hydrofluorocarbons (HFC^s), and Perfluorocarbons (PFC^s) were not calculated because:

- The emitting activities addressed in the 1996 Revised IPCC guidelines, are not relevant to Grenada.
- For SF_6, HFC^s, and PFC^s, imports of products containing these have only recently started.
- Chlorofluorocarbons (CFC^s) are still being used, but calculations for such were not considered in this exercise, since these substances are being addressed by the Montreal Protocol.

2.2.4. Summary

In 1994, Grenada's emissions of the primary greenhouse gas carbon dioxide were 135 Gg. This is equivalent to 1.38 tonnes of CO_2 per capita.

The primary sources of these carbon dioxide emissions were the electricity generation plant (46%), the road transport sector (34%) and the residential, institutional and commercial sector (11%).

These carbon dioxide emissions were mitigated by a natural forest sink of 92 Gg.

Methane emissions were also significant – 71 Gg – emanating primarily from solid waste disposal activities.

The emissions of the other greenhouse gases were insignificant.

2.2.5. Actions for Improving the Compilation of GHG Inventories

In order to improve the quality of future GHG inventories, Grenada intends to take the following actions:

- **Initiate appropriate measures to ensure that the identified information gaps are corrected** through collection of the relevant and updated information/data. This could be achieved by the improvement of existing databases at the Customs & Excise Department, the Central Statistical Office and the Inland & Revenue Departments.

- **Assess the options for capturing annual production and consumption data on primary fuels** (firewood, charcoal, coconut and nutmeg shells, sugar cane products, and the like.)

  This assessment can be done by the Energy Unit, Ministry of Communications, Works & Public Utilities, working along with The Central Statistics Department (Ministry of Finance) and the Ministry of Agriculture. This assessment can include a survey to determine with greater accuracy the levels of fuel wood and charcoal consumption, and the impact that this is having on Grenada's natural forest reserves.

- **Collaborate with other regional countries in the development of emissions factors for activities that emit greenhouse gases, which will more accurately reflect the practices in the region**. This will include a review of emissions factors for activities already reported in this initial inventory, as well as the development of emissions factors for activities not included in this initial inventory.

3. VULNERABILITY ANALYSIS

This National Vulnerability Statement would consider what is currently known about Grenada's vulnerability to the effects of climate change (rising temperatures, sea level rise and increase in extreme events), identify existing gaps in the available information and consider how such information gaps may be addressed.

As Vulnerability and Adaptation (V&A) analysis is a continuous process, it is anticipated that the quality of data would improve with time and that this statement would be complemented in the future by more informed analysis.

3.1. CLIMATE CHANGE SCENARIOS FOR GRENADA

Climate change is a threat to mankind. Although no one is certain about the future effects or severity of climate change, there is conclusive evidence of four (4) changes, viz:

- an increase in temperature,
- an increase in CO_2 concentration,
- a rise in sea level, and
- an increase in the frequency and severity of extreme events.

There are no specific climate change scenarios available for Grenada and pending more accurate regional data on variation in climate, and a consensus on a regional climate change scenario, the scenarios adopted for temperature changes and sea level rise are based on the IPCC (1995) accepted and recommended scenarios i.e. temperature rise of 1.0°C to 3.5°C and sea level rise of 15 cm to 95cm by 2100.

In addition, mean global precipitation is predicted to increase by 3% to 7% by the year 2100 using 8 GCMs with IS92a forcing scenarios. This synthetic scenario is used in the absence of more reliable data being available.

In the case of Grenada, a positive or negative variation of 5% to 20% in total precipitation by the year 2100 may be considered. Shrivastava (1997) reported that annual precipitation would increase by approximately 6% in the Western Caribbean and decrease by 4% in the Eastern Caribbean. Wetter wet seasons and severer and longer droughts during the dry seasons are predicted.

An increase in the frequency of extreme events may also be experienced. It is predicted that by the year 2100, there will be a 5 to 10 percent increase in the wind speeds of tropical storms worldwide for a Sea Surface Temperature increase of 2.2 °C (Knutson et al. 1998)

These projected changes are expected to be updated in time, with improvements in models and increased understanding of the science.

3.2. SENSITIVE SECTORS

The effects of Climate Change are expected to impact on almost all sectors of human activities in varying degrees. The sensitive sectors and exposure to climate change are inter-related within and across sectors. Nevertheless, for vulnerability and impact

assessment in the case of Grenada, the sensitive areas identified are (a) Water Resources, (b) Agriculture (c) Coastal Zone (d) Tourism and (e) Human Health.

3.2.1. Water Resources

Grenada's water resources are surface water based, with a groundwater potential to satisfy about 10% to 15% of the present potable requirement. On the smaller islands (Carriacou and Petite Martinique), domestic water is exclusively from rainwater catchments, while water for livestock is from groundwater. Little water is used in irrigation.

(a) Surface Water

On the main island, the public water supply is from 34 water production facilities with a rated capacity of about 37,300m^3/day (Smith 1999). Potable water comes from the South System and North System, which have storage capacities of 15,696 m^3 and 4,896 m^3 respectively – **Table 5**. The average dry season production is about 20% less than the daily average and about 24% less than the rest of the year. Based on daily production figures for the South, only about 35% of the total production is consumed.

Wastage accounts for 16%. Losses through leakage are estimated at about 45% (OTH, 1995). Discussions with local water authorities suggest that the high level of losses continues. About 80% of the public water supply is treated conventionally i.e. using slow sand filters and chlorine.

Grenada's per capita water consumption is estimated at 130 litres/day/person. Water production cost is dependent on the type of system (surface water $0.06-$0.08 per 1000 gallons; ground water $0.12 per 1000 gallons and desalination $0.26-$0.32 per 1000 gallons).

Table 5 - Non-Agricultural Water Capacity And Demand In Grenada (2000)

	North	**South**
Current Storage capacity (m^3)	4896	15696
Design production capacity (m^3/day)	10775	22766
Current Average Daily Demand (m^3/day)	13573	11340
Projected demand with system improvement (m^3/day)[4] (2002)	9094	9404

Source: National Water and Sewage Authority

Changing land use patterns in the upper watersheds have led to reduced flows in the streams and rivers and siltation of the dams. Growth in population and the tourism industry, and the future implementation of irrigation schemes would lead to a rapid increase in the total water requirements in the future – **Table 6.**

Table 6 - Agricultural Water Demand and Irrigation-Equivalent Area - Grenada

	North	**South**
Current irrigation demand (m^3/day)	4300 (50 Ha)	1720 (20 Ha)
Projected irrigation demand (m^3/day) (2005)	34000 (400 Ha)	8600 (100Ha)

[4] System improvement entails 80% to 90% reduction in distribution leaks and 75% reduction in wastage

(b) Groundwater

The groundwater potential on the main island is not yet fully developed. The main groundwater aquifers can be found at Bailles Bacolet, The Great River, Duquesne, Beausejour, Chemin Valley and Pearls-Paradise. The current exploited groundwater is approximately 1890 m^3/day, with a potential capacity of approximately 3973 m^3/day.

In Carriacou, where there are no perennial streams or rivers, the potential importance of groundwater is higher than on the main island. There have been five previous studies on the groundwater potential in Carriacou (Lehner, 1939; Kaye, 1961; Mather, 1971 Mente, 1985 and Barragne-Bigot, 1987). The potential groundwater resources are shown in the **Table 7** below. Most of the water is of poor quality[5] (low palatability) with high quantities of dissolved salts hardness levels of 300 mg/l to 500 mg/l.

Table 7 - The Groundwater Resource In Carriacou

Watershed	**Water quality**	**Quantity (total potential (m^3/day**	**Dug-well**	**Boreholes Current (potential)**
Craigston-Dover	Good for livestock	55 –75	2	2 (1)
Hillsborough	Potable	90 –97	7	3 (1)
Six Roads	Poor	38 –57	2	1 (2)
Harvey Vale	Poor	20 –38	1	1 (2)
Dumfries-Bellevue	Poor	Undetermined	2	1 (1)
La Ressource-Sabazan	Poor	20	1	2(0)
Grand Bay- Mt. Pleasant	Fair	38	4	2 (2)
Limlair-Dover	Fair	4	2	1(0)
Windward	Very poor	Undetermined	2	0(0)
Petite Carenage	Brackish and poor	5	1	0 (0)
Petite Martinique	Very poor	Undetermined	3	0(0)
Total		**270-334**	**27**	**13(9)**

Changes in weather patterns, particularly extreme events of rainstorms and droughts would impact negatively on the water supply. In Carriacou, a reduction in precipitation would make present cistern sizes inadequate for the dry seasons. Similarly, reduced precipitation would cause reduced flows in the streams and higher irrigation requirements, both of which would create further stress on the water supply.

Sea level rise can lead to saltwater intrusion. As the sea rises the saltwater-freshwater boundary is forced further inland directly proportional to the rise in sea. As most of the groundwater deposits are close to the coast (within 1Km range), such movement would reduce the aquifer volume.

[5] It must be noted however that "quality" is based mostly on taste and acceptability by the local population re use for drinking and cooking purposes.

(c) Summary

With the present population on the main island, the design capacity of the water production plants is sufficient to satisfy current demands. The current demand would be about 55% of the current production capacity if the losses in the current distribution systems were reduced to zero with no change in current storage capacity. The limiting factor in the ability to provide 100% safe water is the current treatment facilities.

3.2.2. Agriculture and Fisheries

(a) Agriculture

Grenada's export agriculture is predominantly forest crop based - nutmeg and cocoa, banana, spices, and non-traditional fruit crops. All these crops are of the C3 type and would respond favourably to CO_2 increases. They are also high consumers of water, exhibiting reduced yields during periods of water stress. These crops are currently rainfed, but it is well established that the use of irrigation would greatly enhance yields for bananas and the non-traditional fruit crops.

Non-irrigated subsistence farming of roots and tubers, peas and maize is wide spread. This type of farming is vulnerable to droughts, pests and diseases. Changes in climate could create more frequent drought situations and increase the incidence of losses by pests and diseases. A single hurricane of moderate intensity could reduce the nutmeg and cocoa industries by 80% to 90% as was the case of the 1955 Hurricane Janet. It would then take up to five to seven years for a recovery of these crops since this is the required time to reach economic yield. Maximum potential yield can take even longer.

Livestock farming is concentrated on the low-lying, drier areas of the country. The Island of Carriacou, which produces 28% of the country's cattle and 30% of sheep and goats (GAC 1995), have a pastured animal population density three times larger than the mainland, Grenada.

(b) Fisheries

In the last 20 years, fish exports from Grenada have shown steady growth. The improved export opportunities stimulated an overall improved production moving from 1.5 million pounds in 1980 to a peak of 4.9 million pounds in 1993. The value of the production towards the end of the 1990s stood at 4.5 million US dollars.

Grenada's fish production could be classified into three main groups: pelagics, demersals and shell with contributions of 87 %, 10% and 3% by volume respectively and 84%, 9% and 7% by value respectively. There has been increasing importance of the pelagics and shellfish, whose contribution of the total production has increased by 15% and 5% over the past 15 years.

3.2.3. Coastal Zone

Although the coastal zone is narrow and accounts for about 3% of the land area it is the location of the main economic infrastructure. All the main towns and commercial centers, all major hotels and (90%) of the 1066 hotel rooms, the three airports, the nerve centers of

all the utilities including the power generating plants, the fuel storage facilities are located on the coastal fringes. All these key sectors in the national economy are susceptible to sea level rise and extreme climatic events including high intensity hurricanes and storm surges.

(a) Human Settlements

The coastal population of Grenada, Carriacou and Petit Martinique comprises of approximately twenty-nine (29) settlements inclusive of six (6) towns. These settlements account for approximately 19% of the nation's population. These communities are also host to a number of schools and other social amenities like churches, supermarkets and the like.

(b) Major Ports

In Grenada, port facilities consist of airports and marine ports, all of which are located within the coastal zone, viz:

- **The Point Saline International Airport,** the only operational airport on the main island, is located on the southwest shore of the island. Other airport facilities at Lauriston Airport, the only facility of its kind in Carriacou and Pearls Airport (the former landing site on the mainland before Point Salines was commissioned) are also located within the coastal zone. The latter is not presently in use, but plans have been announced to re-open it sometime in the future

- There are a number of **marine ports** in Grenada, including:

  - *St. George's:* The St. George's port which is the main commercial seaport is located on the southwestern side of the island. The facility is used by cruise ship visitors and by business operators for export and import of commercial goods.

  - *Grenville Port:* The port of Grenville is located on the east coast of the island and is the second largest port on mainland Grenada. It functions as the main landing site for fishermen on the eastern side of the island and as a shipping facility for agricultural goods and services to and from Trinidad.

  - *Hillsborough (Carriacou):* This port is the main point of entry of goods and services to and from the mainland Grenada and is one of two ports on the island of Carriacou.

  In addition, there are a number of smaller marine landing facilities which service the fishing communities - Gouyave on the western coast and Sauteurs on the northern coast – and one at Petit Martinique, which is that island's only connection to the outer world.

(c) Infrastructure

- **Electricity:** The sole electricity generating station on the main island is located in a flood prone area, very close to the sea (Queen's Park). In addition nine (9) of the forty (40) switches used for isolating services are located within the coastal zone. It

must be noted however that if one of these switches within the coastal zone is affected, the impact on the population will be minimal, provided that the rest of the system is functional. Within the network, an area can receive electricity from several switch locations by methods referred to as isolating and opening an area.

- **Telecommunications:** Telecommunications services are distributed throughout the state via a network of cables, outside plant module (O.P.M.) and cabinets. Cables are distributed along the island roads linking O.P.M.s and cabinets. There are approximately 18 O.P.M.s throughout the state, four of which are coastal and are considered vulnerable to sea level rise by the company. These are located at Hillsborough, Carriacou; Petite Martinique; Victoria; and the Carenage, St. George's. Should sea level rise impact on these facilities, services to the population in Carriacou and Petit Martinique will be significantly reduced as the main services on the two islands are distributed from vulnerable locations (Hillsborough, Carriacou and Chicen, Petit Martinique).

  On the mainland Grenada, the impacts on the population served by facilities which are vulnerable, will be minimal, as a back-up system can be readily adapted to restore services. The undersea cable link to the Eastern Caribbean Fiber Optic lines on the east coast is considered very important by the company – approximately 1,500 meters of cable along the road at Grenville and St. Andrew's bay is vulnerable to possible impacts of sea level rise.

- **Fuel Depots:** All the main fuel depots in the island are located on the coast and damage to the coastal roads servicing these depots can result in fuel shortages and bring the entire country to a standstill.

- **Roads:** The island's roads can be characterized into three categories, primary, secondary and tracks. The primary roads are the main service roads linking towns and regions and can be described as low level and high level coastal roads. Low level coastal roads are roads located at beach level, whereas high level coastal roads are roads constructed along the top of coastal cliffs. Some of these roads are exposed to coastal erosion from wave action and rising sea level.

- **Recreational Facilities:** Throughout the State of Grenada there are sixteen (16) major recreational facilities which are coastal, including ALL the major facilities, viz:

  Major playing fields include:

  - National Stadium/Queen's Park – St. George's
  - Tanteen Playing Field – St. George's
  - Beausejour Playing Field – St. George's
  - Cuthbert Peters Park – St. John's
  - Alston George - St. Mark's
  - Mt. Craven – St. Patrick's
  - Plains – St. Patrick's
  - Progress Park – St. Andrew's
  - Grenville Recreation Ground – St. Andrew's
  - La Sagesse – St. David's

- Hillsborough – Carriacou

There are also important Hard Court facilities at:

- Tanteen Netball court – St. George's
- Grand Anse court – St. George's
- Grenville Hard court – St. Andrew's
- Gouyave Hard court – St. John's
- Victoria Hard court – St. Mark's

- **Historic Sites /Cultural Facilities:** Some of the islands historical resources are distributed within 0.25 mile of the coast. These consist of historic buildings, military sites, archeological sites, geological sites and others. These sites can be divided into two main categories – national landmarks and cultural facilities. Many of these are showcased among Grenada's tourist attractions.

  Key historical sites include:

  - Rum Distilleries at River Antoine and Westerhall
  - St. George's Town/Harbor
  - Quarantine Point
  - River Sallee Boiling Spring
  - Lakes at River Antoine and Levera
  - Marquis Village
  - Fossil Beds, Grand Bay, Carriacou
  - Dover Ruins
  - Lime Factory (Craigston, Dumfries), Carriacou
  - Sandy Island

  Key cultural facilities include:

  - National Trade Center – St. George's
  - National Youth Center – St. George's
  - Seamoon (Simon) Cultural Centre – St. Andrew's

There has been no study on possible effects of sea level rise on any of these historic sites and cultural facilities.

However, it can be assumed that sea level rise will have negative impact on all these sites and facilities since these are located less than 100 meters from the sea, at elevations of approximately 2 meters or less above sea level.

3.2.4. Tourism

Tourism is also an important socio-economic asset in the coastal zone and is contributing significantly to the island's economy. It is presently the leading growth sector, generating more than 50% of the country's foreign exchange earnings and stimulating activity in construction and ancillary services. It is seen as a vital source of revenue for Government and employment (including self-employment) for the people.

In 1998, the revenue generated from stay-over and cruise ship arrivals amounted to EC $156,172,865 and EC$13,160,815 respectively.

The Master Plan for the Tourism Sector states that in 1997, 85% of the island's room stock was located in the southwestern peninsula, viz:

- Twenty-two (22) units or 40% of the room stock in Grand Anse
- Eighteen (18) units or 37% of the room stock in the True Blue, L'Anse Aux Epines area;
- Thirteen (13) units or 8.6% of the room stock in the capital city of St. George's.

There were only eight (8) accommodation units in rural Grenada accounting for 4% of the room stock.

The islands of Carriacou and Petite Martinique account for sixteen (16) properties, one of which is located on Petite Martinique. They represent 9% of the available room stock in Grenada.

3.2.5. Human Health

During the later part of the last century, Grenada espoused the objective of health for all by the end of the century. This was to be achieved by the strengthening of the community health system and by placing greater emphasis on preventative activities. The Health system is in the process of being statutorised in the area of hospital services, to ensure that hospitals become self-financing. In the late 1990s, a number of privately operated health services were established.

The three leading causes of death in Grenada are heart diseases, hypertensive diseases and endocrine and metabolic diseases including diabetes – **Table 8**. These are associated with life style (diet, work and work environment) which may be linked to climatic conditions.

Table 8 - Leading Causes Of Death In Grenada (1996-1998)

Causes of Death	Number	% deaths
Pulmonary, circulation and other heart diseases	235	11.4
Cerebrovascular diseases	224	10.8
Ischaemic heart disease	122	6.0
Other bacterial diseases	98	5.0
Hypertensive diseases	167	8.0
Diseases of other respiratory system	136	7.0
Conditions originating in perinatal period	77	4.0
Endocrine and metabolic diseases (diabetes)	136	7.0
Diseases of urinary system	57	3.0
Neoplasm of digestive organs	91	4.0
Neoplasm of genito-urinary system	58	3.0

Source: Ministry of Health

A number of factors including education, economics, quality of medical facilities and climatic variation among others, affect human health. Although Grenada currently does not experience a high level of communicable diseases associated with the mosquito, the

presence of some mosquitoes - *Anopheles*, *Culex*, and *Aedes Aegypti* - the carriers of Malaria, Elephantiasis, Dengue fever and Dengue Heamorrhagic fever respectively, are confirmed (MOH 2000).

The *Anopheles* mosquitoes are prevalent in low-lying areas associated with flooding e.g. Soubise, Marquis, Gouyave, Grenville and Telescope. From available data obtained from MOH, the incidence of dengue was four and one half times higher during the 1990s than during the 1980s and there has been known cases of malaria, although imported.

The four most common communicable diseases reported for the past 20 years are viral conjunctivitis, influenza, gastroenteritis and respiratory-related diseases – **Table 9**. Other less reported cases include dengue and dengue haemorrhagic fevers, rabies and malaria. The incidence of enteric diseases, gastroenteritis and typhoid has been reported over the last 20 years.

In the case of gastroenteritis, every year 0.75% to 1.75% of the population, particularly children and the elderly in the poorer communities, are positively diagnosed. The high incidence of gastroenteritis is associated with the high use of pit latrines (45%) and the level of use of public facilities or non-use of adequate facilities (15%) in combination with flooding in the low lying areas and contamination of surface water during heavy rains. Every year outbreaks of dengue, viral conjunctivitis, different forms of gastro-intestinal diseases and various strains of the flu are experienced during the hurricane season.

Table 9 – Incidence Of Weather Associated Diseases In Grenada 1976-1995

Disease	Annual average	Peak # of Incidence	Peak Year
Gastro enteritis	1275	2315	1982
Viral conjunctivitis	147	432	1994
Influenza	3422	12346	1977
Respiratory	1825	5026	1982
Enteric fever	4	30	1977
Malaria	1	13	1978
Haemorrhagic fever	1	10	1979

The incidence of many tropical diseases is associated with temperature and/or precipitation. Some of these diseases, including malaria and cholera have been eradicated since the 1950s. As a result of the close proximity to and high human traffic between Caribbean countries and Central America, there is the threat of a reintroduction of such diseases.

3.3. POTENTIAL EFFECTS OF CLIMATE CHANGE (CC)

This analysis of the potential impact of Climate Change in Grenada is constrained by two factors, viz:

- Firstly, there is uncertainty about the interaction of all the global processes - natural and man-made - and the socioeconomic dynamics.

- Secondly, the data sets necessary for rigorous analysis, through simulations of the natural processes are incomplete and therefore restricts how far the results from initial analyses may be interpreted.

This means that efforts would be needed to begin the collection of as much of the baseline data as possible, in order to improve future analyses to guide national planning and development.

3.3.1. Impact on Water Resources

(a) Water Availability

The available water resources in an environment of climate change would depend on a number of weather and environmental elements including cloud cover, temperature, relative humidity, rates of evapotranspiration, soil type, crop cover and rain distribution, intensity and amounts. **The combined effect is not clear at the moment and would require some level of research.** Nevertheless, the current understanding of the hydrologic cycle can give an indication of likely impacts. Shrivastava (1997) reported that *annual precipitation would increase by approximately 6% in the Western Caribbean and decrease by 4% in the Eastern Caribbean. Wetter wet seasons and severer and longer droughts during the dry seasons are predicted.*

Increased temperatures and reduced precipitation would lead to higher rates of evapotranspiration and lower surface runoff, reduced mean available soil-water, reduced rates of groundwater recharge and reduced opportunities for filling of rainwater cisterns in Carriacou. To sustain adequate soil-water and groundwater recharge, water conservation techniques would have to be strengthened.

In Carriacou, where there is high dependency on rainwater catchments, some of the present public water catchments and the private cisterns could become inadequate for meeting the annual distribution needs. Consequently, during the dry season, there could be a shortage of domestic water.

With the wetter rainy season, it can be expected that the overall precipitation would increase. However, it is not clear what the net effect of increased evapotranspiration would be on total surface flows and groundwater recharge on the mainland and filling of cisterns in Carriacou and Petite Martinique. The evapotranspiration and groundwater recharge information for Grenada and Carriacou, presently unavailable, must be obtained and *Mass diagrams of water consumption* for Carriacou and Petite Martinique must be developed. **This is an area for new research**.

Lower stream-flows would also lead to less available water for irrigation. Under the current situation, estimates of the irrigation requirement are easily obtained. However, the detailed information on infiltration rates, crop water uses under varying local climatic conditions, continuous stream flow data and identification of the exact locations of potential lands for irrigation, are not as easily obtained.

(b) Water Quality

Saltwater intrusion from sea level rise would reduce the available groundwater on the main island Grenada. In Carriacou and Petit Martinique, where the 27 major open wells are with 100m of the shoreline, high salinity would lead to abandonment of such traditional wells.

As Carriacou is a small island, the modeling of the groundwater is not clearly understood. In size, Carriacou is similar to the Atolls of the Pacific but its geology is similar to that of large islands. Since the aquifers in Carriacou are narrow, modeling the groundwater like that of an atoll may have some merit. If such a case was true, sea level rise would push the fresh water lens closer to the surface and would be beneficial to the groundwater resource. If this is not the case, then saltwater intrusion would reduce the quality of the present wells and would make those wells in Petite Carenage and Windward, where the water is of a higher salinity, unusable.

3.3.2. Impact on Agriculture and Fisheries

(a) Agriculture

The impact of global climate change on agriculture has been studied extensively for various crops at many different scales. However, studies on the major crops of Grenada - nutmeg, cocoa, bananas and spices - are not available. Current research in 8 countries co-ordinated by the US Water Conservation Laboratory and other institutions on the main global staples - rice, maize, wheat, beans and peas - would provide better insight when completed.

The impact of the combined elements of climate change on agriculture, especially tropical crops, is not clear and would be further complicated by other socioeconomic activities such as commodity prices, labour availability and labour cost.

(i) Crop production

Agricultural crop production would be influenced by changes in soil moisture for bananas, cocoa and nutmegs. Higher temperatures would increase evapotranspiration, while CO_2 enrichment could boost productivity in C3 plants. This includes tree-crops (nutmegs and cocoa), cassava, maize, yams, bananas, coconut, sweet potatoes, pigeon peas, and beans (Wittwer 1992). Greenhouse-grown type vegetables could produce large fruit size, and larger fruit numbers and could show yield increases of 10 to 70% (Wittwer 1992).

Nonetheless, the impact of climate change with reduced annual rainfall, by itself, would be negative on crop yield. Both nutmeg and banana production are positively correlated to precipitation. Of the three main crops, nutmeg would provide the best crop assessment indicator, as the acreage under production spatially and over time has remained steady since 1976.

Higher temperatures and lower precipitation would reduce available soil water, which would lead to reduced yields. For the four most recent El Nino events, the average production during the events was 13% to 18% higher than the periods preceding the events **(Table 10).** Although there should be cautious interpretation of this information since there

is no confirmed link between climate change and El Nino events, the climatic impact on nutmeg production is obvious.

Table 10 - Nutmeg production preceding and during El Nino

El Nino Years	Average production preceding El Nino (x10^6lbs)	Average production during El Nino (x10^6lbs)
1986-1987	4.9	6.05
1997-1998	4.05	5.67

An analysis for annual nutmeg production and precipitation for 25 years data shows that while nutmeg yield is positively correlated (R>0.25) to precipitation, that an optimum yield is achieved with annual precipitation of about 2000mm. During the years of unusually below average precipitation there is very low yield.

In the case of a climate change resulting in a 20% decrease in precipitation, there would be many more occurrences of unusually below current average precipitation, which would lead to reduced annual nutmeg production. Further this would push the nutmeg-growing belt to higher elevations reducing the water producing watersheds.

In the case of a 10% to 20% reduction in precipitation, banana production - now mostly rainfed - would require irrigation schemes for sustainability. The affect of increased temperatures would further exacerbate the situation through increased evapotranspiration and reduced soil water.

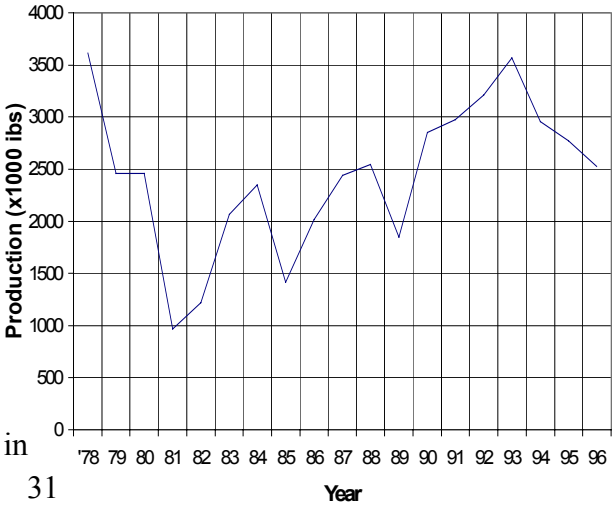
The extent to which carbon dioxide enhancement and natural plant adaptation would alleviate the negative effects on crop yields is not known and should be researched.

(ii) Livestock

Carriacou accounts for 30% of the total livestock population of Grenada. Livestock production in Carriacou is most vulnerable to weather conditions since it experiences less rainfall than anywhere else in Grenada during drought conditions. Past experiences have demonstrated this susceptibility, as losses in some extreme events like the droughts of 1984 and 1992 caused stock losses of 20% to 40% respectively. Recovery from these losses can take many years.

Under normal conditions, pasture grasses are C4 plants and the productivity under higher CO_2 concentrations can be expected to decline. This means that lower animal yields can also be expected as a result of the reduced grass yields.

Fig 6: Grenada's Fish Production



(iii) Fisheries

The global fish harvest has declined sharply – as large as the oceans are, the most valuable species have been effectively fished out (UNEP 1997). The impact of temperature rises and variations in

precipitation on export fish stock is not clear.

There are no available studies, published or unpublished, on the relationship between fish production and climate in Grenada. However the breeding ground of 17 of the main species of demersals, which provides about 43% of the total fish catch in Grenada, may be negatively affected where mangroves, reefs and other mud banks, are negatively affected by climate change and sea level rise.

Preliminary analysis of data provided by the Fisheries Division, Ministry of Agriculture – **Fig. 6** - shows a relationship between fish production and the El Nino phenomenon. In the year preceding El Nino (the 4 strongest El Ninos since 1980 were 1982/83, 1986/87, 1991/92 and 1997/98) fish production is reduced by 25% to 60% of the average. Similarly, at the onset of La Nina, production could be 30% to 50% higher.

During 1999, algae bloom caused significant demersal "fish kill" creating a scarcity of the domestic supply of fish. This algae bloom was associated with environmental changes, including warmer sea temperatures and turbidity and enhanced eutrification from continental flushout due to heavy rainfall. During the 3 months of the "fish kill", fisher-folk who fall into the lower socioeconomic strata were unemployed for 3 to 4 months. The overall lost earnings for these people and the cost to government in the form of financial support are unpublished but are expected to be significant.

3.3.3. Impact on the Coastal Zone

Grenada has been selected as one of the pilot sites for the Coastal Zone Vulnerability and Adaptation Component of the CPACC Project. The final results of this pilot project are not yet available and, when available, will further inform the analysis in this section.

Photo 9: Flooding from Hurricane Lenny Storm Surge

The preliminary results indicate that there could be serious adverse impacts on coastal communities and infrastructure, from flooding and inundation, especially during storm surges. The experience of Hurricane Lenny in 1999 is instructive in this respect. There is also significant potential for salt-water intrusion into the water supply in Carriacou.

(a) Human Settlements

The coastal environment could be seriously affected by sea level rise. Many coastal settlements are located in areas that are at sea level or less than 2 m above sea level. The towns of Grenville and Hillsborough, which are at sea level and are prone to flooding during events of high tides and heavy precipitation, would experience more flooding events from high tides.

Some parts of the main commercial center of St. George's (e.g. the Carenage, Melville Street) and the tourist areas in the southwest peninsula are also susceptible to flooding

during periods of high seas and heavy precipitation. Serious disruption of social and economic life in these areas could be expected to occur as a result of sea level rise.

Coastal erosion from sea level rise and extreme events would also disrupt coastal villages like Gouyave, Grand Mal, Duquesne, Soubise and Marquis.

Roads through these communities and other unsettled areas (e.g. Airport road, Carriacou, and a number of sections of roads on the Western Coast) are practically at sea level and below sea level in some cases. These roads could experience flooding, become impassable during high tides and experience severe damage during storm surges.

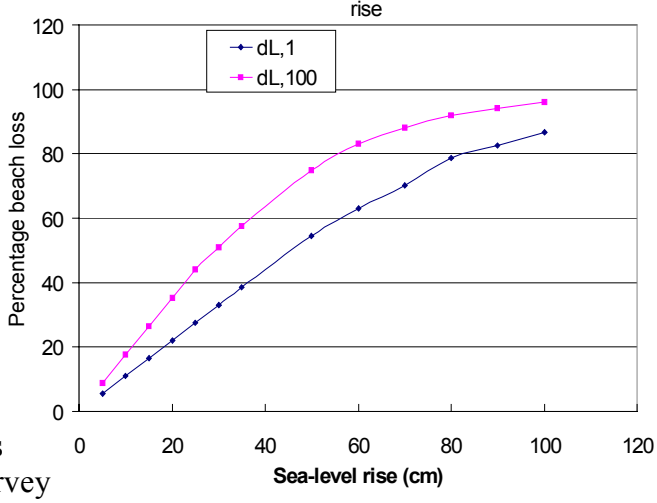
(b) Beach Erosion

The earliest *Beach Monitoring* in Grenada dates back to 1985 with a coastal monitoring programme in response to severe erosion problems identified in Grand Anse and other beaches (Cambers 1996). Early studies showed that the erosion had greater seasonal variation (up to 34% beach profile area) than long-term variation (up to 10.5% beach profile area), particularly in the West Coast. For Grand Anse, annual erosion was about 11% during 1984 to 1986.

Photo 10: Beach Erosion at Telescope

Beaches erode during the winter (November to April) as a result of the winter swells from the Atlantic storms and accrete during the summer. As the Atlantic is expected to experience more frequent and severe storms with climate change, beach erosion on the West Coast during the winter can be expected to worsen.

Fig 7: Simulated beach erosion at Grand Anse due to sea-level rise



Application of the Bruun rule to beach erosion analysis shows that for a 50 cm rise in sea level, significant portions of Grenada's beaches would disappear (Peters, 2000). These beaches include Grand Anse, Morne Rouge, Harvey Vale and Paradise, all of which are important tourist attractions. **Figure 7** shows the simulated beach loss where $d_{L,1}$, and $d_{L,100}$ are the range of depths of closure (Peters, 2000).

(c) Sandy Islands And Reefs

Sandy Island, White Island and a number of Keys, which are one to two meters above sea level, could be wiped out as a result of submergence during storm surges**.** In the past 25 years, Sandy Island on the west coast of Carriacou, has lost about 60% of its area, while

small sand banks that existed for hundreds of years between Carriacou and Petite Martinique have disappeared completely.

Under moderate projections (IPCC IS92a), current and future increases in sea temperature are expected to have severe effects on the world's coral reefs within 20-30 years (Hoegh-Guildberg 1999).

Reefs that are already under environmental stress from pollution and human exploitation could suffer negative impacts from increases in the sea surface temperatures, sea level rise and extreme events.

3.3.4. Tourism

The impact of climate change and sea level rise on tourism would be mostly indirect. As climate in the higher latitudes would be milder, Grenada could be a less desirable climate-influenced destination.

Another possible negative impact on tourism could be the loss of beaches, or the deterioration of the beaches due to erosion from natural phenomena and/or climate change. Water sports, which is currently a rapidly growing sub-sector of tourism, would become less attractive in the absence of quality beaches.

Higher temperatures would increase the operating costs of hotels, as there would be greater per capita water consumption and power consumption for air conditioning. A good analogue of the impact of temperature rise on power consumption can be seen in the annual variation of mean temperature and power usage.

An analysis of the historic power and temperature data for a small tourism plant shows that for a 1.1°C variation in average monthly temperature, there is a 25% variation in power consumption. July to September 1999 was one such period on record, with a 0.9°C above average temperature causing an 11% increase in power consumption.

3.3.5. Human Health

The major effects of climate change on global human health are caused by heat stress, air pollution, alterations in the incidence of communicable diseases, under-nutrition and inundation. (WHO 1990). The ability to assess the human health impacts of climate change is at a very early stage of development (Balbus et al, 1998). The impact on human health is more complex than on other sectors, as, in most cases, health outcomes cannot be simply correlated with climate factors since many other social and economic factors have significant effect on human health.

In this regard, both climate change-related and non-climate change-related factors would influence Grenada's vulnerability to emerging and resurging infections. Demographic changes (such as an aging population, escalating migration to St. Georges and its suburban areas), increased drug dependence and chronic illness would lead to increased stresses on the health services in the South of the island. The expanding prevalence of drug-resistant pathogens and pesticide-resistant vectors can lead to widespread incidences of diseases like dengue fever.

In addition, changes in hydrology, forestry, agriculture, and infrastructure, in response to climate change, may also indirectly affect the interrelationship between the disease vectors, hosts and consequently health.
In Grenada, the main effect is likely to be caused by the increased incidence of vector-borne communicable diseases, for which the vectors are currently resident or are likely to be imported. Respiratory diseases associated with regional dust storms during the hurricane seasons are also likely.

Many organisms that transmit disease respond to climatological and ecological perturbations. The current diversity of infectious disease threats facing humanity is unprecedented. Over the last two decades, malaria, dengue, cholera and tuberculosis (TB) have resurged in many parts of the tropics. No specific study on the impact of environmental and climatic changes on vector-borne or respiratory diseases in Grenada is available. Hence the trends and results of such studies for other tropical countries could be used as good analogues.

The introduction of microbes and vectors by escalating and unprecedented transboundary movements of people could lead to the reintroduction of some old diseases. The accidental introduction in the USA of *Aedes albopictus*, the vector of the virus causing dengue and dengue haemorrhagic fever (Knudsen 1986) demonstrates Grenada's vulnerability to similar situations.

Preliminary analysis of the three most common diseases, influenza, viral conjunctivitis and gastroenteritis show correlation between annual, and July precipitation and these diseases. It is noteworthy that significant positive correlations are observed for the incidence of viral conjunctivitis and influenza and August precipitation - R=0.70 and R=0.62 respectively. **This is an area where further research is required.**

3.4. Summary of Impact of Climate Change

There is still a significant amount of analytical work required in determining the specific vulnerabilities of Grenada to climate change. The specific vulnerabilities of the coastal zone are currently being analysed by the CPACC Project and there is a need to initiate similar specific analyses for the other sensitive sectors.

However, the initial analysis indicates that Grenada is potentially very vulnerable to the adverse impacts of climate change in a number of areas:

- Decreased annual precipitation and higher temperatures could lead to reduced domestic water availability in the dry season, and to reduced yield among the principal agricultural export crops – nutmeg and bananas.

- Higher wet season precipitation and temperatures could increase the spread of tropical disease vectors and could create health problems for the population.

- Higher sea surface temperatures could adversely affect the domestic fish catch and negatively impact on the protein supplies available to the population, as well as on the incomes of fishermen and fisherwomen.

- Sea level rise could result in flooding and inundation and adversely affect the coastal settlements where at least 19% of the population live and where most of the significant socio-economic infrastructure – airports, ports, roads, telecommunications facilities, electricity facilities, tourism plants, sporting and cultural facilities – is located.

- The important tourism industry could be adversely affected through loss of important beaches and threats to hotel plants, *inter alia*.

- Grenada's exposure to extreme climatic events like hurricanes will increase, with consequent implications for damage to property and key infrastructure, as well as loss of human life.

4. INSTITUTIONAL ARRANGEMENTS

4.1. ENVIRONMENTAL MANAGEMENT

The current approach to environmental management in Grenada us sectoral in nature. The Ministry of Health and the Environment has the primary responsibility for the environment along with some twenty agencies, inclusive of Government departments, non-governmental organisations (NGOs) and statutory bodies (Physical Planning Unit – Draft Sectoral Report on the Environment, 2000).

4.1.1. Legislative Framework

The legislative framework for environmental management reflects the fragmentation of the institutional framework. A review of the environmental legislation in Grenada (Alexis, 2000) concluded that "… most of the laws … are sectoral and decentralized … while they have environmental application, they were not legislated to address those concerns and are mainly incidental to environmental management."

The review cites forty-nine (49) separate pieces of legislation that are applicable to one or more of the issues related to Climate Change and that can be applied in the context of climate change.

4.1.2. Policy Framework

There is no coordinated policy framework for the management of the environment in Grenada. Even in cases where there is clear sectoral responsibility, clear-cut policy frameworks are few and far apart.

A small number of initiatives to remedy this situation has been initiated since 1994, the most successful being the institutionalization of the Grenada Solid Waste Management Authority in 1996 and the development of a Forestry Policy and Strategic Plan in the 1997 – 2000 Period. The elaboration of a Biodiversity Strategy and Action Plan in 2000, has also been a significant development in this regard.

4.2. CLIMATE CHANGE INITIATIVES

During the early 1990s, the management of Climate Change initiatives was initially handled by the Ministry of Foreign Affairs and consisted mainly of representation at international meetings and reporting back to the Government.

The commencement of the Caribbean Planning for Adaptation to Global Climate Change (CPACC) Project in 1997 required the appointment of a National Focal Point and the decision was taken to appoint the Ministry of Finance in that capacity. That officer then assumed responsibility for Climate Change activities, including participation in UNFCCC meetings. The responsibilities were further expanded in 1999, when the Initial Communication Project was initiated, to include line responsibility for the implementation of the project within the ministry.

4.2.1. CPACC Project

The CPACC Project is managed at the local level through a Steering Committee comprising of representatives of the main perceived stakeholders in the project. These stakeholders include:

- National Science and Technology Council
- Grenada Meteorological Office
- Physical Planning Unit
- Grenada Ports Authority
- Ministry of Agriculture
- Ministry of Legal Affairs
- Ministry of Finance
- Ministry of Health and the Environment
- Grenada Chamber of Industry and Commerce
- Grenada Tourist Board
- Grenada Hotel Association

Responsibility for the implementation of the different components of the projects is assigned to individual ministries/organizations, or subcontracted to private sector operators, who operate under the guidance of the National Focal Point and the CPACC Regional Office in Barbados.

4.2.2. Initial Communications Project

The Initial Communications Project is managed at the local level by the same Steering Committee that is responsible for the CPACC Project. The day-to-day project activities are managed by a National Coordinator and Administrative Officer, specifically contracted by the Project. Consultants were sub-contracted for the Sectoral analyses required by the Project and these were supervised and coordinated by the National Coordinator.

4.3. SUSTAINABLE DEVELOPMENT COUNCIL (SDC)

Grenada has an active Sustainable Development Council which was established in 1996 under the Capacity 21 Project. It has twenty five (25) active members drawn from the government sector, the private sector and the NGO community. The regular monthly meetings are attended by senior officials of these organisations.

The SDC was appointed by Cabinet. However, it is not formally institutionalized, in the sense that it does not have an independent legal basis for its operations, nor does it have a secretariat to guide its operations.

The SDC has confined itself to operating as a discussion forum on topical issues and provides a useful service to its members in this regard. It has occasionally been requested by the Government to address specific issues or perform specific tasks, the most recent of which has been to act as the Steering Committee for the National Biodiversity Project.

5. NATIONAL RESPONSE MEASURES

The national response measures described in this section are based on the foregoing analyses of greenhouse emissions and vulnerability to climate change impacts, in the context of the projections for the socio-economic development of Grenada into the medium term.

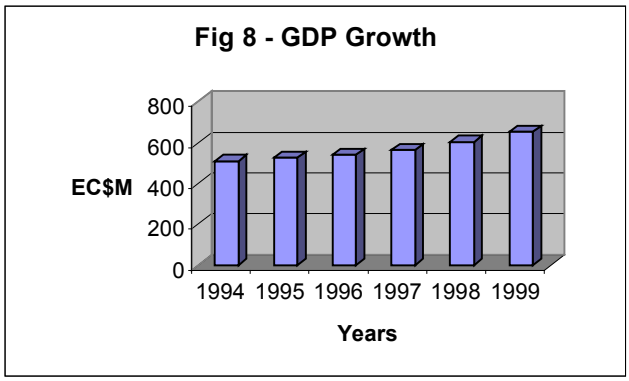
The measures recognise the critical need for Grenada to expedite the analysis and implementation of its options to adapt to the adverse impacts of climate change, while fulfilling its obligations under the Convention to reduce greenhouse gas emissions.

They represent a mix of strategies and actions that will be kept under constant review and will be revised and adapted based on evolving circumstances in each of the relevant sectors and in the overall scenario of climate change.

5.1. SOCIO-ECONOMIC SCENARIO

5.1.1. Economic Growth

The Grenadian economy has achieved relatively high rates of economic growth for the period 1995 to 1999 – **Fig 8.** The real Gross Domestic Product (GDP) expanded by an average of 7.8 percent for the period 1998 to 1999.



This relatively high growth rate must be seen against the backdrop of a stagnant economy in the early 1990's, when growth rates averaged less than 2 percent from 1990 to 1995 and 3.6 percent for the period 1995 to 1997 (MTESP 2000, IMF 2000).

The growth achieved over the last five years has been attributed to expansionary fiscal policies introduced by the Government. This included reform of the taxation system, expanded Government expenditure on infrastructural projects, public sector reform and economic diversification.

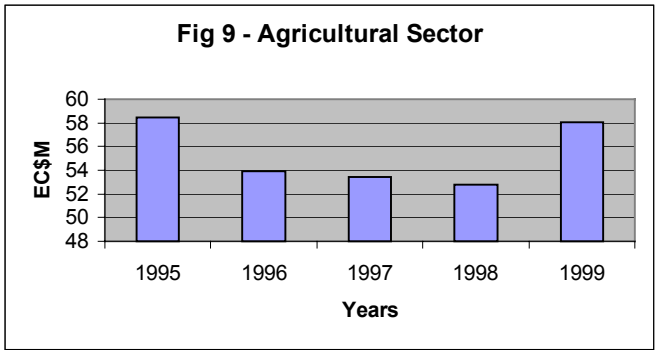
The overall growth has been fueled by the implementation of large construction projects - the National Stadium, the Ministerial Complex, the Port Expansion Project, Road Rehabilitation and Construction Projects, Residential Housing Programmes, Coastal Erosion Sea Defense Project, Basic Education Reform Project and Basic Needs Trust Fund Project.

In addition to high growth rates, the economy has experienced marked increases in real per capita income. In 1999 real per capita GDP stood at US $3,600 up from US $2,900 in 1995 (IMF Report).

The economy is expected to achieve relatively high rates of growth annually for the medium term. An annual growth rate of 5 percent is projected for the period 2000 – 2004 (MTESP 2000).

5.1.2. Sectoral Performances

(a) Agriculture, Forestry, Fisheries



Despite significant decline in the 1980s and early 1990s, agriculture is essentially the mainstay of the economy and is particularly so for the rural economy. In 1999, the sector accounted for 9 percent of the GDP, 15 percent of the employed labour force and 50 percent of merchandise exports. The 1999 growth shows a significant turn around from the negative growth achieved in earlier periods. In 1996 the growth rate was -7.8 percent (MTESP 2000, IMF 2000).

The sector has been characterized by decreased productivity and production volumes, infestation of pest and diseases, inadequacy of inputs and resources and low product prices. Attempts to address these problems achieved a measure of success in recent years. The sector remains a major source of income, employment and foreign exchange and is particularly important for the rural economy.

Fishing is an important economic activity in several coastal communities in the country. In 1999, fishing accounted for 2 percent of the GDP. Construction of a new fish market located at city center and valued at EC $ 26 million is now at an advanced construction stage and scheduled to be completed in 2001.

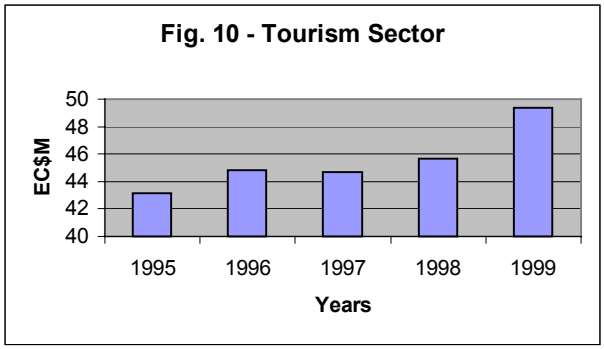
In 1999, Forestry accounted for 1 percent of the GDP. The recently concluded forestry study has outlined a medium term strategy for forestry development. Implementation of several recommendations of the study is presently underway.

The medium term outlook for the agricultural sector is for continued growth and improvement. The sector is expected to grow at an average annual rate of 10 percent for the medium term. The Government's stated policy for the sector aims to:

- achieve efficiency and economic and financial viability in the production of traditional export products, and
- promote agricultural diversification aimed at sustainable growth, food sufficiency and the development of the rural agricultural economy.

The government has embarked on a series of rehabilitation projects in this regard.

(b) Tourism



The tourism sector recorded growth of 2.0 percent and 8.2 percent for the years 1998 and 1999 respectively and is expected to grow at an average of 7 percent of the GDP in 1999. Tourism generates in excess of 50 percent of the country's foreign exchange and provides significant levels of employment. In 1999, tourism accounted for 11 percent of direct employment and 10 percent of the GDP.

The main tourism plants are located on the south coast of Grenada and coastal areas of Carriacou, mainly Hillsborough and Harvey Vale.

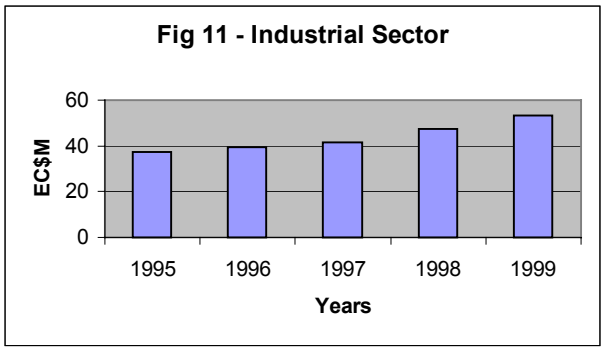
Planned plant expansion includes the construction of several hotel facilities within the next three years. The recently concluded *Master Plan for Tourism Development* detailed a medium to long-term vision of the sector, which included the following:

- The development of new attractions/sites to improve and diversify the tourism product;
- Strategic marketing programmes with airlines;
- Destination marketing based on a three-year marketing plan;
- Human resource development for industry workers including vendors, taxi
- drivers and tour guides;
- Promote the offerings of the cruise tourism sub-sector;
- Special support for the small hotels group; and
- Incentives for hotel developers thereby increasing the total bed-capacity.

The Government has embarked on the implementation of the programme and several projects are at advanced planning stages. The major Tourism Projects planned for the medium term are the following:

- 250 room hotel facility in the Grand Anse area;
- 225 room hotel facility at Mt. Hartman estimated at EC $150 million;
- Cruise ship facility and bus terminal at city center estimated at EC $170 million;
- The rehabilitation of Pearls Airport and coastal feeder roads to Levera/Chambord and construction of a 300 room hotel facility;
- The development of Marina at Ballast Ground next to the St. George's Harbor including a hotel facility;
- Hotel construction along the south east coastline in the parishes of St. George and St. David;
- The expansion and rehabilitation of the Point Salines International Airport estimated costs EC $70 million;
- Completion of the final stages of the port expansion project at the inner harbor.

(c) Manufacturing



The manufacturing sector has achieved high rates of growth of 14 percent and 12 percent for the years 1998 and 1999 respectively. The sector's contribution to GDP however remains relatively small. In 1999, the sector contributed 6 percent to the GDP and 8 percent of the labour force.

The country's manufacturing activities are concentrated in the Parish of St. George, particularly the Frequente Industrial Park. The Seamoon Industrial Park is being developed as an information center and is expected to generate 2000 jobs within the next two years. The sector is expected to grow by 3.5 percent annually in the medium term.

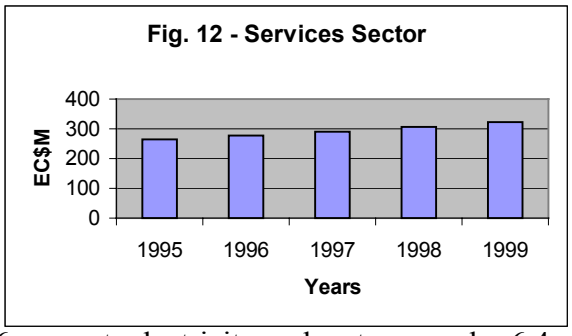
As part of the economic diversification thrust, Government is providing the enabling environment, through the establishment and expansion of industrial infrastructure, in order to encourage joint ventures between local entrepreneurs and strategic foreign investors.

(d) Construction

The construction sector has achieved a high average annual growth rate of 10.5 percent for the period 1997 to 1999. In 1999, the sector contributed 8 percent to GDP and accounted for approximately 13 percent of the labour force. The high growth has been fueled by the implementation of relatively large construction projects, namely the National Stadium, Ministerial Complex, the Port Expansion Project, Road Rehabilitation Project, Construction Project and Residential Housing Programmes.

Heightened construction activities are expected to continue in the medium term as the country embarks on a programme of infrastructure development following the impact of Hurricane Lenny. The Airport Expansion and Rehabilitation Project and the World Bank Education Reform Project are on going. Several major private sector projects have received planning approval and scheduled to begin in year 2000. As a consequence, the sector is expected to grow at a rate of at least 8 percent for the period 2000 – 2004.

(e) Services



The services sector has become increasingly important in its contribution to growth and economic and social development. Consistent with the policy of economic diversification, expansion of the services sector is evident. For the years 1998 and 1999, wholesale and retail trade has grown by 5.6 and 6 percent respectively. For those representative years, the transport sector grew by 5.6 and 4.6 percent; electricity and water grew by 6.4

and 6.2 percent; government services grew by 4.4 percent and 5.2 percent and other services grew by 4.0 and 4.9 percent.

It is significant to note that the services sector accounted for 61.4 percent of GDP in 1998, as compared with 50 percent of GDP in 1994 (MTESP 2000).

The services sector is expected to assume increased importance as the macroeconomic programme is being implemented. The financial services sector, including offshore financial services, is expected to lead the growth in the sector in the medium term. In addition, telecommunication services are expected to be a major area of focus.

5.1.3. Macro Economic Performance Indicators

(a) Unemployment

The economic recovery experienced for the period 1996 to 1999 has been accompanied by a significant decline in unemployment. In 1999, the unemployment rate was estimated at 13 percent down from 19 percent in 1996 and 26.7 percent in 1997. Unemployment rates are expected to fall in the medium term to approximately 9 percent by 2002, in response to the job creation potential in the services sector, particularly informatics.

(b) Inflation

Inflation rates have also been declining for the years 1996 to 1999, falling from 2.9 percent in 1996 to approximately 1 percent in 1999. Inflation rates are expected to remain in the vicinity of 1 percent for the years 2000 to 2002.

(c) Fiscal Operations

The economic recovery experienced for the period 1996 to 1999 was initially accompanied by deterioration in the fiscal position of the Central Government, mainly as a result of the expansionary fiscal policies adopted. During that period, income tax was reduced, higher wages were paid to government employees and the government embarked on an ambitious capital investment programme.

The Central Government deficit widened from approximately 1 percent of GDP in 1995 to 6 percent of GDP in 1997. The deficit narrowed to 3 percent and 2.5 percent of GDP respectively for the years 1998 and 1999 as improved revenue collection mechanisms were introduced, accompanied by efforts to limit the growth of recurrent expenditures and significantly improved revenue takings from the offshore financial sector.

In the medium term, it is envisaged that capital expenditure will average about 10 percent of the GDP and work on infrastructural improvement will continue. The Government will continue the policy to sustain rates of economic growth to the tune of 5 percent and will continue efforts of poverty reduction and alleviation, bolstering of employment opportunities and economic diversification.

5.1.4. Social Sector Characteristics

The characteristics of the social sector have been the focus of a recently concluded Poverty Assessment Survey, which was done by the Government of Grenada in collaboration with the Caribbean Development Bank. This survey found that 32.1% of the population was poor and 12.9% indigent.

(a) Health

Grenada attained a Medium Human Development Status and was ranked 52 on the United Nations Development Programme Human Development Index in 1998. For the period 1996 to 1999, there were improvements in Grenada's public health - **Table 11.**

The government has embarked on a health sector reform programme and is currently engaged in discussions to complete a five-year strategic health plan.

Table 11 - Key Health Indicators 1996 - 1998

Key Health Indicators	1998	1997	1996
Under-five mortality rate - total (Age 1- 4 based on total population)	0.6	1.3	1.1
Infant mortality rate – total	14.7	15.4	19.5
Maternal Mortality ratio	0	0	1.1
Underweight - moderate and severe - total (Age 0 - 4 per total population)	155	82	79
% of Under-5 Children Underweight (Age 0 - 4 based on total population)	13.9	7.4	6.9
Access to safe drinking water – total (%)	93.2	93.2	93.2
Access to safe drinking water – urban (%)	97.4	97.4	97.4
Access to safe drinking water – rural (%)	92.80	92.80	92.80
Access to sanitary excreta disposal – total (%)	96.90	96.90	96.90
Access to sanitary excreta disposal – urban (%)	96	96	96
Access to sanitary excreta disposal – rural (%)	97	97	97
HIV prevalence	1.4	1.5	1.6
DPI Immunization Coverage (%)	95	95	80
Measles Immunization Coverage (%)	97	92	85
Polio Immunization Coverage (%)	95	95	80
Skilled attendant at birth (%)	99	99	99
Low birth weight	11	8	10
Females with low haemoglobin (based on data from antenatal services)	24.5	24.7	28.4
Exclusive breastfeeding rate (<4 months) (based on antenatal services)	32.6	32	39

Source: Ministry of Health

Primary health care is a focus. The government is also committed to the construction of a new general hospital to the tune of US $26 million. The new facility is expected to be completed in 2002. Work continues on the Solid Waste Management Project, which started in 1997. The project is valued at EC $21 million and includes the construction of solid waste facilities at Perseverance and Dumfries.

(b) Education

The Basic Education Reform Programme financed by the World Bank began in 1996 and is the central project of Grenada's Education Reform Programme. The programme aims to prepare a strategic long-term plan for the education sector in the country. It includes capacity building in the sector and improvement in the existing infrastructure. The programme runs in concert with the OECS Tertiary Education Project, which seeks to build capacity and infrastructure at the tertiary level and the computerization of schools project, which seeks to equip all schools with state of the art computer facilities.

The government has declared that the development of the country's human resources constitutes the single most important element of its education and development strategy.

The recently concluded poverty assessment survey analysed the education sector and found that the educational attainment of the population is generally low with a correspondingly low level of educational certification. Access to secondary and tertiary education was found to be very limited and constitutes a significant barrier to the transformation of the economy to skill and knowledge based productive activities.

It is envisaged that significant increases in resources will be available for the education sector.

(c) Housing

The previously referenced Poverty Assessment Survey revealed that about 40 percent of the Grenada housing stock are in need of significant improvements and may be classified as inadequate or unfit for human habitation. Attempts to address this concern are ongoing and are expected to intensify in the medium term.

(d) Community Development

In the areas of community development, the Government aims to improve the social infrastructure of communities especially in the rural communities. A rural development policy document has been prepared and submitted for comments from civil society organisations. Within the medium term, the Government plans to implement human resource development training for community groups and to actively support small and micro enterprise development.

To this end, there are plans to establish a rural development commission and a micro enterprise development board. Plans are also afoot to establish a rural development fund. The government has established a Multipartite Consultation committee comprising senior members of government and leaders of civil society organisations - private sector organisations, the trade union movement and the NGO community - to interface on all issues of national development including community development activities.

(e) Population

The 1999 estimate of Grenada's population stands at 100,500 persons, with an estimated population density is 292 per square kilometer. The annual rate of population growth for the last ten years stands at 0.6 percent. The last population census conducted in 1991

revealed that 95,597 persons were resident in the country (Central Statistical Office). The authorities are presently preparing for the year 2001 census scheduled to begin in April 2001.

The 1991 census revealed that there were 21,974 households in the country. The 1999 estimate of the number of households stands at 25,125. The average household size is approximately 4 persons (MTESP 2000).

The current annual population growth rate is 0.6%. However, given the reduced opportunities for emigration (net immigration decreased from an average of negative 2700 in the 1970s to less than negative 1000 by mid 1990s), the growth rate is expected to increase. The population is therefore expected to grow faster during this century than during the previous during which time population grew by 60% (Central Statistics 1997). Conservative projected population for 2011 is 104750 (Central Statistics 2000).

Based on the current trends, the greatest portion of Grenada's population will be located in the Grand Anse-St. Georges area. Unless economic activities can be stimulated in the rural areas, the rural-urban drift will continue.

The environmental stress resulting from an increased population would be increased by the increasing tourist arrivals. Stay over visitors increased annually by about 7% during the 1990s (GOG/OAS 1997), while cruise ship visitors grew by about 5%. At such rates, human activities and the associated stress on the environment would double before the next 20 years.

(f) Land Use Patterns

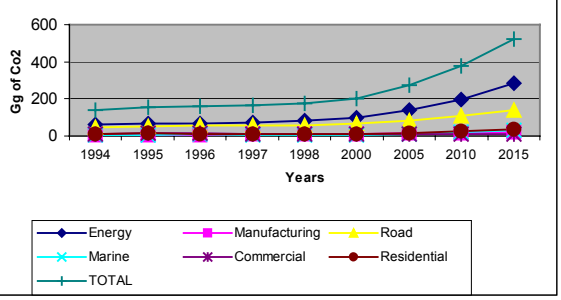
The competition for available land for housing, agriculture and tourism development would see a shift in the current land use pattern. Planned hotel and golf course developments would see significant tracts of prime agricultural lands going to the tourism sector.

There is a culture of land ownership where there is a great desire to own an individual lot of land and parents view it as a parental responsibility to ensure that, as far as possible, their children own a lot of land. This would contribute to continued fragmentation of present land holdings and would lead to difficulties in future planned development involving lands. Agricultural development would have to be more intensive involving irrigation and high agrochemical use. This would be one way of making agriculture sustainable. However, this would lead to pollution of the water resources.

5.2. GHG EMISSIONS SCENARIO

The rapid economic growth in the 1994 – 1998 period has been accompanied by comparable increases in GHG emissions. $CO_{2\ emissions}$ from electricity generation increased by 33%, from road transport by 20% and from manufacturing and construction by 142% - **Fig. 13.**

Fig. 13 - Trend in GHG Emissions



Given the characteristics of energy demand, no fundamental changes are envisioned in the pattern of consumption of petroleum products and the latter will continue to maintain the majority share in the total energy demand.

Significant rates of increase of CO2 emissions can therefore be expected to continue in the immediate future based on the projections for economic growth.

Fig. 13 highlights the baseline GHG projections to 2015, assuming no change is made to the current pattern of energy consumption within the economy. The projection is based on the exhibited trend for the past five years. Using the extreme values of the 1994 – 1998 sectoral energy consumption data, the growth rates were computed using the following formula:

$$\text{Growth rate} \quad i = (Z_f/Z_o)^{1/t} - 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Subsequently, the sectoral demand was computed by applying the growth rates values in the formula (1) to give:

$$Z_f = Z_o\,(1+I)^t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where;

Z_f = the final demand in a sector in year t.

Z_o = the sector demand in the base year (to = 1994).

t = the time that has transpired (with reference to the base year).

5.3. SPECIFIC POLICIES AND MEASURES

5.3.1. Institutional Framework

Grenada will establish a coherent institutional framework for the management of the environment.

This framework will maximize the synergies which exist between climate change and the many other environmental issues that are of concern at the national level and will maximize Grenada's participation in the various environmental conventions to which it is a signatory.

This institutional framework will include:

- *Responsibility/Authority* – A centralized locus of responsibility and authority will be identified for the management of environmental issues and concerns. This centralized authority will be responsible *inter alia* for providing overall guidance and management on environmental issues, as well as for the facilitation and co-

ordination of the relevant activities being implemented in other ministries and organisations.

- *Policy Framework* – A Policy Framework will be developed for the management of climate change issues. This framework will use, as a starting point, the policies and measures proposed by this Initial Communications Project. It will expand and develop on these basic proposals through a participatory process that will involve stakeholders at every level in the society, including the residents of the communities expected to be impacted by climate change.

- *Legislative Frameworks* – Appropriate legislation to support the implementation of climate change policies and measures will be enacted, once the appropriate analysis has been completed.

5.3.2. Mitigation Strategies And Options

The principal objective of the National GHG Mitigation Plan is the reduction of greenhouse gases emanating from the energy and non-energy sector, through the implementation of policies, strategies, and specific measures for the different GHG emission sectors. The plan addresses:

- the supply and demand of energy;
- the management and treatment of waste;
- the protection of forestry reserves; and
- the management of land use.

(a) General Options

The available options for mitigating the level of GHG emissions are:

- Increasing the efficiency of energy use throughout the energy chain. This will contribute to the reduction of GHG from this sector, and will positively impact on the cost of production (thereby enabling or enhancing national and international competitivity).

- Optimizing electricity generation, transformation and distribution systems, in order to improve the overall efficiency.

- Developing and implementing demand-side management, and energy conservation programs in the electricity sector by the respective utility, in order to:
  - Invest in new technology, and more efficient processes and equipment; and;

  - Induce or convince the consumer to behave differently and thereby conserve energy.

- Pursuing energy diversification, through the application/use of appropriate and sustainable alternative sources of energy.

- Development and execution of forestry management plans that are designed to protect and conserve forestry reserves and to increase their stocks of carbon.

- Effective management and treatment of wastes (Solid and Liquid) from landfills.

(b) Mitigation Strategies

The strategies for the mitigation of greenhouse gas emissions have been formulated in an integrated manner, taking into consideration the following factors:

- Information campaigns
- Technical assistance
- Policies and incentives (including fiscal incentives)
- Standards and legislation/regulations
- Prices
- Financial support, and
- Enabling institutional frameworks (with responsibility for application of the proposed mitigation strategies).

In order to reduce Grenada's current and future levels of GHG emissions, due consideration and support will be given to the development and implementation of relevant/appropriate strategies, including:

- Strengthening the technical capacity of the departments of the various ministries - Energy, Forestry, Land Use, and the Environment - which are charged with the responsibility of developing policies and the implementation of measures related to the mitigation of GHG emissions.

  This will involve not only investment in human resource development, but also in the required resources/tools to enable proper planning, forecasting, modeling, establishment and maintenance of relevant databases. Consideration will be given to the strengthening of capabilities in the area of project preparation, evaluation, and management.

- Promotion and encouragement for the strengthening of national capacity/potential within the public and private sectors to deliver specialized technical assistance in the field of Energy and Environmental Audits, and the conducting of feasibility studies for the implementation of projects related to GHG mitigation.

- Developing and encouraging a culture of efficient use of energy using analysis, identification and application of persuasive and corrective instruments, in order to:

  - Raise awareness and change consumer behaviour;
  - Achieve a gradual substitution of high energy consuming equipment by greater energy efficiency equipment;
  - Encourage the substitution of conventional energy sources by renewable sources;
  - Replace old contaminating/polluting technology and processes with clean ones.

- Requesting technical assistance for the formulation and development of an integrated National Energy Plan, that would address, among other things, energy

conservation, energy diversification, and the application of clean, appropriate technologies, through the use of demonstration, or pilot projects.

- Development and execution of public awareness and education programmes to address issues relating to:

  - Climate Change and the effects of GHG emissions on Global Warming; and
  - the Promotion of GHG Mitigation Programs proposed for specific/targeted sectors.

- Defining and establishing innovative and proper financing mechanisms to encourage the execution of programmes and projects designed to reduce GHG.

- Adopting other appropriate measures, including the use of the Grenada Bureau of Standards, in the definition and development of national standards for atmospheric emissions (industries, vehicles), minimum efficiency ratings for appliances (residential), industrial (motors and equipment in general), commercial (illumination) and others. The enforcement of these standards should ensure that obsolete equipment and appliances from developed countries are not being dumped into Grenada as a result of higher standards being introduced into these developed countries.

(c) Specific Elements of the National GHG Mitigation Plan

The following identifies and summarizes several instruments/tools and measures that will form part of Grenada's GHG Mitigation Plan. These have been divided into two broad categories: *persuasive and corrective*.

(i) Persuasive Tools (**Fig. 14**)

- **Information and Technical Support Measures:** The principal objective of these measures are to sensitize/ build awareness, educate and inform the general public on the importance of energy as an essential factor for the social and economic development of the country, and likewise, of the necessity to make effective use of energy resources in a sustainable manner.

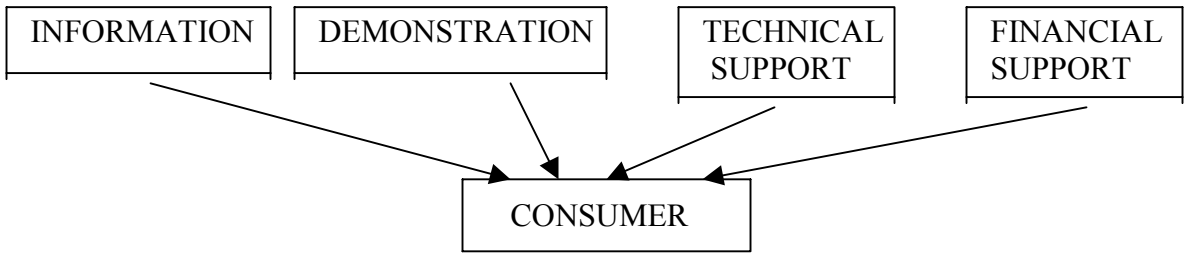
- **Demonstrative Measures:** In order to demonstrate the technical feasibility and economic viability of proposed mitigation projects and programs, it will be necessary to execute/ realize pilot projects in the targeted consumption and supply sectors. For example, consideration could be given to the use of alternative energy (solar/photovoltaic) to provide street lighting in several communities.

  The introduction of programmable controls for the operation of lights and air-conditioners, as well as the retrofitting of government buildings with low wattage high efficiency lighting are candidates/areas for pilot projects of this kind. It will be equally important to make the results of these pilot projects available to the relevant enterprises, and umbrella organizations of the chosen sector.

- **Financial Support Measures:** One of the obstacles or barriers to the execution of programs is the unavailability of financial resources. It would be necessary to

establish adequate and *appropriate financial support mechanisms: e.g., Special Credit Lines, and other innovative modalities. Rebates and tax concessions, and a quota of duty-free imports can be possible ingredients for the menu of financial measures*. In this regard, consultations should take place between the Government (Ministry of Finance) and the financial sector to encourage support for these measures.

Fig. 14 – Persuasive Tools



BARRIER	**TOOL FOR BARRIER REMOVAL**
IGNORANCE	INFORMATION
SCEPTICISM	DEMONSTRATION
LACK OF TECHNICAL RESOURCES	TECHNICAL SUPPORT
LACK OF FINANCIAL RESOURCES	FINANCIAL SUPPORT

(ii) Corrective Tools (**Fig. 15)**

These are intended or designed as complementary measures to the afore-mentioned persuasive measures/tools. They consist of:

- **Regulations:** The formulation, adoption and enforcement of regulations geared to:

  - Establish incentives and benefits to encourage research and development of non-conventional energy resources and the use of clean technology.

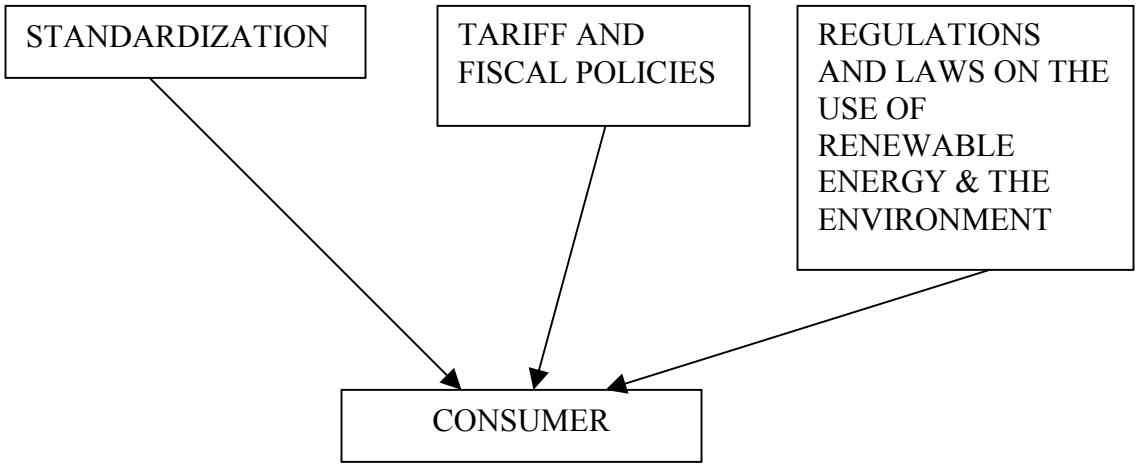
  - Establish legal obligations on the part of the producers, consumers of energy, the manufacturers and importers of equipment with regard to energy efficiency levels and the environmental impact of products imported and consumed.

  - Promote the marketing of products and services that contribute to environmental protection and the efficient use of energy.

- **Tariff and Fiscal Policies:** To formulate and implement tariff structures and fiscal policies designed to promote the rational use of energy and reduce the associated environmental impact of such energy use.

- **National Standards:** Grenada currently does not have any national standards relating to emissions of contaminating gases. Hence, by adoption of relevant standards, one shall be able to control both local production and importation of equipment which shall comply with, or fulfill, certain prerequisites of efficiency and environmental friendliness. Additionally, the standard should also be able to inform the user of the said equipment of its energy consumption rating.

Fig. 15 – Corrective Tools



BARRIER	**TOOL FOR BARRIER REMOVAL**
LACK OF EMISSION STANDARDS	NATIONAL STANDARDS
LACK OF INCENTIVES	TARIFF AND FISCAL POLICIES
RETICENCE	LEGISLATION AND REGULATIONS

(iii) Targeted Sectors

According to the structure of energy demand in Grenada, the electricity sector is the largest consumer, followed by the transport, residential, the industrial manufacturing, and the hotels/restaurants (hospitality) sectors.

Priority for the application of GHG mitigation measures is assigned to those sectors with the highest energy consumption, because of the scope for greater reduction in GHG emissions.

(d) Proposed Action Plan

The following summarizes the series of activities and projects under the areas of energy demand and energy supply.

In order to apply mitigation measures, priorities are assigned to the sectors with the largest energy consumption, because in these sectors it would be possible to achieve the greatest reduction of greenhouses gases.

(i) Energy Demand - Transport Sector

- Energy Efficiency and Environmental Protection Program.

    - Better engine and tyre maintenance, and driver training;
    - Introduction of trade regulations, tariffs aimed at fuel efficiency, and domestic fuel taxes.
    - Formulation and implementation of a procurement policy for vehicles in the public (Government) sector. The latter should be aimed at increasing fuel efficiency - shifting the mix of vehicles towards more efficient models, and the utilizing vehicles with capacity to transport large groups of passengers and load.

- Implementation of proper (scientific) Transport/Traffic Management.

    - Control changes in traffic flow through improved traffic signal timing,
    - Adopt measures to encourage increased capacity utilization.

- Public education and information campaign.

- Dissemination of leaflets, pamphlets, and brochures on vehicle selection, maintenance, control of fuel combustion and emissions and good driving practices.

(ii) Energy Demand - Residential Sector

- Public education and information campaign designed to change the behaviour/consumption pattern in this sector, viz:

    - Introduction of the population/public to more efficient equipment (Toasters, Microwave Ovens, Refrigerators/Freezers, Air-conditioners, Washing Machines, Dryers, Electric Irons etc.).

    - Introduction of Compact Fluorescent bulbs and timers/switches to low-income consumers via the removal of CET, and domestic taxes/levies.

    - Adoption of Standards for the Certification of electronic and electrical equipment/apparatus.

- Solar Building Designs Project - This project is aimed at providing the public with a menu of architectural designs for residential buildings that would take advantage of among other things, optimal natural lighting and cooling of the building envelope.

- Introduction of incentives for the substitution of electricity by renewable energy, e.g. the use of solar/wind energy for water heating and water lifting (pumping), etc.

(iii) Energy Demand - Industrial Sector

- Program/project to disseminate information on energy audits, rational use of energy, energy diversification and clean technologies.
- Project to build national consulting capacity in topics relating to energy and the environment.
- Project for the Standardization and Certification of industrial equipment.
- Integration of Climate Change Topics/Issues in curricula of technical studies.

(iv) Energy Demand - Service Sector

- Information program in the efficient use of energy and energy diversification.
- Retrofitting of existing public lighting with more efficient low energy consumption types/models.
- Procurement and application of more energy efficient lighting, air-conditioners, and the like.
- Energy conservation Program in the Public Sector.
- Program of training and technical assistance in order to achieve and sustain efficient use of energy.

(v) Energy Supply - Generation

- Pilot project to generate electricity on the Island of Carriacou using renewable source of energy: Wind.
- Project to improve the efficiency of generators.
- Cogeneration Project.

(vi) Energy Supply - Distribution

- Project for the reduction of Losses (technical and non technical).
- Improvement in the efficiency relating to the control and administration of electricity distribution.

(vii) Production

- Program for the achievement of greater energy efficiency in energy transformation centers.

(viii) Methane/Waste Sector

There are two approaches to reducing the methane emissions from landfills, these are:

- The resultant methane can be recovered and then either flared, or used to produce energy; or

- The quantity of landfill waste can be reduced through source reduction, recycling, or other waste management practices.

With respect to the first option, there are no immediate plans to recover the methane generated in Grenada's new sanitary landfills. However, consideration will be given to the recovery and utilization of the methane produced for the supply of GSWMA's energy (cooking, lighting, and refrigeration) needs on the new landfills. This may be the object of a future demonstration project.

The Grenada Solid Waste Management Authority (GSWMA), is currently focusing on the second option, the ***recycling***, ***reuse***, ***composting***, and ***the smart selection of materials for use***, as practical low-cost measures for waste reduction.

It is evident that there are low cost options for controlling /reducing methane emissions, as well as some longer-term opportunities which can be assisted by suitable technology development.

In addition to plans to reduce the production of domestic waste, there are also plans to treat commercial and industrial waste before discharge into aquatic and terrestrial environments. 'Raw' effluent contains pollutants which can disrupt the dynamics/operations of organisms present in these environments. This can lead to extinction in some cases, resulting in a loss of biodiversity and/or the collapsing of an entire ecosystem(s).

(ix) Forest Conservation

Support for the implementation of the Forestry Policy and Action Plan which is aimed at ensuring that the national forest reserves are preserved and developed in a manner that would preserve their biodiversity, and would contribute to maintaining the ecological balance within the country.

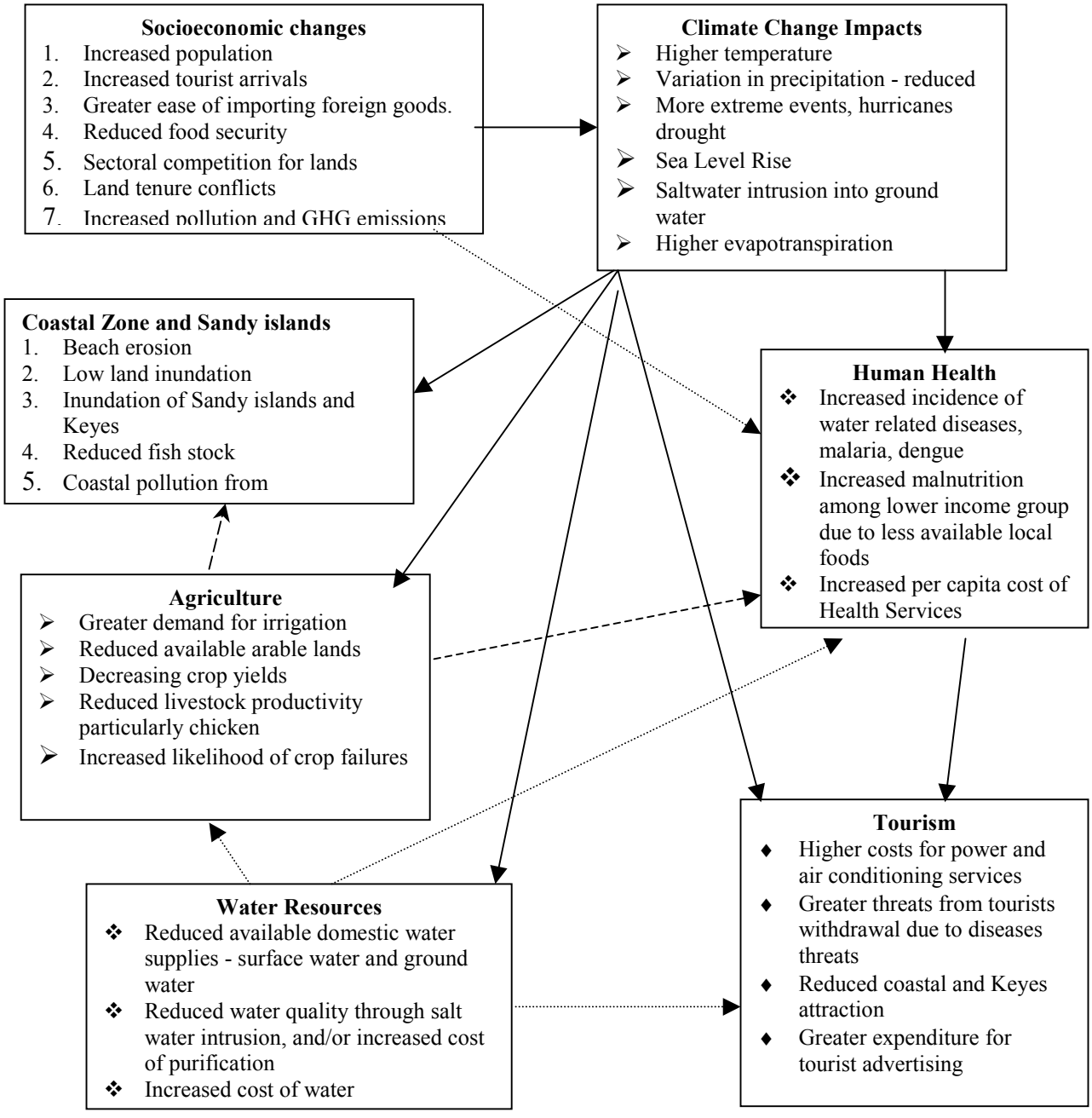
5.3.3. Adaptation Strategies And Options

Grenada, as a Small Island Developing State is vulnerable to seal level rise and the other potentially adverse impacts of climate change. Adaptation to these adverse impacts of is therefore critical to Grenada.

Adaptation should not be considered exclusively from a closed climate change perspective, since socioeconomic issues would influence the impact of those changes. The adaptation strategies must therefore be considered in their relationships with other change factors within the country.

As a first step to guiding the analysis of the adaptation options, the interaction of effects is simplified and summarized in **Figure 16.**

Figure 16: Interrelations Of Sensitive Sectors To Climate Change Adaptation



The level of understanding of the interaction of these factors needs to be upgraded. A critical activity in this regard is the closure of the data gaps identified in the Vulnerability Analysis.

These data gaps and strategies for addressing them are summarized in **Table 12** below:

Table 12 – Critical Data Gaps for Understanding Impact of Climate Change

SENSITIVE AREA	DATA REQUIRED	AVAILABILITY	DATA LOCATION AND QUALITY	RECOMMEND-ATIONS
Water Resources				
Ground water	Aquifer thickness (geology) Aquifer boundaries ** Yields Chemical composition	Very little Very little Limited to a few sites Limited to test sites	NAWASA	Development of a comprehensive program to investigate the ground water potential and to map out the ground water resource.
Surface water	Stream flow	Available for Castaigne Bridge (1989-1990), Nianganfoix (1989-90); St.Marks(1989-1990); Marquis 1987-1988)♣	NAWASA/CMI Data records very short Some data missing from NAWASA	A project to collect stream flow data on a continuous basis must be established Retrieve data from CMI to develop a total data set at a center responsible for Climate Change
	Temperature	Available for Pearls and Point Salines on a continuous basis	PSIA & Statistical Department The minimum period of 30 years is not available for any set of data	As the significant portion of agriculture is in the mountain regions, temperature and humidity data at these points should be collected
	Precipitation	Available for many stations throughout the island	Much of the data is non continuous Land Use Dept	Research on hydrologic characteristics needed
	Catchment areas and hydrologic characteristics	All areas available	Most data on GIS NAWASA	
	Water demand, supply, storage and quality	All data available	Good Data	
Rainwater	Precipitation Evapo-transpiration			
Agriculture	Crop yield	Crop yield data not available for major crops	MOA, Statistical Dept. Commodity Boards.	The Ministry of agriculture should set up a monitoring project to collect a good data set on the yield for the major export crops
	Annual crop production	Annual nutmeg, cocoa and banana production	The data is disjointed and is of moderate quality	

♣ Hydropower Development Plan Grenada 1990

	Total annual acreage per crop Damages by pests and diseases	Not available Not available		
Coastal environment	Rates of beach erosion Storm surges and history Tide properties State of mangrove and wetland areas Health of corals Geology, landforms, soil types	Data available for 1984 onwards Tidal gages recently installed and data being collected Some data is available	National Science and Technology Council CPACC Land Use Dept	The current beach monitoring project (UNESCO) should be continued and strengthened with capacity building Need to research previous work particularly from the colonial period
Human Health	Records of communicable diseases Vector breeding grounds Climate cycle Health Facilities	Good data for at least 25 years on most common diseases Available Available	Ministry of Health Good quality data Public Health Dept MOH and Private Hospitals	Need to create a digital form of the existing data. Need to research disease occurrence and various weather conditions Need to collect and document all the facilities available in the country
Population	Current population Project population	Data available from previous census,	Statistical Department Pre 1960 data suspect	The practice of regular census is sufficient

From a strategic adaptation perspective, there are many options available. Many of these are 'no regrets" options, which would be beneficial to Grenada, whether or not the anticipated adverse impacts of climate change actually materialize.

(a) Water Resources

The Adaptation responses must address the immediate objectives of making water accessible to all in adequate quality and quantity at affordable prices. The responses must also address anticipated changes in water availability due to climate Change and Sea level Rise.

There has been extensive capital investment in water supply infrastructure, US$18.2 M during the 1990s, (Smith 1999) and the high projected investment now being considered by NAWASA. These include (EC$ 72.0 M mostly external funds as loans and grants) for domestic supply. *The development of these projects has not addressed the impacts of Climate Change at the design stage, nor has it been considered in the overall sustainability*

of these projects. As no regret option, consideration of climate change impacts would now be included in the design and formulation of all future investments.

In addition, there are many other adaptation options that can be implemented in order to achieve the desired objectives.

(i) Improved Water Resources Assessment and Monitoring

To truly develop adaptation approaches for water resources a good picture of the current status of the available water resources is needed. There is need to *adequately assess and monitor the present situation*. Good long records of stream flows and the quantity and quality of ground water are not available. Efforts to obtain these data in the past have not been sustainable. A regular monitoring program implemented by well-trained staff is a good approach. External assistance for such programs will be considered, as local funding may not be adequate.

(ii) Planning and Management of Water Resources

Effective *land use planning and management* are crucial for the protection of water resources to ensure quality - i.e. non-contamination from point sources, or from agriculture - and quantity, in terms of stream flows to upper reservoirs. Although current legislation may be adequate, enforcement of laws to protect the upper watersheds is lacking. The ground water potential, not yet exploited, should be strictly protected from pollution through solid waste, nitrates from agriculture, or from sewage contamination. Residential development in groundwater catchments would be constrained.

Reducing the high level of leakage in the present water distribution systems would significantly increase the available water. The leakage detection program and an upgrade of the current distribution system, now partially in place, would be strengthened and expanded to take in the entire country.

The short history with metering of homes has demonstrated the huge benefits from the programme through water conservation. A *universal metering program*, "a pay for what you use" is critical to sustainable water supply in the future.

The integrated management of human, social and economic activities, with care for catchments and groundwater units, forms the backbone of affordable and sustainable water supplies for communities, farms and industries in the future (World Water Vision). The water resources should therefore, be managed in an integrated manner.

(iii) Protection of forest reserves

The importance of forests in the sustainability of the water resources is well documented. Through its recent Forestry Policy, Grenada has identified environmental services, water supplies for domestic use, tourism, soil and water conservation and biodiversity as important links to forestry (Bass, 2000). *The Forestry Policy and revised regulations would be implemented* to ensure that sustainable supplies are achieved. In addition, deforested areas in Carriacou: Petite Carenage, Belle Vue and Petite Martinique would be reforested.

(iv) Rainwater collection

Carriacou, Petite Martinique and some remote communities have a long experience with the use of rainwater as their prime water resource. On Carriacou and Petite Martinique and remote areas in Grenada, there is still scope for the *expansion of the rainwater collection from all community buildings*. *Minimum sized water storage tanks* would be part of the building requirements, similar to the approved design standards for septic tanks.

(v) Desalination

Desalination plants are used in some Caribbean Islands e.g. Aruba, U.S. Virgin Islands, Cayman Islands, Antigua and Bermuda, with new plants planned for Trinidad and Barbados. In Grenada, 3 plants have been set up.

Desalination is a relatively expensive and complex method of obtaining water for small Islands (UNESCO, 1991). The cost of producing desalinated water ($18.00/1000 gallons to $26.00/1000 gal) is much higher than developing the surface water ($6.00/1000 gallons to $8.00/1000 gal and groundwater (($10.00/1000 gallons to $12.00/1000 gal) supplies.

These other sources would be exhausted before establishing dependence on desalination.

(vi) Importation

Importation of water to Carriacou and Petite Martinique during extreme drought or emergencies from mainland Grenada or another Windward Island could be considered an adaptive method. However, if the rainwater option is fully expanded, this might be unlikely.

(vii) Non-potable water sources

Non-potable water sources include seawater, brackish groundwater and wastewater. Seawater and brackish ground water could be used in coastal areas for toilet flushing and fire fighting and could be an adaptation option for Carriacou and Petite Martinique. Brackish water found in areas like Windward, Petite Carenage and Belle View in Carriacou can be used for bathing and washing in some instances.

(viiii) New water storage

The construction of new water infrastructure as an adaptive measure should only be considered after all efforts to improve the current facilities are considered and implemented.

(ix) Community Education and Awareness

There is a common belief that water is gift from God and should not be paid for. This cultural belief is reflected in how the population treats and uses water. The need for *effective Education and Awareness about the issues related to water resources*, is not only influenced by the possible impact of climate change on water resources, but also by the other factors that impact on sustainable water resources management.

As the population increases, as more emphasis will be placed on irrigated agriculture and, as the need for new lands push the lower borders of the water yielding watersheds towards the mountains, the available water resources would be placed under increasing pressure. It is thus important that the population be encouraged to be involved in water supply and water management issues.

(x) Conservation

Although there is an abundance of rain during part of the year there are periods of great shortages. It is particularly during periods of shortages that good conservation techniques should be applied. Many households have installed water storage tanks so that they have sufficient water during periods of rationing. Tax incentives for households with such tanks may be considered.

Further, women and children are the prime users of domestic water. To reduce the current wastage and to improve conservation at the domestic level, the support of these groups is essential. The current efforts of NAWASA will be complemented by other programs at school and community levels.

(b) Agriculture

With the loss of preferential markets, the future trends in agriculture in the Caribbean and in Grenada in particular, would be based on an increasing export orientation, with larger producers who will indiscriminately produce on limited land area using increased mechanization, irrigation, agro-processing and agro-chemical use (Paul 1997). This would require Policy interventions that address more water for irrigation, more intensive production systems and improved management of the arable land base.

Adaptation responses in agriculture in Grenada must address the anticipated impact of Climate Change on the traditional sector, keeping in mind at the same time, the possible direction of the agricultural industry.

(i) Development of a National Land Use Policy

One of the missing components of the enabling environment for the development of agriculture, is a national land use policy. The competition for lands for varying purposes has seen the shift of some of the best agricultural lands away from agricultural production, to housing and other sectors. In some cases, steep lands unsuited to farming have been cultivated, leading to substantial soil erosion (no official estimates of affected soils are available).

During the past 100 years, four land use laws were enacted to create an enabling environment to promote cultivation at the highest level and to the make best use of Grenada's land. These acts are: "The Land Settlement Act of 1933', 'Land Acquisition Act 1945', The Land Development Control Act of 1968' and 'The Land Development And Utilization Act of 1982'.

The effect of these acts has been of little success. In 1999, the Government once again initiated the development of a National Land Use Policy which would create the environment for orderly socioeconomic development involving lands. The implementation

of this policy is crucial as most of the adaptation options for the sensitive sectors of agriculture, coastal zone, tourism and water resources depend on optimum land use.

(ii) Efficient Irrigation Water Use

Higher temperatures, higher evapotranspiration and longer and severer dry seasons would create larger soil-water deficits (reduced naturally available water for plants) and a need for irrigation water. In order for future agricultural production to be competitive, the methods applied by farmers have to change. Efficient banana production requires large quantities of water.

This has not been the case in Grenada, at least in the past 20 years and now strong recommendations for irrigation schemes involving 400 to 500 acres have been proposed (Banana Recovery Plan, 1998). Further expansion, in the future, of this initial proposal would mean greater water requirements. Currently, a request is before the FAO for assistance in undertaking a project to develop a national policy and program for irrigation.

The development and maintenance costs for these schemes would be substantial particularly in the cases of small farmers. The cost of the water would be high and in the case of extreme dry events, limiting. In this regard, at the onset, such irrigation schemes should ensure optimum use of water through the use of drip and micro-sprinkler irrigation techniques.

(iii) Agricultural Diversification

Since Hurricane Janet in 1955, crop diversification has been a key element in Grenada's agricultural strategy. The wide range of crops and the experiences gained in the past 45 years in producing in such an environment, give farmers a natural advantage to respond to climate change. The degree of impact on the various crops would differ. A wider selection of crops would allow farmers to identify the most resilient and sustainable crops over time.

As an adaptation measure, the agricultural diversification program would be strengthened to include research and development in different cropping patterns and yields, under different field conditions, for existing crops.

(iv) Soil and Water Management

Climate change would bring a variation in the amount of precipitation. This means that in the future the management of soil and water for efficient agricultural production is a critical issue.

There is currently a gap in the theory and practice of soil water management in Grenada. As an adaptive response to environmental changes it is important that the Ministry of Agriculture develop and implement a soil and water management program. This would include soil and water conservation techniques, particularly low cost techniques like zero tillage and grass contour barriers. Soil and water management impinges on a number of entities including NAWASA, Forestry, Ministry of Agriculture and Fisheries. Therefore an integrated approach to the management of these resources would be ideal.

In addressing the recommendations in the various sectors in the Small Island Developing States (SIDS) Programme of Action adopted in Barbados in 1994, it was recognized that a more integrated approach to water resources was necessary. A number of meetings on Integrated Water Resources Management have been convened in the region (Trinidad, 1997, Trinidad, May 2000 and August 2000) and have recommended a Water Resources Master Plan for the region to be possibly funded by national, regional and international agencies. Such a project could be eligible for GEF funding through the International Waters focal area.

(v) Agroforestry

Grenada has a rich history in forest crops namely nutmegs, cocoa and other spice trees. The advantage of this form of agriculture is that there is an enhancement of natural soil and water management through conservation. The use of economic forest trees with other economic crops like christophene, passion fruits and tropical cut flowers would be encouraged.

(vi) Research and Development Unit

Most of the research and development that would be needed in response to climate change adaptation would generally be outside the budgetary means of Grenada. However to benefit from research innovations, the Ministry of Agriculture must set up a Research and Development Unit that would primarily source and apply new innovations to local situations.

(c) Coastal Zone and Tourism

For the hundreds of thousands of Europeans and North Americans that visit Grenada every year, it is Grenada's coastlines which form the focus of interest. And of the coastline elements, it is the beaches which are the most visible and attractive and for many encapsulate most completely the Grenadian experience. Grenadians on the other hand generally view the beach more pragmatically as a place or recreation or a place where boats can be built, launched, pulled up or a place to collect sand for construction.

Measures to protect coastal zones are important to ensure their long term sustainable management. Such measures include policy, legislation and enforcement to ensure that construction and extraction activities do not endanger sensitive margins.

(i) Engineering Works

To mitigate the impact of coastal erosion, major engineering works including the construction of well-designed sea walls, from concrete, stones and other appropriate materials, currently being undertaken, will be continued. The costs of sea defense work is high - for example work on the Duquesne road excluding sea walls was two million Eastern Caribbean dollars (GOG 1999) while the cost of sea wall is EC$4500.00 per meter. Hence the use of this option should be in critical situations. The sustainability of this adaptation option requires a planned program of adequate maintenance.

(ii) Building Setbacks

Development on the seacoast is limited to 50 meters from the high-water mark, or 3 meters above sea level. Unfortunately this has not been practical in some cases and the law is not enforced. The minimum distance would be more stringently enforced and may be revisited to take into consideration the effects of climate change and sea level rise. All these would be included in a New Building Code and a Land Zoning Policy, that would consider structures throughout the country addressing particularly extreme events-scenarios.

(iii) Flood Control Measures

Research into appropriate technology for sustainable flood control measures in the major commercial centers that are prone to flooding – e.g. Grenville in St. Andrew's and Hillsborough in Carriacou – will be initiated. The historic records show that Grenville once had such a flood control system in place using wind energy.

(iv) Mangrove Replanting

Most mangroves now form part of the national park reserves where activities are controlled. The mangroves at Tyrell Bay, Carriacou, a major source of oysters needs to be included as a national park. In addition, where possible, efforts would be made to reforest some of these areas.

(v) Relocation

The storm surges of late 1999 displaced The Lance community in Gouyave after 12 homes were destroyed. A few months afterwards, residents have been returning, reconstructing in the same area. Efforts were made by Government and other NGOs to encourage these affected residents to shift to higher grounds. Without the necessary legislation and enforcement mechanisms, recurrence of similar situations is likely.

In areas where the cost of the protection work is excessive for the given benefits to be realised, abandonment and relocation would have to be used as an adaptation option. As an example, the beach communities on The Lance, Gouyave or the beach communities at Soubise and Marquis in St. Andrew's.

(vi) Location of Hotels

Most of the Hotel plant is located on the coastal beaches. As Grenada is not a large country, most locations are within easy reach of the sea by road. To reduce the vulnerability of the hotel plant to sea level rise and climate change, government will encourage the development of hotel and other tourism facilities inland, away from the coastline.

(vii) Roads

Where coastal roads are to undergo major upgrading, relocation of such roads further inland would be considered. The roads on the Carenage (Inner Habour) which cannot be relocated would be studied to obtain suitable alternatives.

(viii) Substitution for Local Sand

Beach erosion, particularly in areas like Telescope in St. Andrew's and Palmiste in St. John's, are associated with sand mining. Alternative sources of sand, or its substitute, for concrete mix must be explored. Inland sand may be imported from Guyana, Trinidad or Martinique if this meets the physosanitary requirements. Crushed local red and black gravel has been shown by the Gravel and Concrete Company to be an adequate replacement (Samuel 2000).

(d) Human Health

The great uncertainty regarding the impact of climate change on human health requires resources to be provided for understanding the current health problems and how they may be affected by climate change. As these resources may be outside the reach of Grenada, regional collaborative approaches would be developed to ensure such an adaptation requirement.

At the local level adaptation to climate change to ensure good health would require comprehensive national health policies to include planned education programs with community involvement. However, adaptation measures need to be relevant to the current situations and not be over emphasized on predictions of future events. Specific adaptation methods would include:

(i) Surveillance and Monitoring

The Ministry of Health will install or reinforce surveillance and monitoring systems for health problems and monitor the levels of mosquitoes (*Aedes, Anopheles, Culex*). Malaria, dengue and dengue heamorrhagic fever awareness programmes are essential to reducing public health risk of these diseases.

Eradication of mosquitoes by spraying has been effective in the past. However, the high financial and environmental costs have led to a reduction of this approach. There must be a balance between spraying and the need for integrated pest management designed to control recently introduced agricultural pests.

(ii) Infrastructure Development

Although the entire population has access to clean drinking water for most times in the year, there are occasional health risks from water supply facilities where treatment is below accepted standards. Improving these facilities would have substantial current benefits. In Carriacou where 90% of the water is from rainwater collection, a programme for water purification on the island would be critical to health in the future.

(iii) Public Education

People's behavior can have considerable influence on the incidence of some diseases. Behavior related to waste disposal or water storage during shortages, for example, could create a favorable environment for rapid reproduction of disease agents.

Ongoing public education aimed at instilling good health practices in the population would go a long way in ensuring that the necessary preventative measures are taken, that would ensure that the conditions favorable to the development of vector-borne diseases are eradicated from the island.

5.3.4. Capacity Building

Grenada lacks the capacity at every level to adequately fulfill its commitments under the UNFCCC and to adequately respond to the potential adverse impacts of climate change.

(a) UNFCCC Commitments

Grenada's primary commitment under the UNFCCC is to *"develop, periodically update, publish and make available to the Conference of Parties ... national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies agreed upon by the Conference of Parties"*[6]

This Initial Communication has been Grenada's first attempt to fulfill these commitments and it has been prepared primarily with the use of independent consultants financed by the GEF. However, the preparation of such National Communications is an ongoing process under the UNFCCC and Grenada must therefore develop the capacity to prepare and submit its national communications as part of its routine operations.

At the systemic level, this will require the identification of a locus of responsibility for regularly collecting, analysing and reporting the GHG information. It will also require the establishment and/or strengthening of data systems in many sectors of the economy to routinely collect, categorise and report the required data.

At the human resource level, it will require the training of personnel in the compilation and analysis of GHG inventories. One government technician was trained in the skill required to complete the inventory. However, the ongoing process will require more than these basic skills. There will be the need, for example, to develop appropriate emission factors for the localized activities that were not covered by the IPCC methodologies. These latter methodologies are themselves being refined, and there will be a need to keep abreast of these refinements and continually upgrade the human resource capacities in this regard.

Grenada will therefore need to immediately embark on a capacity building initiative aimed at strengthening and institutionalizing its ability to prepare and report GHG data in fulfillment of its commitments under the UNFCCC.

(ii) Responding to Adverse Impacts (V&A Skills)

Grenada will also need to enhance its capacity to analyse, plan for and implement policies and strategies aimed at responding to the potentially adverse impacts of climate change.

[6] UNFCCC, Article 4.1 (a)

This will require capacity building at many levels, viz:

- Systemic Level - At the systemic level, there is a need for:

  - The development of a policy framework and action plan for responding to climate change.
  - The establishment of an institutional framework for managing climate change issues in a coordinated manner. This framework should maximize the potential synergies with the other international environmental Convention to which Grenada is a party. The present situation where the Ministry of Health and the Environment has the primary responsibility for the environment along with twenty other agencies, inclusive of Government departments, non-governmental organisations (NGOs) and statutory bodies is inadequate.
  - A review and rationalization of the legal basis available to decision-makers for responding to climate change issues.

- Human Resource – At the level of human resources, there is a need for skill development in the following areas:

  - Methodologies used in conducting V&A analyses. One government technician was trained in conducting the overview assessment presented in this Initial Communication. However, there is a need for persons to be trained in the specifics of conducting the analyses for the individual sectors. Each of these sectors have their unique characteristics and training will be required in the development and use of simulation models appropriate to the specific sectors being assessed.

    Grenada should target to have separate persons trained to conduct the relevant analyses for each of the sensitive sectors.

  - The collection and analysis of relevant data within the sensitive sectors. This is sorely lacking at this time.

  - Project formulation and implementation techniques.

(c) Participation in UNFCCC Negotiations

There is also a need to upgrade the negotiating skills and knowledge base of the technicians who represent Grenada at the UNFCCC negotiations.

These negotiations are very complex and deal with many "ground-breaking" issues e.g. establishment of emissions trading systems. However, they are important in that the Convention caters for the provision of technical and financial assistance to developing countries in responding to climate change. The nature and scope of this assistance is addressed at these negotiating sessions and failure to participate could potentially result in lost opportunities to access needed assistance.

5.3.5. Technology Transfer

Grenada needs access to modern technology in order to fulfill its obligations under the UNFCCC and to address the potentially adverse impacts of climate change. This new technology is needed in the following areas*, inter alia*:

(a) GHG Inventories

Grenada needs access to the technologies used in developing emission factors relative to its local situation. This is necessary to ensure that the GHG inventories submitted to the UNFCCC are accurate.

(b) Mitigation Technologies

Access to the range of technologies available for increasing energy efficiency, utilizing non-fossil fuel sources of energy and implementing demand-side management strategies is also needed in order to mitigate against the increases in GHG emissions which have been projected in this Initial Communication.

(c) V&A Analysis

Access to simulation models for the various sectors is urgently needed to refine the overview V&A analysis which has been presented in this Initial Communication. Models which can develop climate change scenarios appropriate to Grenada's small physical size are also needed in order to adequately analyse the potential impacts of sea level rise.

5.3.6. Public Awareness

A national public awareness program on climate change will be developed and implemented. The objectives of this program will be:

- To sensitise the general public to the reality of climate change and its potential impacts on Grenada.
- To educate the public on measures that can be taken at the individual or household level, to assist in adapting to the impact of climate change.
- To prepare the population for the implementation of specific policy measures aimed at responding to the impact of climate change.

The program will utilize a variety of techniques, including the electronic media, community-level activities and school-based activities.

5.3.7. Financing

The small size of Grenada's economy makes it impossible to generate the financing necessary to respond to the threat of climate change from its internal resources.

The Convention on Climate Change in Article 4.3. specifies that *"The developed country parties and other developed Parties included in Annex II shall provide new and additional*

financial resources to meet the agreed full costs incurred by developing country Parties in complying with their obligations under Article 12, paragraph 1[7]*. They shall also provide such financial resources, including for the transfer of technology, needed by the developing country Parties to meet the agreed full incremental costs of implementing measures …".*

Grenada will therefore rely heavily on this commitment by its international partners in accessing financing to meet the costs of responding to climate change. In this regard, it must be noted that the Conference of Parties has made various decisions regarding the provision of resources to developing countries.

Grenada intends to access these resources as a matter of priority in order to commence the development and implementation of its climate change action plan.

5.3.8. Priority Action Plan

The focus of this Priority Action Plan is to establish the institutional framework for a sustainable approach to addressing climate change at the national level. This is not a restrictive listing, but rather, an indicative outline of the approach which Grenada intends to pursue.

1. Strengthening of the Institutional Framework. This will include:

    - the establishment of a co-ordination mechanism for environmental management, including climate change;
    - the strengthening of the legal frameworks, including the Building Code to provide for management of climate change issues;
    - the development of a policy framework on climate change with full stakeholder participation; and
    - the strengthening of the technical capacity within the country to address climate change issues, through training of appropriate personnel.

2. Strengthening of the data collection and monitoring systems to facilitate the collection and analysis of data relevant to climate change. This will be applicable to all sectors of the economy that are sensitive to the impacts of climate change.

3. The development and implementation of a National Energy Plan, with emphasis on increased energy efficiency and the use of renewable technologies.

4. The provision of tariff and fiscal incentives for the use of renewable technologies.

5. The development of national standards for vehicle and industrial emissions, minimum efficiency ratings on domestic appliances and industrial equipment, as well as a mechanism for ensuring the implementation of these standards.

6. The implementation of the Solid Waste Authority's plans aimed at reducing the volume of waste that has to be accommodated in the landfill.

[7] This Article refers to the preparation of National Communications

7. The elaboration and implementation of a Land Use Policy.

8. The implementation of the Forestry Policy.

9. Initiation of research into flood control technologies that can be used in the flood prone areas.

10. Compulsory inclusion of climate change considerations into all national projects being developed in the sensitive sectors. The climate change considerations will be a component of the Environmental Impact Assessments which will be required for these projects.

11. Public Awareness and Education on the climate change in general and the role of the individual in mitigating and adapting to climate change. These programs will be done in conjunction with all the sensitive sectors – water, health, energy use, coastal zone management. The activities will include:

    - General public education programs
    - In-community education and mobilization
    - Inclusion of Climate Change into the social studies and science curricula at the primary and secondary levels.

12. Continuation of the analysis of Grenada's vulnerability to the adverse impacts of climate change with the objective of informing policy response measures. This will include:

    - strengthening of systematic monitoring and observation systems e.g. monitoring the actual sea level rise that is being experienced;

    - participation in the development of climate change scenarios, impact models and methodologies relevant to Grenada and the Caribbean, that will facilitate better understanding of the potential impacts of climate change;

    - data collection and analysis aimed at closing the information gaps and reducing the lack of understanding of the climate change impacts identified;

    - improving the accuracy of Grenada's greenhouse gas inventories through the development of local emission factors for activities that are generic to Grenada and the Caribbean.

13. Strengthen Grenada's participation in the UNFCCC negotiation process, in order to strengthen the developing country lobby for the provision of resources to cope with the adverse impacts of climate change.

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