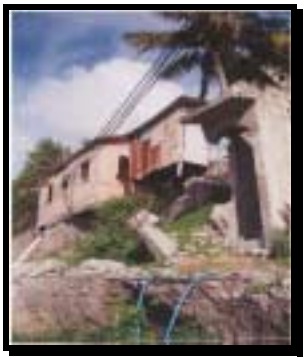

COMMONWEALTH OF DOMINICA

INITIAL NATIONAL COMMUNICATION

Under the United Nations Framework Convention on Climate Change

Environmental Coordinating Unit, Ministry of Agriculture and the Environment

Roseau, October 2001

INITIAL NATIONAL COMMUNICATION

OF THE

COMMONWEALTH OF DOMINICA

UNDER

THE UNITED NATIONS FRAMEWORK

CONVENTION ON CLIMATE CHANGE

NOVEMBER 2001

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FOREWORD

In 1994, the Government of the Commonwealth of Dominica recognizing that Climate Change is a major environmental phenomenon with serious ramifications for all nations of the world ratified the United Nations Framework Convention on Climate Change (UNFCCC). This demonstrated the country's commitment to meeting the goals of the Convention, which are essentially to reduce global greenhouse gas emissions and to address the actual and anticipated effects of climate change.

This Initial National Communication is part of the Government of The Commonwealth of Dominica's efforts to comply with Article 12 of the Convention.

The presentation of this Initial National Communication bears testimony to the unwavering determination of the government, as a responsible party to the Convention, to faithfully fulfill its commitment to minimize the potential negative impacts of Climate Change, particularly on vulnerable Small Island Developing States such as Dominica.

It is my greatest pleasure to present this Initial National Communication to the Conference of Parties of the United Nations Framework Convention on Climate Change. The Communication consists of chapters outlining Dominica's national circumstances, greenhouse gas inventory, vulnerability analysis, institutional framework and national response measures.

The Government of The Commonwealth of Dominica looks forward to, and remains committed to, continuing to work with the rest of the international community in the effort to find solutions to the problems of global climate change and in particular, the protection of the climate system for present and future generations.

……..
Hon. Vince Henderson
Minister of Agriculture and the Environment

ACKNOWLEDGEMENT

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A number of government departments, private sector institutions, non-government organizations and individual members of civil society, made important contributions to the compilation and finalization of the Communication. Such assistance is greatly acknowledged.

The unwavering support and encouragement of the Hon. Vince Henderson of the Ministry of Agriculture and the Environment and his Permanent Secretary, Mr. Raymond Austrie is also recognized

Special thanks is also extended Mr. Albert Bellot, National Climate Change Project Coordinator for his commitment and dedication to completing the report on time and to Bernard Mark John, Head of the Environment Coordinating Unit of the MOAE for editing the report.

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BDD	British Development Division
CANsave	Canada Save the Children Fund
CARIBISS	Caribbean Business Information System
CARICOM	Caribbean Common Market
CEIS	Caribbean Energy Information Studies
CH_4	Methane
CMO	Chief Medical Officer
CO	Carbon monoxide
CO_2	Carbon dioxide
CSO	Central Statistical Office
COP	Conference of Parties
DAC	Dominica Agricultural Census
DBMC	Dominica Banana Marketing Corporation
DOC	
DOMLEC	Dominica Electricity Company
DOMsave	Dominica Save the Children
DOWASCO	Dominica Water and Sewage Company
EC	Eastern Caribbean
ECCB	Eastern Caribbean Central Bank
EC$	Eastern Caribbean Dollars
ECU	Environment Coordinating Unit
EIA	Environment Impact Assessment
ENSO	El Nino Southern Oscillation
EWS	Early Warning Systems
FAO	Food and Agricultural Organization
GCM	Global Circulation Models
GEF	Global Environment Facility
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GNP	Gross National Product
GOCD	Government of the Commonwealth of Dominica
HFC	Hydrofluorocarbons
ICZM	Integrated Coastal Zone management
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
LPG	Light Petroleum Gas
MOAE	Ministry of Agriculture and the Environment
MOCW	Ministry of Communication and Works
MOFP	Ministry of Finance and Planning
MSW	Municipal Solid Waste
NH_3	Ammonia
NGO	Non Governmental Organization
NOx	Nitrogen Oxides
N_20	Nitrous Oxide
NMVOC	Non - Methane Volatile Organic Compounds
PPD	Physical Planning Department

OECS	Organization of Eastern Caribbean States
OECS/NRMU	Organization of Eastern Caribbean States Natural Resource Management Unit
SIDS	Small Island Developing States
SWDS	Solid Waste Disposal Sites
SO_2	Sulphur dioxide
SPAT	Small Projects Assistance Team
SRES	Special report on Emission Scenarios
TAR	Third Assessment Report
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WMO	World Meteorological Organization

EXECUTIVE SUMMARY

This Initial National Communication was prepared in fulfilment of The Commonwealth of Dominica's (Dominica) commitments under Article 12 of the United Nations Framework Convention on Climate Change (UNFCCC).

It consists of a description of Dominica's National Circumstances, a National Greenhouse Gas Inventory for 1994, an assessment of Dominica's Vulnerability to the potential adverse impacts of climate change, an outline of the existing institutional framework, a description of the National Response Measures that will be pursued by the Government and a listing of the Priority Actions that the Government of Dominica intends to implement in the short term.

1. NATIONAL CIRCUMSTANCES (1994)

The Commonwealth of Dominica (Dominica) is situated in the Caribbean Sea, at 15º12'-15º39' N Latitude and 61º14'-61º29' W Longitude. – **Fig 1.1**

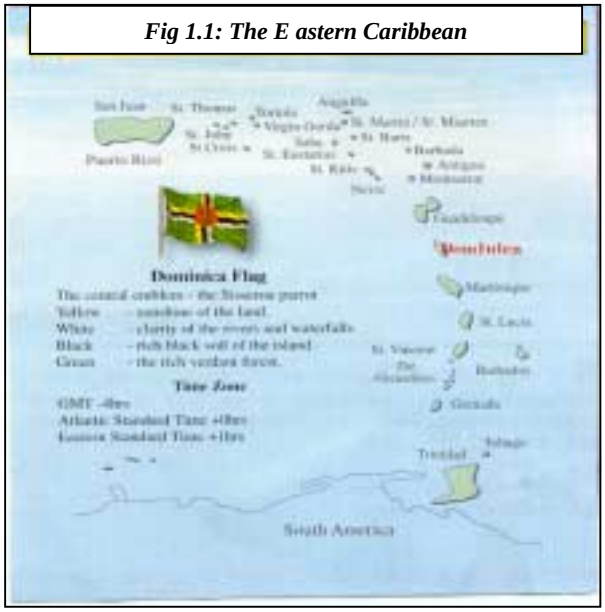


Fig 1.1: The E astern Caribbean

Formerly a British colony, it has retained a Parliamentary system of Government with a President as the Head of State. The Government is run by an elected Prime Minister and House of Assembly, both of whom are elected to office on five-year terms. In addition to a central administration, there is a system of local government made up of a Town Council, Urban Council, Carib Council, City Council and 37 village councils and 41 local authorities.

Dominica is the only English-speaking Caribbean country to have a significant number of the original Carib (Kalinago) Amerindian inhabitants still resident on the island and practicing their indigenous culture.

1.1. PHYSICAL CHARACTERISTICS

Size **- Dominica is the largest Windward Island with a total land area of 750.6 sq. km (290 sq. miles). It is 48 km long, and 24 km wide at its widest point. Dominica has a total land area of 79,000 hectares (ha).Fig.1.2**

Topography **- Dominica is a volcanic island with a series of complex mountain ranges, characterized by very rugged and steep terrain. Flat land is restricted to coastal areas in the northeast, in river valleys and in certain areas in the centre of the island.**

The topographical diversity has produced a rich array of flora and fauna with extensive rainforests, a multitude of rivers, and cascading waterfalls and this has earned the island the name *"The Nature Island of the Caribbean"*.

Forest and Vegetation **- Forest dominates the island's landscape. Sixty six percent (66%) of the land area (51,752 ha) is covered by vegetation ranging from dry scrub woodland on the coast to lush, tropical forest in the interior. This vegetation consists of approximately 155 families, 672 genera and 1226 species of vascular plants (Nicolson, 1991).**

Dominica has an extensive operational and legislative protected area system consisting of forest reserves and national parks covering approximately 17,084 ha (41,000 acres). The island's legally defined forests reserves and national parks together incorporate 20 percent of the country's forest base.

Dominica is also host to the most diverse assemblage of wildlife species remaining in the Eastern Caribbean. The greatest diversity of animal life occurs in the rain forest and includes two endemic parrot species *Amazona imperialis* and *Amazona arausiaca* that are considered endangered and threatened, respectively, (IUCN Red Data List), and are listed as specially protected birds under Dominican law. Other types of wildlife include reptiles, amphibians, freshwater fish, crustaceans and insects.

- *Water Resources* - Dominica's interior contains an extensive network of surface and underground water and is interspersed with rivers, waterfalls and lakes. The island is widely reported to have 365 rivers – one for each day of the year. The ten largest rivers all have average annual flows of 10 million gallons per day. This extensive supply of surface water has provided the island with significant potential for hydro-electricity, some of which has already been tapped, providing up to 56% of gross electricity generated in 1994.

- *Coastal Ecosystems* - Dominica has 153 kilometers (95 miles) of coastline, which adjoins a 715 sq. km coastal shelf. The critical ecosystems in the coastal areas are Beaches**,** Coral Reefs, River Estuaries**,** Sea Grass Beds, Mangroves/Wetlands**,** Fish, Seaweeds, Turtles, Crustaceans, Porifera, Echinoderms and Molluscs, Seabirds and a variety of Marine Mammals including several species of whales and dolphins.

- *Seismic Activity* - Dominica experiences a significant amount of seismic activity. During the period 1998/99 there were recordings of 183 movements in one day on October (23rd) 1998. It is estimated that over 90% of the population live within 5 kilometers of a live volcano. Recent eruptions scenarios developed by Sherperd et. al. (2000), indicate that it is more likely than not that Dominica will experience a magmatic eruption in the next one hundred (100) years, with a probability of "1 in 5" that it will occur in the next ten (10) years.

1.2. CLIMATE

The island has a maritime tropical climate, which is influenced by the North East Trade Winds. The island's rugged topography results in micro-climatic variability within very short distances.

The main climatic characteristics are:

- A *relative humidity* of about 95% with little seasonal, or diurnal variation.
- *High rainfall*, which makes the country susceptible to landslides, particularly in the more mountainous regions. This is distributed between a drier season from December - April and a wetter season from June - November.
- Average *temperatures* of 27°C. This varies between a maximum of 33°C along the coast and 27°C in the mountains during the day, and a minimum of 18°C and to 12°C respectively, during the night.

Dominica is situated in the tropical Atlantic "*hurricane belt*" and since 1979, has been impacted by fifteen (15) tropical weather systems, eleven (11) of which were hurricanes. Statistically Dominica averages a direct strike or close range hit (within 60 miles) by a cyclonic storm system every 3.82 years. The frequent hurricanes have had a significant adverse impact on the development of the social and economic infrastructure of the country.

1.3. SOCIAL CHARACTERISTICS

1.3.1. Population

Dominica is the least populated of the Windward Islands, with a 1994 population of 74,750 and average population density of 99.59 per sq. km. The provisional results of the 2001 National Census indicate that the population is 71,242 with an average density of 94.91 per sq. km.

The population is comprised primarily of persons of African decent (89%), mixed (7%), together with a significant Carib population (2%). These three groupings comprise 98% of the population, with the remaining 2% being of European, American and Chinese origin.

Dominica has a relatively young population. Approximately sixty two percent (62.5%) of the population of 74,750 is below the age of 30.

1.3.2. Other Demographic Indicators

Other key demographic indicators are:

- *Life expectancy at birth* in 1994 was 64 years for men and 71 for women. In 2000, life expectancy was estimated at 71 and 74 years for males and females respectively.

- The *adult literacy rate* in 1994 was 81.2%. This had risen to 95% by the year 2000.

- A 1995 Draft Poverty Assessment, by the British Development Division (BDD) estimated the *level of poverty* in Dominica at 27.6%[4].

Table 1.1. – Table of National Circumstances 1994

CRITERIA	1994
Population	74,750
Area (Sq. Km.)	750.60
GDP (1994 US M$)	149.55
GDP per capita (1994 US$)	2,000.67
Estimated share of the informal sector in the economy in GDP (%)	n.a.
Share of Industry in GDP (%)	6.72
Share of services in GDP (%)[1]	39.31
Share of Agriculture in GDP (%)	22.42
Land Area used for agricultural purposes (sq. Km.)	200.93
Urban population as a percentage of total population	34
Livestock population[2]	
- Cattle	2,970
- Goats	10,150
- Sheep	3,060
- Pigs	3,780
- Chicken	57,100
Forest Area (sq. Km.)	450
Population in absolute poverty (%)	27.6[3]
Life expectancy at birth (years)	
- **Men**	64
- **Women**	71
Literacy Rate (%)	81.2

1.4. ECONOMIC CHARACTERISTICS[5]

1.4.1. Gross Domestic Product (GDP)

Gross Domestic Product[6] in 1994 was US$149.55M.

Over the period 1994 to 2000, GDP increased by 11.8% to US$167.13M, with annual growth rates ranging between 0.17 and 3.08 percent.

The main sectoral contributors to GDP in 1994 (**Table 1.2**) were:

- Agriculture – 22.42%

[1] *Services include Banks/Insurance (12.28%), Government Services (17.84%), Communications (8.02%) and other services (1.17%). Source: Central Statistical Office/Eastern Caribbean Central Bank*
[2] *Based on 1995 Dominica Agricultural Census (Final Results)*
[3] *Based on Draft Poverty Assessment by the British Development Division, 1995. Poor households are defined as "households spending more than 60% of their income on food".*
[4] *Poverty was defined as households spending 60% or more of their income on food.*
[5] *Based on data from the Central Statistical Office and the Eastern Caribbean Central Bank*
[6] *GDP at Factor Cost in constant (1990) price*

- Government Services – 17.84%
- Banks and Insurance – 12.28%
- Wholesale and Retail Trade – 12.14%
- Transport – 9.84%
- Construction – 8.07%
- Communication – 8.02%
- Manufacturing – 6.72%
- Others- 2%.

Table 1.2 – Sectoral Contribution to GDP 1994 & 2000*s*

SECTOR	1994 %	2000 %	CHANGE
Agriculture	22.42	18.24	(4.18)
Government	17.84	17.83	(0.01)
Banks/Insurance	12.28	13.19	0.91
Wholesale/Retail	12.14	12.95	0.81
Transport	9.84	9.57	(0.27)
Construction	8.07	8.23	0.16
Communication	8.02	11.37	3.35
Manufacturing	6.72	7.18	0.46

By 2000, the structure of the economy had undergone some changes, with a significant decline in the agricultural sector and a significant increase in the contribution from the communications sector – **Table 1.2.**

1.4.2. Macro-economic Indicators

The key macro-economic indicators were:

- *Per Capita Income* - GNP per capita in 1994 was US$2,000.67[7] but had increased by 48.5% to US$2,967.72 by the end of 2000.

- *Unemployment* - Unemployment in 1994 was 20%. This had increased to 23% by the year 2000. The quality of the labour force remains largely non-technical and untrained for the industrial and service thrust of the economy.

- *Inflation* - The inflation rate, measured as the average annual percentage change in the consumer prices index was1.6% in 1994 and has fluctuated between 0.086 and 2.4% in the 1994 – 2000 period.

- *Exchange Rates* - Dominica 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.

- *Fiscal Operations* - Government recurrent revenue had increased by 35.7% from US$55.89M in 1994 to US$75.85M by 1998. During this period, the Government has maintained a current account balance, which peaked at 3.95% of recurrent revenue in 1998.

- *Public Debt* - The outstanding public debt in 1994 was US$115.19 M. This had increased to US$175.9 M in 2000.

[7] *Calculated on the basis of GDP at Factor Cost in constant (1990) prices*

2. GREENHOUSE GAS INVENTORY

This Inventory of Net Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases was undertaken in compliance with Articles 4 and 12 of the United Nations Framework Convention on Climate Change (UNFCCC) and in accordance with Inter-Governmental Panel on Climate Change (IPCC) Revised (1996) Guidelines. The Reference Year was 1994.

2.1. GREENHOUSE GAS INVENTORY RESULTS

Table 2.1 provides a national summary of the Greenhouse Gas Inventory, with the data disaggregated on a sectoral basis.

Table 2.1: 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

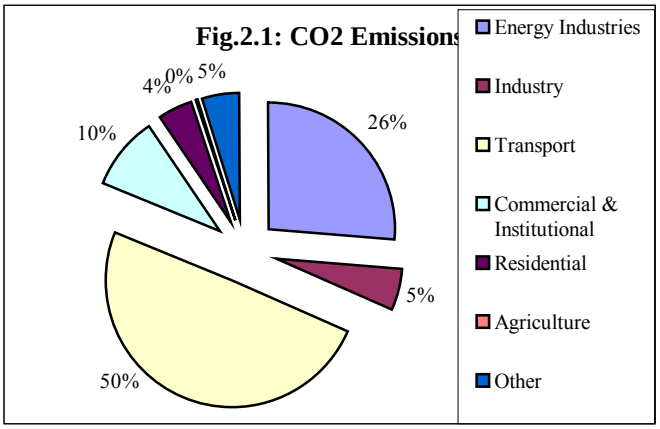
Greenhouse Gas Source and Sink Categories	CO2	CH4	N2O	NMVOC	SO2
Total (Net) National Emission (Gigagrams per year)	**(295.14)**	**2.97**	**0.042**	**6.26**	
1. All Energy	76.53	0.01	0.00		
Fuel Combustion					
Energy and transformation industries	20.21				
Industry	4.10				
Transport	37.68				
Commercial-Institutional	7.33				
Residential	3.41				
Agriculture, Forestry, Fishing	0.10				
Biomass burned for energy	3.70				
Fugitive Fuel Emission					
Oil and natural gas systems	n.a				
Coal mining	n.a				
2. Industrial Processes					
Road paving asphalt				6.13	
Alcoholic beverages				0.06	
Food production				0.07	
3. Agriculture					
Enteric fermentation		0.226			
Leaching of agricultural fields			0.01		
Cultivation of histosols			0.02		
Manure management		0.014			
Grazing animals			0.0015		
4. Land Use Change and Forestry					
Changes in Forestry and other woody biomass stock	(354.92)				
Forest and Grassland Conversion	26.53				
Abandonment of Managed Lands	(43.65)				
Carbon release from agriculturally impacted soils	0.37				
5. Other Sources as appropriate and to the extent possible					
Solid Waste disposal on land		2.73			
Sewage			0.01		

Notes: n.a. – Not applicable.

The data shows that Dominica is a net sink for Carbon Dioxide amounting for net removals of 295.14 Gg of carbon dioxide in 1994. There were also small quantities of

methane, nitrous oxide and non-methane volatile organic compounds – 2.97 Gg, 0.042 Gg and 6.26 Gg respectively.

The carbon dioxide emissions (%) by sub-sectors within the energy sector utilising the Sectoral approach is presented in **Fig 2.1**.



The key sources of carbon dioxide emissions are:

- Transport – 50%.
- Energy Industries – 26%.
- Commercial and Industrial Uses – 10%.
- Industry – 5%.
- Residential – 4%.
- Other – 5%

These emissions of carbon dioxide are mitigated by removals from changes in forest and other woody biomass stock and from the abandonment of managed lands.

2.2. UNCERTAINTIES

The calculations of sources and sinks of GHG's for the different sectors, as described above, incorporate several levels of uncertainty with respect to both the country activity data and the various conversion and emission factors. These uncertainties are detailed in the National Communication.

Dominica does not have the expertise or the resources to improve upon these uncertainties. However, with assistance from the UNFCCC, or other funding agencies, the capacity can be improved and studies can be attempted to address these uncertainties.

2.3. RECOMMENDATIONS FOR IMPROVING ACCURACY

Based on the problems encountered in the preparation of the GHG inventory, it is recommended that future efforts focus on training, research and data collection activities. There is need for greater local capacity to undertake future inventory compilations.

There is also need for research in such areas as forest species coverage, using, for instance, remote sensing coupled with GIS methods. But the most pressing need is for obtaining local data on emission factors in the various sectors.

3. VULNERABILITY ANALYSIS

The vulnerability assessment provides baseline information on Dominica's vulnerability to the impacts of climate change to the year 2050, as can be determined by the available information.

It uses internationally accepted climate change scenarios and examines possible impacts on the coastal zone, forestry, freshwater resources, human settlements, tourism, agriculture, fisheries, and human health.

It also identifies data gaps, capacity building needs and implementation requirements for conducting more in depth vulnerability and adaptation activities.

3.1. CLIMATE CHANGE SCENARIOS

Vulnerability is defined by the IPCC as *" the extent to which climate change may damage or harm a system. It depends not only on a system's sensitivity but also on its ability to adapt to new climatic conditions"*(IPCC, 1995). Vulnerability to climate change can therefore be seen as a complex mixture of ecological, economic and societal factors. The five scenarios for climate change in **Table 3.1** are used in the assessment[8]. They are based on data developed by various internationally recognized Global Circulation Models (GCM's). Synthetic scenarios, utilized to demonstrate possible levels of sensitivity to climate change, supplement these.

Table 3.1- Summary of Climate Change Scenarios

Climate Change Impact (To 2050)	Low Scenario	Medium Scenario	High Scenario (synthetic)
Mean Annual Temperature (degrees Celsius)	+1.71	+2.5	+3.5
Seasonal Mean Temperature Change (degrees Celsius) - December to February - June to August	 +1.68 +1.71		 +2.0 +2.5
Mean annual precipitation change (%)	- 30	-20	+30
Sea Level Rise (cms)	26	39	50
Tropical Storms/Hurricane Scenario (%)			+20

3.2. SOCIO-ECONOMIC SCENARIOS

Analysis of the available socio-economic data and plans for the future indicate that the present stress on Dominica's natural resource base would continue, if not intensify, viz:

- Increased population will mean heightened pressure for land for housing, commercial, institutional, and infrastructural development.

- Increasing pollution of coastal and marine areas from land-based sources (manufacturing, agriculture and tourism) would continue based on the economic development strategy which focuses on these sectors.

[8] *Percentages relate to variations from the present mean averages*

- Generation of increasing amounts of solid and liquid wastes from domestic, tourism and agricultural uses.

- Other negative environmental trends including deforestation and consequent effects on watersheds and biodiversity.

Projections for impacts arising from global climate change will therefore likely be additional to the existing challenges of sustaining socio-economic progress and environmental integrity.

3.3. VULNERABLE SECTORS

3.3.1. Forestry and Terrestrial Resources

Dominica's 51,752 hectares of forest and vegetation are important as a base for the country's eco-tourism initiative, as a source of economic products and services, as the home for a wide range of the country's terrestrial biodiversity and as the source for the country's water supply and hydro-electric potential.

Climate change is expected to impact on this sector in three ways, viz:

(a) Temperature Changes

The possible impacts of temperature change on forests and terrestrial ecosystems could be summarized as follows:

- Alteration in the range of species.

- Reduced water flow in watersheds.

- Increase in forest pests and disease.

- Reduced food availability for wildlife.

- Increased species competition for scarce resources.

- Greater vulnerability to extreme events (e.g. hurricanes).

(b) Sea Level Rise

The threat presented by sea level rise to the coastal habitats (e.g. coastal freshwater ponds, brackish water systems, mangroves and arable floodplains) is substantial, viz:

- Increasing pressure on forest reserves due to loss of coastal agricultural lands by salinization.

- Loss of coastal forests due to inundation and increasing storm events (e.g. mangroves and low lying tropical dry forests).

- Migration or loss of wildlife species from altered habitats.

(c) Hurricanes and Tropical Storms

With climate change there is also the possible increase in the frequency and intensity of storms in the Caribbean and therefore an increase in the risk of landfall. The terrestrial ecosystems are severely impacted on during the passage of tropical disasters. The main types of damage are windblown trees, damage to soils due to landslides and soil erosion.

3.3.2. Coastal Ecosystems

The coastal zone of the island covers both the marine and terrestrial components of the coast. It *"…includes extensive areas of complex and specialized ecosystems such as mangroves, coral reefs and sea grass beds, which are highly sensitive to human intervention" (IPCC 1994)*.

Climate change and climate variability are likely to place additional stress on the already vulnerable coastal systems and resources.

- *Beaches* - A rise in mean sea level will result in loss of beach area due to erosion and inundation.

- *Coral Reefs* – In many parts of the tropics (e.g. the Caribbean Sea and the Pacific Ocean) some species of coral already live near their limits of temperature tolerance. Elevated sea temperature (above seasonal maxima) can therefore result in serious damage to coral due to bleaching. In addition their reproductive functions can be impaired, leading to increased mortality (*IPCC, 1997*).

  Signs of coral bleaching have already been seen in the reefs of Dominica. Studies done by the Fisheries Development Division in 1998, reported that approximately fifteen percent (15%) of the coral shows some sign of bleaching ranging from minor to severe (*Guiste 2000, personal communication*). High temperatures due to climate change are therefore likely to result in the bleaching of an already stressed ecosystem and subsequently increase the stress factors within the coastal zone of the island.

- *Mangroves* - Mangroves in Dominica generally occupy low-lying coastal areas. It is expected that as sea levels rise, there will be increased mortality among existing species. This will result from a reduction of the availability of fresh water for the maintenance of salinity balance, as the sea encroaches onto these low-lying areas and into the lower course of river systems.

  The shoreline erosion which will result from sea level rise will induce coastal land loss and in so doing reduce the natural capacity of mangroves to adapt by migrating landwards. In addition, the natural capacity of mangroves to adapt and

migrate landwards is also expected to be hindered by land use practices (such as the construction of infrastructure within the coastal zone) that have fragmented existing habitats.

- *Sea Grasses* - Sea grass beds are likely to be negatively affected by climate change effects, particularly as a result of sustained elevation of sea surface temperature, or due to decreases in water salinity resulting from increases in fresh water run off from land. As large volumes of silt are deposited over sea grass beds, the biodiversity of this habitat will be altered. Such changes in biodiversity will affect fish stocks and lead to changes in fish abundance, distribution and/or behaviour.

- *River Estuaries* - The main impact on river estuaries is the inundation of habitats within the estuary due to sea level rise. This will result in increased mortality and loss of habitats for organisms which enjoy brackish water, or water of varying salinities, loss of biodiversity resulting from above and threats to the survival of the near shore fisheries.

- *Coastal Species Diversity* - There are no studies available to identify the nature of climate change impacts on each specific group of flora and fauna. It must be noted however that past storms and hurricanes have for example, destroyed a variety of shrubs and herbaceous plants that play an important role in protecting the coast from wind and sea erosion. The impact of their loss is reflected therefore in the loss of the unprotected coastline, which is rendered more susceptible to future tropical cyclonic events (*Cambers 1997*).

3.3.3. Freshwater Resources

The freshwater resources in Dominica are used for domestic purposes (drinking, eating, bathing and washing), agricultural purposes (farming/irrigation), industrial purposes (bottling and mining), and for the generation of hydroelectric power. This freshwater comes from 10 major watersheds and their accompanying river basins.

The present supply systems are generally adequate to satisfy demands, although intermittent shortages are experienced in a few of the systems during the dry season (*Martin, 1999*).

Increased precipitation from climate change can result in landslides, gully erosion, flooding, decline in water quality and damage to water intakes and supply lines

Decreased precipitation will cause the base flow of rivers to drop significantly with negative consequences for domestic and commercial water supply and for the generation of hydro-electricity.

Dominica's water supply is also vulnerable to major hurricane impacts. Hurricane Lenny revealed the extent of damage that can occur as a direct result of a storm surge. The cost to DOWASCO in line repair, maintenance and relocation after Hurricane Lenny was US$125,852.

3.3.4. Human Settlements

Much of the critical infrastructure and many of the socio-economic activities are located along the coastline, in many cases at, or close to, present sea level. This makes them vulnerable to flooding and to the impacts of hurricanes and storms.

Ninety percent (90%) of the population of Dominica is dispersed among coastal villages, the city and a town. The country's two main population centres, namely, Roseau, the capital city and the town of Portsmouth, all major seaport facilities, one of the airports (Canefield), as well as the majority of the island's road and communication infrastructure are located along the leeward coast.

Most settlements have very little room for expansion except through hillside residential development, or density increases in already built up areas. As a result, population increase in certain districts is leading to the increasing emergence of hillside developments on the fringes of the existing towns and on small coastal headlands. These areas are highly susceptible to the ravages of extreme events such as hurricanes.

3.3.5. Agriculture

It is difficult to quantify the impact of climate change on Dominica's agriculture at this time, as most contemporary crop response studies are being conducted in temperate regions. It is therefore not possible to assess the impacts of carbon dioxide fertilization, changes in temperature and changes in precipitation levels on tropical islands such as Dominica, where other variables are also of major significance. In addition, the data sets required for such analysis are not available.

Banana is the most significant crop and the production is very sensitive to levels of precipitation. A stark contrast in optimal productivity is observed when the above average rainfall production is compared to drought production levels. There was a 17-37% difference in the 1970's and a staggering 53-60% difference in the 1980's.

In addition, crops such as vegetables are extremely sensitive to the fluctuations in precipitation. Excess rainfall tends to increase the incidence of pest and diseases leading to declining productivity, whilst drought conditions lead to reduced yields.

Extreme events inflict damage directly on food systems through the destruction of crops and livestock and the erosion of farmlands.

The effect of climate change will vary depending on the nature of the impact. All types of impact – higher temperatures, reduced precipitation and increased hurricane activity – will adversely affect the agricultural sector.

3.3.6. Fisheries

The fishing sub-sector is an important source of protein especially in low-income coastal communities; makes an important contribution to the agricultural sector; is a major part of Dominica's eco-tourism package; and is an important source of employment. In

addition, the coastal habitats associated with fisheries, particularly coral reefs, mangroves, and beaches, also perform other important economic, environmental, and ecological functions.

The fisheries sub-sector is vulnerable to the projected impacts of climate change through the impact of higher sea temperatures on the coral reefs and the impact of sea level rise on the mangroves and sea grass beds, all important breeding grounds for fish.

Hurricanes also have major social and economic impacts on the fisheries sector. Hurricane David in 1979 virtually wiped out Dominica's fishing fleet. About twenty years later, damage to the fishing industry caused by Hurricane Lenny was valued at US$2,827,238.80 (EC$7,577,000.00). This was due to damages to coral reefs and sea grass beds, beach landing sites, fishing gear and equipment and associated infrastructure.

3.3.7. Tourism

Dominica, "*The Nature Island of the Caribbean*", is a newly emerging tourist destination, still in the relatively early stages of development of the sector.

Dominica's tourism is focused mainly on the eco tourism product rather than the traditional SSS (sun, sea and sand) image of the other Caribbean islands. The tourism base is therefore the natural resources.

The cultural and heritage resources of the island are also an important component of the tourism package. In addition, the island has a small number of sandy beaches that are also a part of its tourism product even if it does not promote itself as a beach destination.

The tourism industry is also highly dependent, though not exclusively, on activities in, or close to, coastal areas. Most of the major hotels are located along the coastal strips and all major air and seaports with the exception of the Melville Hall airport are located along the western coast of the island.

The vulnerability of Dominica's tourism to climate change comes from three (3) sources, viz:

- *Eco-tourism* – the increasing reliance on eco-tourism means that the vulnerabilities of the forestry and terrestrial and coastal eco-systems are also vulnerabilities of the tourism sector.

- *Coastal Vulnerability* – The location of Dominica's tourism infrastructure along the coast make them highly vulnerable to hurricane/storm and sea surges.

- *Competition From Other Destinations* - If winters temperatures are to rise as the IPCC predictions suggest this may have serious implications for tourism in the Caribbean as a region, as milder winters will reduce the inducement for tourist to travel during this period.

3.3.8. Human Health

It must be noted here that efforts to assess the likely impacts of climate change on health have not been as well developed as in some other fields of climate change research. Within this context, climate change is likely to present a special set of challenges for the health sector in Dominica, which in many instances already experience health impacts associated with present day climate variability.

In Dominica, extreme weather events such as hurricanes and droughts, as well as longer-term alterations in weather patterns are likely to have significant implications for those sections of the population already exhibiting vulnerability either by virtue of medical predisposition (e.g. cardiac and sickle cell patients) or by virtue of socio-economic and environmental conditions.

Temperature-The most direct effect of global warming on human health is that of heat stress. This usually affects the young, the very old, and people engaged in manual labour or prolonged outside exposure, such as farming, or fishing. Individuals with chronic illnesses, such as heart disease, are also at increased risk of complications from heat exhaustion or heat stroke.

Drought-Some potential drought related impacts include: increased risks associated with dengue arising from enhanced opportunities for breeding of the Aedes Aegypti mosquito; increased incidence of gastroenteritis, a "dry season" affliction affecting particularly poorer sections of the community; intensification of scabies and other "water wash" diseases associated with the absence of adequate water supplies for personal hygiene; increasing incidence of asthma and other respiratory diseases caused by rising air pollution as a result of air-borne movement of bacteria and other pathogens and brush and forest fires

Drought, can also have negative impact on agricultural production of domestic and export food crops (especially bananas) affecting farm incomes and the availability of fresh foods; decreasing productivity of offshore fisheries through reduced nutrients from land based sources as well as stresses to mangrove habitats. This would affect the nutritional levels of many coastal communities dependent on free access to near-shore and estuarine species for protein intake.

Hurricane-Potential increases in the intensity of storms and hurricanes are expected to have the following impacts: considerable damage to health infrastructure already inadequately maintained particularly in rural areas; water and food borne diseases such as typhoid, shigella, and hepatitis A and E arising out of contamination by floodwaters; acute and/or chronic health problems from chemical contamination of water by agrochemicals and other hazardous wastes; increases in vector borne diseases.

One potentially significant problem in this regard is leptospirosis a potentially fatal disease spread through the urine of rodents. Another is the spread of malaria and dengue by mosquitoes. Other impacts of hurricanes indirectly affecting health include loss of shelter and population displacement, contamination of water supplies, loss of food production and storage and increased risk of infectious diseases.

There is also the potential for damage to health infrastructure resulting from hurricane activity

Sea level Rise - Sea-level rise is not expected to have any direct health impacts in Dominica but will likely result in the displacement of persons, damage to housing (and possibly health infrastructure) and consequent indirect health impacts in terms of physical and psychological effects.

Other impacts of sea-level rise on fishery and agricultural productivity can be expected to have impacts on food availability and therefore possibly nutritional levels. Specific health hazards could arise from heightened storm surges and from damage to coastal infrastructure, including wastewater and sanitation systems.

3.4. SUMMARY

It is clear from the foregoing, that all of the principal social and economic sectors in Dominica are vulnerable to the potential impacts of climate change.

4. INSTITUTIONAL FRAMEWORK

4.1. ENVIRONMENTAL RESPONSIBILITY

The Environmental Coordinating Unit in the Ministry of Agriculture and the Environment is charged with the responsibility for coordinating all environmental activities on the island. It also serves as the focal point for the multilateral environmental agreements to which Dominica is a party.

At the sectoral level, the responsibility for environmental conservation and management is dispersed among a number of government agencies, non-governmental organizations, statutory bodies and other interest groups.

There is often overlap between the roles played by these bodies/organizations even if they all have different focus and different jurisdiction over the same resource base.

There is therefore an urgent need for strengthening partnerships between institutions, for developing clearer definitions of responsibilities and for strengthening of the capacity for implementing environmental conservation and management measures.

4.2. ENVIRONMENTAL REGULATIONS

Dominica has a range of regulations in force for the protection of the environment, viz:

- *Coastal Zone* - A number of laws have been enacted which address issues of environmental management which are applicable to the coastal zone. These include the *Beach Control Act (1966, 1990), the Public Health Act (1968)*, the *Pesticides Control Act (1974, 1987), and the Litter Act (1990).*

- *Forestry* - The main legal instruments governing forest use and management are *The Forest Act (1959), The Forestry and Wildlife Act (1976), The National Parks and Protected Areas Act (1975*), and *The Water and Sewerage Act (1989**).***

Fisheries - Various legislative and regulatory instruments govern management of Dominica's fishery resources. Principal of these are the Fisheries Act of 1987, and the Territorial Sea, Contiguous Zone, Exclusive Economic and Fishery Zones Act of 1981.

Physical Planning - Physical Planning is the responsibility of the Physical Planning Division (PPD). This Division is responsible for, inter alia, the administration of the Town and Country Planning Act (1975), enforcement of land sub-division and building regulations and providing advice to local and central government authorities on issues of land use and building control.

The Act also provides a framework for managing, guiding and coordinating public and private sector developments in accordance with overall development policy. The Act therefore empowers the Division to exercise planning control over all development activities.

4.3. ENVIRONMENTAL IMPACT ASSESSMENTS

Dominica is presently considering enacting into law (under the Physical Planning Act) an established policy, which seeks to ensure that an Environmental Impact Assessment (EIA) precedes all major national development projects that are likely to have negative environmental impact.

It is however reported that the policy is not always enforced, particularly for projects such as the construction of sea defense works and quarry operations.

4.4. ENFORCEMENT

The enforcement of legislation is a problem throughout all sectors. Some of the constraints being experienced are linked to the lack of financial and human resources necessary for the implementation of the task. There is also what has been described as the absence of political will to enforce and enact certain legislation, e.g. to ensure that Environmental Impact Assessments are conducted for coastal and land based development projects.

Additionally, as the legislation that exists is scattered over various government ministries, the degree of enforcement depends on each ministry's primary area of focus and responsibility.

5. NATIONAL RESPONSE MEASURES

Dominica joined the international response to climate change when it ratified the United Nations Framework Convention on Climate Change in March 1994.

This Initial National Communication represents the start of the national process of responding to climate change, within the framework agreed upon by the Conference of Parties (COP).

In developing this national response strategy, Dominica is guided by the principles of Article 4 of the Convention, and subsequent COP decisions, wherein the developed country parties have committed to assisting the developing country parties in the implementation of response measures to combat the negative effects of climate change.

The preceding sectoral analyses indicate the wide-ranging nature of the potential adverse impacts that anthropogenic climate change can have on Dominica, notwithstanding the high levels of uncertainty as to the timing, nature and extent of these possible changes in climate parameters and consequently their impacts.

Dominica however fully subscribes to the Precautionary Principle enshrined in the Convention and does not believe that one has to await full scientific certainty before initiating measures to combat climate change.

Given the scarcity of resources, Dominica's approach will not be based on climate change considerations only. The measures to address the likely, or potential, impacts of climate change would be linked to wider considerations and would be directed in the first instance, towards reducing existing vulnerabilities and risks to present day weather and climate extremes, as well as advancing wider development objectives.

It must be noted however that given the low levels of greenhouse gas emissions, the emphasis will be placed on the adaptation aspects, as this is the area where Dominica will experience the most serious adverse impacts.

The Initial Communication contains a listing of the measures that the Government intends to pursue in this respect. From this listing, the following six (6) priority areas have been identified as being central to enabling meaningful adaptive response measures to anthropogenic climate change in Dominica. Successful implementation of the actions proposed here, will establish a strong foundation from which Dominica can continue to strengthen it program of response to climate change.

5.1. Public Awareness

The ultimate objective of the public awareness programme is to sensitize stakeholders to the likely impacts of climate change and the measures that can be taken to ameliorate adverse impacts.

This will require a carefully developed information programme that incorporates and utilizes latest available data as a guide for decision-making at household, enterprise,

community, sectoral and national levels. The *Phase Two funding from the Global Environment Facility (GEF) for Enabling Activities under the UNFCCC will be used to initiate a comprehensive climate change public awareness project.*

5.2. Sustainable Coastal Resource Management

Strategies for coastal protection on climate change would encompass efforts at enhancing natural resources such as mangroves and coral reefs. They would also be targeted at land-based sources that negatively impact on the long-term sustainability of coastal ecosystems.

This will require the type of holistic and integrated management approaches articulated in the Coastal Zone Management concept[9]. Critical to the success of this type of programme is the involvement of a wide range of stakeholders in the development and implementation of these activities.

5.3. Strengthened Disaster Management Capabilities

An important element of Dominica's response to climate change would be to strengthen its disaster management and response capabilities. In addition to measures for further strengthening the national Office of Disaster Preparedness, particularly important will be the need to strengthen telecommunication links and to enhance even further the role of local response units to coordinate local level response.

5.4. Integrated Water Resource Management

A combination of resource enhancement activities (reforestation, agro-forestry, land acquisition) and management measures (water conservation, land use policy, legislation) are advocated as adaptive measures to promote adequacy of water supply. In view of the centrality of water to all development activity – health, agriculture, tourism, industry – the government will put in place the necessary technical and institutional capabilities that will allow for sustainable use of Dominica's water resources in a context of increased rainfall variability.

5.5. Strengthened Physical Planning

Many of the sectoral recommendations point either directly, or indirectly, at the need for strengthening physical planning and development control functions so as to reduce existing pressures on climate change sensitive sectors and resources.

In light of the above, the following initiatives will be taken with respect to the physical planning and development control process:

- Strengthening of these agencies to enable them to adequately carry out forward planning, development control, and monitoring functions necessary for ensuring that development activities do not heighten vulnerability to climate change.

[9] *A useful introduction to coastal zone management of relevance to island States is " A Workbook of Practical Exercises in Coastal Zone Management for Tropical Islands", Commonwealth Science Council, Bacon et al, 1998*

- Greater use of hazard mapping and risk assessment technologies as tools for enabling decision making in physical planning.

- Encouragement of retrofitting in old buildings to facilitate compliance with relevant building guidelines, particularly so as to increase resistance to storm conditions.

- Incorporating parameters of climate change into the development control decision-making process. This would include consideration of temperature increase, flooding, and enhanced storm surge and wave action in coastal areas.

5.6. Capacity Building for Climate Change

Underlying all of the identified areas for priority action is the need to develop the national capacity within Dominica to respond to the challenges presented by changes in weather and climate parameters associated with anthropogenic climate change.

As such, the first requirement in enabling sustainable adaptation responses is for the identification and empowerment of an agency charged with responsibility for promoting adaptation to global climate change. To a great extent, this mandate already rests with the Environmental Coordination Unit of the Ministry of Agriculture and Environment. The need at this time is to further strengthen the Unit's capabilities as it pertains to climate change. This requires additional training, legal empowerment, and full-time staffing allocations and budgetary resources for climate change.

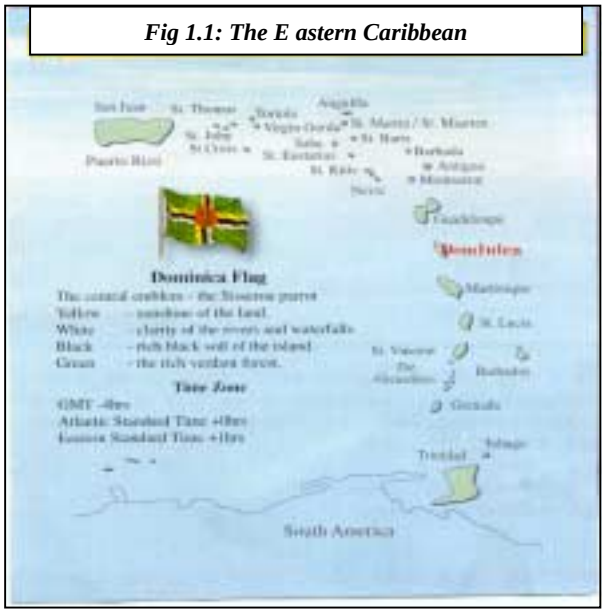
It will also be necessary to develop a national climate change strategy aimed at providing the policy framework for infusing climate change concerns into development planning. In this regard international cooperation would be sought for developing a Climate Change Action Plan, an element of which should be establishing the framework for the operation of the focal point (s) and building capacity in priority agencies and sectors. This would also form one of the areas to receive attention during the *Phase 2 Enabling Activities being supported by the Global Environment Facility under the UNFCCC process.*

The need to strengthen technical capabilities at the sectoral level in agencies such as those involved with freshwater and coastal resource management has already been noted. Related to this is the need to strengthen data collection of climate parameters. Regional and international cooperation would also be pursued with regard to Dominica's participation in climate observation networks such as those spearheaded by the WMO. These would all form elements of the national climate change strategy noted above.

1. NATIONAL CIRCUMSTANCES (1994)

The Commonwealth of Dominica (Dominica) is situated in the Caribbean Sea, at 15º12'-15º39' N Latitude and 61º14'-61º29' W Longitude. It is the most northerly of the Windward Islands and lies between the French Departments of Guadeloupe, to the north, and Martinique, to the south – **Fig 1.1**

Fig 1.1: The E astern Caribbean



The island was the last of the Caribbean islands to be colonized by the Europeans, due chiefly to the fierce resistance of the native Carib (Kalinago) people.

The island changed hands between the French and English seven times and finally ended up in the hands of the British in 1763. It remained a British colony until 1978, when it became an independent Republic within the British Commonwealth.

It has retained a Parliamentary system of Government with a President as the Head of State. The Government is run by an elected Prime Minister and House of Assembly, both of whom are elected to office on five-year terms. In addition to a central administration, there is a system of local government made up of a Town Council, Urban Council, Carib Council, City Council and 37 village councils and 41 local authorities.

Dominica is the only English-speaking Caribbean country to have a significant number of the original Carib Amerindian inhabitants still resident on the island and practicing their indigenous culture. They are based mainly in a 1,497 hectares Carib (Kalinago) Territory, a protected area established in 1903 for the Carib (Kalinago) population of 1653[10].

1.1 PHYSICAL CHARACTERISTICS

1.1.1 Size

Dominica is the largest Windward Island with a total land area of 750.6 sq. km (290 sq. miles). It is 48 km long, and 24 km wide at its widest point**.** Dominica has a total land area of 79,000 hectares (ha) - **Fig.1.2**.

[10] *2001 Census*

1.1.2. Topography

Fig 1.2 Map of Dominica

A volcanic island with a series of complex mountain ranges, Dominica is characterized by very rugged and steep terrain. This mountainous topography has made it difficult to clear the lush vegetation and has contributed greatly to the island's dramatic beauty and the conservation of its natural resources.

Flat land is restricted to coastal areas in the northeast, in river valleys and in certain areas in the centre of the island. The main river valleys are found in the centre of the island and include the Layou and Roseau Valleys on the leeward side, as well as the Clyde, Pagua, Castle Bruce and Rosalie valleys on the windward side.

Two peaks dominate Dominica's rugged terrain, Morne Diablotin (1,447 m) in the north and Morne Trois Piton (1,424 m) to the south – **Photo 1.1**.

Photo 1.1 - Morne Trois Piton (1,424 m)

Photo 1.2 - Trafalgar Water Fall

The topographical diversity has produced a rich array of flora and fauna with extensive rainforests, a multitude of rivers, and cascading waterfalls-**Photo 1.2** and this has earned the island the name "*The Nature Island of the Caribbean*".

1.1.3. Forest and Vegetation

The biodiversity of Dominica, concentrated in such a small geographical are, is exceptional. Several plant and animal species are unique to the island.

There is general consensus that the forest of Dominica is the finest in the Caribbean. Indeed in the Eastern Caribbean, the word "rain forest" is almost synonymous with the name Dominica. Forests dominate the island's landscape; they have been a key geographic determinant in shaping its history and development and continue to inspire images of true tropical splendor. Sixty six percent (66%) of the land area (51,752 ha) is covered by vegetation ranging from dry scrub woodland on the coast to lush, tropical forest in the interior. **Table 1.1**

Two types of vegetative zoning characterize the island and are determined by its current climate. Firstly, a wetter eastern coast due to prevailing rain-bearing systems, which leads to a more lush vegetative community and a rain –shadowed western coast that has a more scrub-like characteristic. Secondly, and more importantly, is an altitudinal zonation of plant communities that is very dependent on precipitation, temperature and wind levels.(Parry, 2001, personal communication)

Dominica boasts of a remarkable plant diversity and has the most extensive and diverse vegetative cover in the Eastern Caribbean. This vegetation consists of approximately 155 families, 672 genera and 1226 species of vascular plants (Nicolson, 1991).

Table 1.1 - Major Vegetation Types Found On Dominica

Vegetation Type	Area (ha)	% Landmass
Coastal Swamp Forest	30	0.1
Littoral Woodland	140	0.2
Dry Scrub Woodland	6,240	7.9
Deciduous/Semi-Evergreen Forest	7,170	9.1
Rain Forest	33,562	42.5
Montane Rain Forest	4,440	5.6
Elfin Woodland	170	0.3
Total	**51,752**	**65.7**

Source: Adapted from Prins (1987) State 40% Private 60%

Malary (1993) lists the number of indigenous species as *Pteridophytes* (194), *Gymnosperms* (1), *Monocotyledons* (518) and *Dicotyledons* (1,445). Dominica has several plant species, which are endemic to the island, i.e. *Sabinea carinalis* (Bwa kwaib) the National Flower. Also, Dominica has two genera, *Agave* and *Furcrea* that are endemic to the Caribbean (Malary, 1993). Nicolson (1991) states that the flora of Dominica, Martinique and Guadeloupe are similar and species thought to be endemic to Dominica are being identified in the other islands.

Ten species of trees comprised over 90 percent of the total volume composed of 22 percent gommier *(Dacroydes excelsa)*, 14 percent carapite *(Amanoa caribaea*), 14 percent bois cote *(Tapura latifolia)*, 12 percent chataignier *(Sloanea spp.)*, 10 percent mahot cochon *(Sterculia caribaea)*, 7 percent bois diable (*Licania ternatensis*), 4 percent bois riviere (*Chimarris cymosa*), 3 percent mauricif *(Byrsonima martinicensis)* and 11 percent other species (CCA, 1991).

Dominica has an extensive operational and legislative protected area system consisting of forest reserves and national parks covering approximately 17,084 ha (41,000 acres). The island's legally defined forests reserves and national parks together incorporate 20 percent of the country's forest base. There are two Forest Reserves - the Central Forest Reserve (410 ha) and the Northern Forest Reserve (5476.9 ha). In addition, there are three National Parks - Morne Trois Pitons (6879.8 ha) established in 1975, officially declared as a UNESCO World Heritage Site in 1998; Cabrits National Park (531 ha) established in 1986, and Morne Diablotin National Park (3335.49 ha) established in January 2000.

Dominica's forests are relatively rich in timber and composition and have a large timber utilization volume estimated at 4.9 million cubic meters. A 1989 FAO study showed that timber richness was 200 cubic meters on 12,500 ha and 600 cubic meters on an estimated 3,500 ha.

The forest is a source of a wide range of economic products and services including:

- *Fuel wood from charcoal* – a popular fuel among rural and urban residents

- *Medicinal plants* – Adjanohoun et al (1985), reported 167 species of plants of medicinal and pharmaceutical value widely used in curing diseases such as cardiovascular, digestive, genital and urinary, respiratory, and nervous system disorder.

- *Bwa bandé* (*Richeria grandis*) - the bark of this rainforest species is believed to possess aphrodisiac properties. It is used in the production of local drinks and many other products, which are readily found on the supermarket shelves and also successfully exported.

- *Gommier* (*Dacryodes excelsa*) - The timber has traditionally been used by the indigenous Carib people in the production of canoes for the fishing community and is widely used in the local furniture industry. The latex is also tapped and used for various indigenous purposes.

- *A variety of reeds, seeds, fruits, dyes, spices, leaves, latex, roots, and flowers* that are harvested for local consumption and production of craft items particularly in the rural communities and by the Caribs.

Dominica is also host to the most diverse assemblage of wildlife species remaining in the Eastern Caribbean. All the faunal groups are well represented. The greatest diversity of animal life occurs in the rain forest.

- *Birds* - Dominica has one of the most diverse avifauna of the Lesser Antilles, despite its geographic location within the centre of the island chain. One hundred and seventy-five species of birds have been recorded from Dominica. Many of the birds are migratory and sixty species breed on the island. Dominica's resident birds include two single-island endemics (unique to Dominica) and nine regional endemic species.

  Dominica's two endemic parrot species *Amazona imperialis* and *Amazona arausiaca* are considered endangered and threatened, respectively, (IUCN Red Data List), and are listed as specially protected birds under Dominican law.

- *Mammals*- Eighteen species of terrestrial mammals have been recorded for Dominica. The wild mammalian population includes twelve native species of bats, one species of opossums, one species of feral pig and four species of rodents including the agouti.

- *Reptiles* - The sixteen terrestrial reptiles consist of eleven lizard species, four snake sub-species and one tortoise species. Of the eleven species of lizards, two are endemic (unique to Dominica), viz. the Ground Lizard (*Ameiva fuscata*) and the Tree Lizard (*Anolis oculatus*).

- *Amphibians* - The amphibian fauna in Dominica consists of four species of frogs, one of which is endemic to the island while two are regionally endemic.

- *Fishes* - The freshwater fish of Dominica include the Mountain Mullet *(Agonostomus monticola*), American Eel (*Anguilla rostrata*), Stripped Mullet (*Gobiesox pontulatus*), and Gobies (*Sicydium spp*.).

- *Crustaceans* - The terrestrial and freshwater decapod crustaceans in Dominica include eleven species of freshwater shrimps and twenty species of freshwater/terrestrial/semi-terrestrial crabs (Chace & Hobbs, 1969, (Swank & Julien, 1975). .

- *Insects* - The class Insecta has not been fully surveyed on the island and as a result the species list is incomplete. Many species of Hymenoptera, Hemiptera, Diptera, Coleoptera, Lepidoptera, and Tricoptera are found. The population status of most of the species listed is not known.

  Fifty-five species of butterflies have been recorded in Dominica. Two species, the Dominican Snout *(Libytheana fulvescens)* and Dominican Hairstreak *(Electrostrymon dominicana)* are endemic (unique) to Dominica.

  Eleven species of *Phasmids* (stick insects) have been recorded for Dominica. *Diapheromera saussurei* is a confirmed endemic of Dominica

1.1.4. Water Resources

Dominica is blessed with an abundance of water. The lush forested interior enjoys an average annual rainfall in excess of 7620 mm at the central peaks. This reduces to an

average of about 1270 mm per annum along the central portion of the west coast, which tends to be the driest section of the island. This rainfall regime is sufficient to sustain a steady flow in a number of rivers throughout the island. The interior contains an extensive network of surface and underground water and is interspersed with rivers, waterfalls and lakes.

The island is widely reported to have 365 rivers – one for each day of the year. The ten largest rivers all have average annual flows of 10 million gallons per day. This extensive supply of surface water has provided the island with significant potential for hydro-electricity, some of which has already been tapped providing up to 56% of gross electricity generated in 1994.

1.1.5. Coastal Ecosystems

Dominica has 153 kilometers (95 miles) of coastline, which adjoins a 715 sq. km coastal shelf. The west coast of the island is washed by the Caribbean Sea and the east coast by the Atlantic Ocean. There is a generally narrow coastal plain. Extending from this narrow coastline is an equally narrow continental shelf that measures less than 1 kilometer in width, except in the area of Marigot on the east coast where it increases to approximately 5 kilometers. The submarine topography is similar to that of the land, comprising generally of rugged and steep terrain.

The differing currents that operate on each coast, coupled with the varying topography as well as geological features, rainfall and microclimates, have produced pockets of unique ecosystems, which give rise to a rich diversity of coastal resources. The critical ecosystems in the coastal areas are:

- *Beaches* - Given the coastal topography, beaches are not as abundant as in some other Caribbean islands. They are generally narrow, existing mainly in the bays separated by lengths of cliffs. They are comprised mainly of stones and black volcanic sand, with the exception of the north east coast where a few stretches of coral sand can be found. The colour of the island's sandy beaches therefore vary from black, to grey, to light cream.

- *Coral Reefs* - Coral reef habitats are not extensive due to the steep topography and rugged terrain. Given the narrowness of the coastal shelf on the west coast of the island there is not a very large expanse of coral reef there. The east coast has a wider expanse of coastal shelf and as a result there are marked differences between the species that inhabit the two different areas, though there are some similar species as well. The coral diversity of the western coast, which is washed by the calmer Caribbean Sea, is greater than that of the east coast. However, the coral reefs of the east coast are healthier with very little algal growth and are larger in extent in comparison to the reefs in other locations. In addition, the east coast species can also withstand the greater wave impact, which is produced by the turbulent waters of the Atlantic Ocean.

  The most significant coral reef formations are found at Scott's Head, Soufriere, Pointe Guignard, Mero, Grand Savanne, Pointe Round, Portsmouth, the Cabrits,

Petite Baie, Toucari, Calibishie, and Pointe Baptiste. These all play a vital role in coastal stability, and serve as fish breeding and nursery grounds, avifauna habitat, and silt trap and nutrient exporters.

- *River Estuaries* - Dominica is widely reported as having three hundred and sixty five (365) rivers that originate from the Island's mountainous interior and drain out into the Caribbean Sea on the west coat and into the Atlantic Ocean on the east coast. In some instances, the sea meets the river for some significant distance inland forming a huge pool of brackish water. This condition provides a habitat and nursery for many of the organisms which require brackish water, or water of varying salinities, for survival. This habitat also provides a haven for anadromous fish and some crustaceans that live most of their adult life in rivers (Guiste 2001).

- *Sea Grass Beds* - Sea grass beds are not very extensive given the topography and terrain of the coast. They can however be found in the vicinity of Bioche, Dublanc and Morne Espagnol and to a lesser extent off Coulibistri, Colihaut and the Cabrits.

- *Mangroves/Wetlands* - Four small mangroves stands and some larger areas of *Pterocarpus officinalis* swamp forest and marsh can be found, restricted to the northern and western section of the island. The most important expanse of these types of vegetation are found at the Cabrits Swamp, Indian River Flats and Lagoon, Canefield Pool and adjacent meadows, Melville Hall and on the north coast. Many of these wetlands provide important fishery and avifauna habitats.

- *Fish* - A documented list of fish species has not been compiled for Dominica. It is well known, however, that the coastal waters provide a habitat for many different types of fish. Some of the most common types identified in fish landings are several species of Grouper and Snapper, Squirrel Fish, Black Bar Soldier Fish, Goat Fish, Grunts, several species of Wrasse, Parrot Fish, various Tuna and Tuna like species, Dolphin, Wahoo, Flying Fish, Ballyhoo, Sardines, Jacks, Scads and Sprats and File Fish.

- *Seaweeds* - Seaweeds are harvested for both household and commercial sea moss production.

- *Turtles* - Four species of turtle are found in the Dominican waters. They are the Hawksbill (the most common), the Green Turtle, the Leather Back and the Loggerhead.

- *Marine Mammals* - The coastal waters of Dominica present a haven for many marine mammals, including several species of whales and dolphins. These include Sperm Whale (*Hyster catodon),* Bryde's Whale (*Balaenoptera edeni),* hort-fined Pilot Whale (*Globicephala macrorhynchus),* Cuvier's Beaked Whale (*Ziphius cavirostis),* Pygmy Sperm Whale (*Kogia breviceps),* Whale Shark Spotted Dolphin (*Stenella sp),* Spinner Dolphin (*Stenella clymene),* Frasers Dolphin (*Lagenodelphis hosei),* and Bottlenose Dolphin (*Tursiops truncates).*

Dominica has developed a whale watching industry where day trips are organised for visitors and locals alike. The whales are located from about 0.5 miles to 4 miles from the coastline. In some cases, land-based whale watching can also be done. Sperm Whales are the most commonly observed mammals, seen all year round on the west coast of Dominica. The waters of Dominica appear to serve as a breeding ground for the Sperm Whale. Mating behaviour, as well as adults with newly born calves with the umbilical cord still attached, has been observed on many occasions.

- *Crustaceans* - The coastal waters of Dominica are home to a great number and variety of crustaceans. These include land, marine and white brackish water mud crabs, marine and fresh water shrimp and four species of lobster.

- *Porifera, Echinoderms and Molluscs* - Many species of sponges, exist in the same habitats as the corals and a fairly diverse range of echinoderm species (for example, sea cucumbers, the Brittle Star and two species of Sea Urchin) are found. The molluscs found include whelks, which are only harvested seasonally.

- *Seabirds* - Twenty-seven (27) species of seabird have been recorded in Dominica's coastal waters. Seven (7) species breed in small numbers on the relatively inaccessible cliffs and offshore islets, mainly on the east and south east coast where predation pressures are lower. One of the seabird species of regional interest is the "Diablotin" or Black-capped Petrel *(Pterodroma hasitata)* recorded on Dominica up to the later half of the 1800s. The "Diablotin" was considered to be extinct on Dominica. However, a sighting in 1982 could be an indication that the species may be breeding on remote inaccessible coastal cliffs.

- *Coastal Vegetation* - The coastal vegetation of Dominica varies with location. Nevertheless the various shrubs, herbaceous plants and trees all play an important role in protecting the coast from wind and sea erosion.

1.1.6. Seismic Activity

Dominica experiences a significant amount of seismic activity. During the period 1998/99 the activity was particularly intense, with recordings of 183 movements in one day on October (23rd) 1998.

It is estimated that over 90% of the population live within 5 kilometers of a live volcano and Roseau the capital city and most densely populated center is reported to be virtually "*looking into the gun barrel of a set of active and dangerous volcanoes*" (Indee).

Recent eruptions scenarios developed by Sherperd et. al. (2000), indicate that it is more likely than not that Dominica will experience a magmatic eruption in the next one hundred (100) years, with a probability of "1 in 5" that it will occur in the next ten (10) years.

1.2. CLIMATE

The island has a maritime tropical climate, which is influenced by the North East Trade Winds. The island's rugged topography results in micro-climatic variability within very short distances, influenced by the high moisture content of the air masses that enter the region from the Atlantic Ocean.

1.2.1. Humidity

A relative humidity of about 95% prevails with little seasonal or diurnal variation. This seldom falls below 85% in the interior. On the leeward coast humidity ranges between 58% and 86%. At night, the humidity levels rise, particularly in the interior where temperature drops sharply.

1.2.2. Rainfall

Rainfall tends to be orographic in nature due to Dominica's rugged terrain. It is one of the wettest islands of the Caribbean. The eastern Atlantic coast receives an annual average rainfall of 2,500mm - 3,800mm. This is distributed between a drier season from December - April and a wetter season from June - November. The western Caribbean coast lies in the "rain shadow" of the mountainous interior. Average annual rainfall along the west coast is less than 2000 mm. The high rainfall makes the country susceptible to landslides, particularly in the more mountainous regions.

1.2.3. Temperature

Temperatures average 27°C. This varies between a maximum of 33°C along the coast and 27°C in the mountains during the day, and a minimum of 18°C and to 12°C respectively, during the night.

1.2.4. Hurricanes

Dominica is situated in the tropical Atlantic hurricane belt and since 1979, has been impacted by fifteen (15) tropical weather systems, eleven (11) of which were hurricanes. Statistically Dominica averages a direct strike or close range hit (within 60 miles) by a cyclonic storm system every 3.82 years.

The frequent hurricanes have had a significant adverse impact on the development of the social and economic infrastructure of the country, as illustrated by the following examples, viz:

- Hurricane David in 1979, a category 4 hurricane, caused severe damage to the forest of Dominica.

Photo 1.3 – A Deforested and Severely Battered Roseau River Valley after Hurricane David 1979

It is estimated that 60% of the tropical forest was damaged. Unda (1986) reported that most of the trees were debranched, 42% of the standing volume was damaged and 11% completely destroyed (broken off or uprooted. In addition 60 percent of the population was left homeless and 39 deaths were reported.

- In 1995, 100% of Dominica's economically important banana crop was lost to Hurricanes Luis, Marilyn, and Iris. Dominica also suffered major coastal damage from these hurricanes.

- In 1999, Hurricane Lenny occurred in November. It was the most unusual hurricane for nearly 100 years to visit Dominica's shores since the hurricane season normally ends in October. In addition, it approached the island from a northerly direction representing a departure from the normal southern approach. It caused hundreds of millions of dollars of damage to the coastline, sea defense structures, roads, fishing, hotel and tourism industry, housing and utilities.

Photo 1.4 - Damage to coastal housing by Hurricane Lenny at Soufriere

1.3. SOCIAL CHARACTERISTICS

1.3.1 Population

(a) Size

Dominica is the least populated of the Windward Islands, with a 1994 population of 74,750 and average population density of 99.59 per sq. km.

(b) Growth

The rate of natural increase in the population increased in the 1994 – 1999 period as a result of marginal increases in birth rates and fertility rates. Historically, this has been offset by high net migration rates. (*Chief Medical Officer's Report, 2000*).

Table 1.2 - Table of National Circumstances-1994

CRITERIA	1994
Population	74,750
Area (Sq. Km.)	750.60
GDP (1994 US M$)	149.55
GDP per capita (1994 US$)	2,000.67
Estimated share of the informal sector in the economy in GDP (%)	n.a.
Share of Industry in GDP (%)	6.72
Share of services in GDP (%)[11]	39.31
Share of Agriculture in GDP (%)	22.42
Land Area used for agricultural purposes (sq. Km.)	200.93
Urban population as a percentage of total population	34
Livestock population[12]	
- Cattle	2,970
- Goats	10,150
- Sheep	3,060
- Pigs	3,780
- Chicken	57,100
Forest Area (sq. Km.)	450
Population in absolute poverty (%)	27.6[13]
Life expectancy at birth (years)	
- **Men**	64
- **Women**	71
Literacy Rate (%)	81.2

The provisional results of the 2001 National Census released by the Central Statistical Office (CSO) indicate that the 2001 population is 71,242 with an average density of 94.91 per sq. km.

(c) Ethnic Composition

The population is comprised primarily of persons of African decent (89%), mixed (7%), together with a significant Carib population (2%). These three groupings comprise 98% of the population, with the remaining 2% being of European, American and Chinese origin.

(d) Age Profile

Dominica has a relatively young population. Approximately sixty two percent (62.5%) of the population of 74,750 is below the age of 30 - **Table 1.3.**

[11] *Services include Banks/Insurance (12.28%), Government Services (17.84%), Communications (8.02%) and other services (1.17%). Source: Central Statistical Office/Eastern Caribbean Central Bank*
[12] *Based on 1995 Dominica Agricultural Census (Final Results)*
[13] *Based on Draft Poverty Assessment by the British Development Division, 1995. Poor households are defined as "households spending more than 60% of their income on food".*

(e) Location of Population Centers

Most population concentrations are along the coast, due to the rugged nature of the interior.

1.3.2. Life Expectancy

Life expectancy at birth in 1994 was 64 years for men and 71 for women. In 2000, life expectancy was estimated at 71 and 74 years for males and females respectively.

1.3.3. Literacy Level

The adult literacy rate in 1994 was 81.2%. This had risen to 95% by the year 2000.

Table 1.3 - Estimated End of Year Population by Age Group and Sex - 1994

AGE GROUP	MALE	FEMALE	TOTAL	%
0 –4 yrs	4,394	4,094	8,484	11.34
5 – 9 yrs	4,441	4,254	8,695	11.63
10 – 14 yrs	4,261	4,147	8,408	11.25
15 – 19 yrs	4,330	3,640	7,970	10.66
20 – 24 yrs	3,535	3,293	6,828	9.13
25 – 29 yrs	3,223	2,787	6,010	8.04
30 – 34 yrs	2,778	2,322	5,100	6.82
35 – 39 yrs	2,171	1,820	3,991	5.35
40 – 44 yrs	1,594	1,513	3,107	4.16
45 – 49 yrs	1,353	1,259	2,612	3.49
50 – 54 yrs	1,093	1,071	2,164	2.89
55 – 59 yrs	1,048	1,059	2,107	2.82
60 – 64 yrs	1,092	1,198	2,290	3.06
65 – 69 yrs	976	1,025	2,001	2.68
70 – 74 yrs	814	944	1,758	2.35
75 – 79 yrs	615	646	1,261	1.69
80 – 84 yrs	430	541	971	1.30
85 + yrs	238	398	636	0.85
Not stated	193	160	353	0.47
TOTAL	**38,579**	**36,171**	**74,750**	**100**

S

Source: Central Statistical Office 1996

1.3.4. Poverty Level

A 1995 Draft Poverty Assessment by the British Development Division (BDD) estimated the level of poverty in Dominica at 27.6%[14].

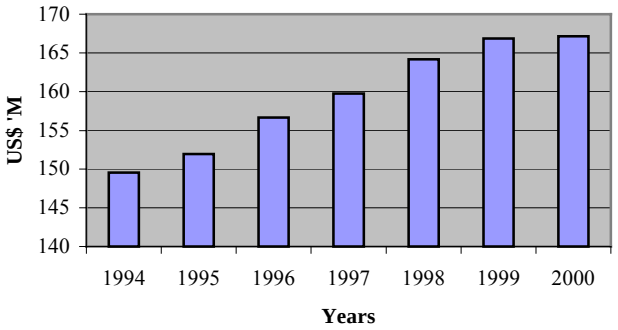
1.4. ECONOMIC CHARACTERISTICS[15]

1.4.1. Gross Domestic Product (GDP)

Gross Domestic Product[16] in 1994 was US$149.55M.

Over the period 1994 to 2000, GDP increased by 11.8% to US$167.13M, with annual growth rates ranging between 0.17 and 3.08 percent. (**Fig 1.3)**

Fig. 1.3: GDP Trends 1994 - 2000



The main sectoral contributors to GDP in 1994 (**Fig 1.4**) were:

- Agriculture – 22.42%
- Government Services – 17.84%
- Banks and Insurance – 12.28%
- Wholesale and Retail Trade – 12.14%
- Transport – 9.84%

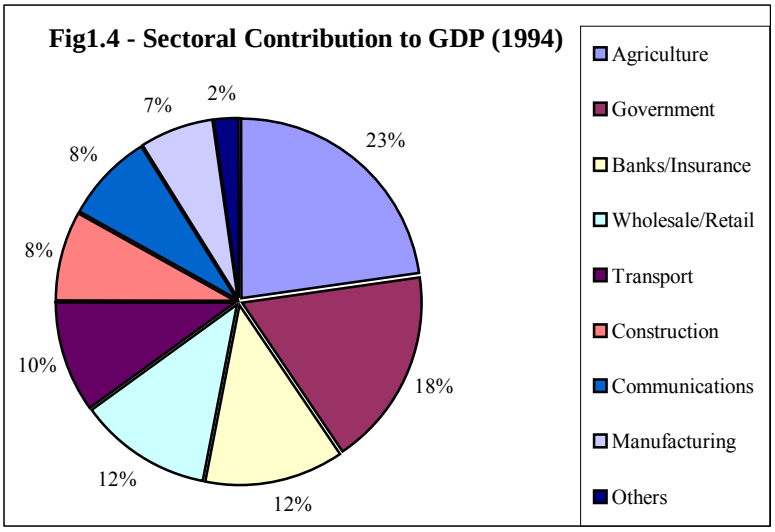
[14] *Poverty was defined as households spending 60% or more of their income on food.*

[15] *Based on data from the Central Statistical Office and the Eastern Caribbean Central Bank*

[16] *GDP at Factor Cost in constant (1990) prices*

- Construction – 8.07%
- Communication – 8.02%
- Manufacturing – 6.72%
- Others- 2%.

By 2000, the structure of the economy had undergone some changes, with a significant decline in the agricultural sector and a significant increase in the contribution from the communications sector – **Table 1. 4**.



1.4.2. Main Economic Sectors

(a) Agriculture

Agriculture has been the base of the economy for many years, accounting for the largest proportion of the island's GDP, foreign exchange earnings and employment.

In 1994, the Agricultural sector registered negative real growth. Overall output declined by 3.4 % with a contribution to real GDP estimated at 22.42%. Banana export volumes contracted by 22.9%, from 55,485 in 1993 to 42,790 tonnes in 1994. The decline was attributed largely to low banana crop yield, falling export earnings, financially weak support institutions and failure to link production initiatives with critical marketing initiatives, with added emphasis on shipping. In addition, adverse weather conditions and a prolonged dry spell in the year and the passage of tropical storm Debbie damaged about 25.5% of the banana cultivation.

Table 1.4 – Changes in Sectoral Contribution to GDP 1994 – 2000

SECTOR	1994 %	2000 %	CHANGE
Agriculture	22.42	18.24	(4.18)
Government	17.84	17.83	(0.01)
Banks/Insurance	12.28	13.19	0.91
Wholesale/Retail	12.14	12.95	0.81
Transport	9.84	9.57	(0.27)
Construction	8.07	8.23	0.16
Communication	8.02	11.37	3.35
Manufacturing	6.72	7.18	0.46

Source :CSO

(b) Manufacturing

The manufacturing sector contributed 6.7% to overall GDP in 1994. It experienced a 9.65% drop over 1993. The largest decline in the economy was experienced in this sector. It was in an embryonic state with activities concentrated around the soap and detergent industry and spring water, as well as in agro-products of coffee and fruit preserves.

The main constraints to the development of this sector included the underdeveloped entrepreneurial talent, limited access to capital, a small domestic market, inadequate marketing and transport infrastructure and a shortage of skilled manpower.

(c) Tourism

Dominica targets the eco-tourism niche market in an effort to take advantage of its natural vegetation, rugged topography, rural ambience and limited urbanization. In spite of its enormous potential the tourism sector in Dominica in 1994 was small, with the hotel and restaurant sector contributing 2.8% of real GDP. Notwithstanding, the sector recorded the fourth largest increase in real GDP among the other sectors in the economy.

Tourist arrivals/stay over visitors increased by 8.8% in 1994 moving to 56,522. However, growth in the sector was constrained by the inadequate infrastructure and services, limited marketing resources and transportation links with major markets. In the cruise sector growth in passenger arrivals was estimated at 13.6% moving to 125,541. Total visitor arrival was recorded at 190,872 visitors with a visitor expenditure of EC$86 million.

In 2000, tourism accounted for 60% of the foreign exchange earned by the service sector, 35% of total exports and approximately three times the export earnings of the banana sector.

1.4.3. Macro-economic Indicators

(a) Per Capita Income

GNP per capita in 1994 was US$2,000.67[17] but had increased by approximately 48.5% to US$2,967.72 by the end of 2000.

(b) Unemployment

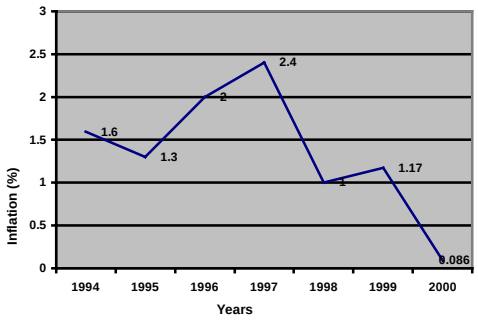
Unemployment in 1994 was 20%. This had increased to 23% by the year 2000. The quality of the labour force remains largely non-technical and untrained for the industrial and service thrust of the economy.

(c) Inflation

The inflation rate, measured as the average annual percentage change in the consumer price index has been relatively low.

It averaged 1.6% in 1994 and has fluctuated between 0.086 and 2.4% in the 1994 – 2000 period - **Fig.1.5**.

Fig.1.5: Inflation Rates (1994-2000)



(d) Exchange Rates

[17] *Calculated on the basis of GDP at Factor Cost in constant (1990) prices*

Dominica 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) Fiscal Operations

Government recurrent revenue had increased by 35.7% from US$55.89M in 1994 to US$75.85M by 1998. During this period, the Government has maintained a current account balance, which peaked at 3.95% of recurrent revenue in 1998.

(f) Public Debt

The outstanding public debt in 1994 was US$115.19 M. This had increased to US$175.9 M in 2000.

2. GREENHOUSE GAS INVENTORY

This Inventory of Net Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases (GHG's) (CO2, CH_4 and N_2O) and related gases (NOx, CO, NMVOC), was undertaken in compliance with Articles 4 and 12 of the United Nations Framework Convention on Climate Change (UNFCCC) and in accordance with Inter-Governmental Panel on Climate Change (IPCC) Revised (1996) Guidelines.

The Reference Year was 1994.

2.1. METHODOLOGIES

The Inventory covers the following main Greenhouse Gases (GHG's) - Carbon Dioxide (CO_2), Methane (CH_4) and Nitrous Oxide (N_2O). Other gases that contribute to Tropospheric Ozone (O_3) formation, such as Non-Methane Volatile Organic Compounds (NMVOC), Carbon Monoxide (CO) and Nitrogen Oxides (NO_x) were also included in the inventory.

The GHG Inventory was done on an individual sector basis for the Energy, Industrial Processes, Agriculture, Land Use and Forestry and Wastes Sectors. The Solvents Sector, for which the IPCC methodology is not yet available, was not completed.

In accordance with the Guidelines set out by the IPCC, Carbon Dioxide emissions from International Bunkers and burning of Biomass as an energy source were not included in the national totals, but they are reported separately as Memo Items.

For purposes of verification and transparency, the completed relevant IPCC Worksheets for all Sectors, in addition to the Summary Report Sheets and uncertainty tables, used to prepare the Inventory Report are included in the appendices (**See Appendices 1 to 10**).

Uncertainty is also addressed.

2.1.1. Energy Sector

Both the aggregate fuels supply top-down Reference Approach and the policy-oriented source categories bottom-up Sectoral Approach were used to calculate the GHG Inventory for the Energy Sector.

There is no production of primary and /or secondary fossil fuels in the Commonwealth of Dominica. Secondary liquid fuels are imported for local consumption. Bitumen (mainly for road paving) and lubricants are other fuels imported -**Table 2.1.**

Energy is produced through the combustion of these secondary fuels for the use in power-generating utilities, transport, agriculture, fishing, manufacturing, commercial, residential and tourism and international bunkers sectors.

Local activity data for the fuels imported and supplied were converted from kilograms (kg) to an appropriate unit (kt) so as to facilitate the direct application of the IPCC Conversion Factor (TJ / kt) in order to derive the Apparent Consumption in TJ.

Table 2.1: Supply (Import) of Fuels (kt) for Dominica in 1994

Fuel Imports Categories	(kt)	%
Gasoline	11.06	32.1
Jet Kerosene	0.06	0.002
Other Kerosene	0.32	0.93
Gas / Diesel Oil	9.29	27.0
Residual Fuel Oil	0.71	2.06
LPG	1.81	5.26
Bitumen	10.75	31.22
Lubricants	0.34	0.99
Other Oil	0.09	0.26

In all cases, for lack of country-specific data, the Default Values of the Conversion, Emission and Carbon Oxidation factors as furnished by the IPCC, when available, were used. In certain instances, as for example Conversion Factor for solid biomass (Charcoal, Agricultural Residue and Firewood), default values were extracted from countries of similar characteristics, or from the same geographical area (Antigua and Barbuda, St. Lucia).

2.1.2. Memo Items

The current IPCC methodology requires that emissions from International Bunkers and Biomass used as a fuel in the energy sector be reported separately in the GHG Inventory of a country.

Emissions from international bunkers are limited to emissions from jet kerosene sold to aircrafts that fly regionally and to marine bunkers.

CO_2 emissions from aviation international bunkers for the year 1994 were calculated using the IPCC Tier 1 approach.

2.1.3. Industrial Sector

Dominica does not have a strong Manufacturing or Industrial sector so that CO_2 and non-CO_2 emissions from light manufacturing or heavy industries are minimal or non-existent. The Food and Beverage industry and Road Paving with Asphalt are the main emitters of non-CO_2 gases in the form of NMVOCs. Furthermore, the consumption and use of halocarbons for air-conditioning and refrigeration causes the release of HFCs. Also, there are small emissions of SO_2 from the manufacture of pumice stone.

NMVOC emissions derive from bitumen used in road paving asphalt, the manufacture of alcoholic beverages (rum and beer mainly) and food production (bread, crude coconut oil and edible oils).

HFC emissions, also reported under the Montreal Protocol, derive from the import and consumption of halocarbons, including leakage and disposal, in refrigeration and air-conditioning activities.

All activity data are country-specific and were obtained from the Statistics Division of the Ministry of Finance and Planning and the National Documentation Centre. However, all emission factors were taken as Default Values from the IPCC Workbooks.

2.1.4. Agriculture Sector

A wide range of agricultural crops is produced for export and local consumption. These include bananas, plantain, coconuts, root crops, citrus, coffee, cocoa and spices. The main export crops are bananas, plantains, root crops and citrus.

The livestock sector is not well developed and consists of relatively small numbers of cattle, pigs, goats, sheep and poultry.

Methane (CH_4) and Nitrous Oxide (N_2O) are the only perceptible greenhouse gases emitted by the Agriculture Sector. CH_4 emissions are limited to emissions from Enteric Fermentation and Manure Management from animal stocks.

N_2O Emissions derive from nitrogen-rich Histosols, fertilizer application to cultivated soils, excretion from grazing animals, atmospheric deposition of NH_3 and NO_x and from leaching of agricultural soils.

Activity data on animal population according to species, for CH_4 and on agricultural soils for N_2O, are country-specific and were obtained from the Livestock Division of the Ministry of Agriculture. However, emission factors for enteric fermentation and manure management, in the case of CH_4, and for soil processes in the case of N_2O, were taken as default values from the IPCC Workbooks. Where this was not possible, as for instance emission factors for poultry, this was taken from other similar country reports.

2.1.5. Land Use and Forestry Sector

Limited data sets and expert estimations (*Forestry Division, Government of The Commonwealth of Dominica*) place total forest acreage that is anthropogenically-impacted at 14.23 kilohectares, consisting mainly of Mixed Fast-Growing Hardwoods (4.54 kilohectares), Mixed Hardwoods (2.45 kilohectares) and Other Forests - Dry (3.19 kilohectares, Other Forest Seasonal (3.59 kilohectares), Other Forests – Moist (0.46 kilohectares) and Mangroves (0.0004 kilohectares).

The number of Non- Forest Trees could not be accurately calculated, but conservative calculations by the Environmental Coordinating Unit (ECU), using data obtained from the 1995 Agricultural Census, put the number at 8,089,000 trees. Furthermore, based on local expert judgment, changes in these acreages over the last 20 years have been estimated to be minimal.

Activity data on Species and Areas (hectares) of forest/biomass stocks, on Annual Growth Rate (t dm/ha) of forests and other trees and savannas and on Commercial Harvest (m^3) are country-specific and were obtained from the Forestry and Wildlife Division of the Ministry of Agriculture in Dominica and to a limited extent from the FAO Statistical Yearbook. However, Conversion and Emission factors relating to Carbon Fraction, Biomass Conversion/Expansion and Fraction of Biomass Oxidized were taken as default values from the IPCC Workbooks. Furthermore, where published data was lacking, as for instance fraction of biomass burned on-site and off-site, these were estimated from comparisons with other countries in the region.

2.1.6. Waste Sector

In the Waste sector, greenhouse gas emissions are limited to Methane (CH_4) from Solid Waste Disposal Sites (SWDS) and to indirect Nitrous Oxide (N_2O) emissions from Human Sewage.

(a) Solid Waste Disposal on Land

Solid Waste Disposal is limited to two (2) managed Sanitary Landfills located at Roseau and Point Ronde near Portsmouth where a large part of the waste is buried for decomposition. There are also small, illegal, open dumps scattered in the rural areas, but the volumes involved are very small and are therefore not included in the Inventory.

Activity data pertaining to Municipal Solid Waste (MSW) disposed to SWDS are country-specific data that was obtained from the Dominica Solid Waste Corporation. Per capita waste generation rates were determined based upon current waste arrivals recorded at the landfills. However, the IPCC Default values for Methane Correction factor, Fraction of DOC in MSW, Fraction of DOC that degrades and Fraction of Carbon Released as methane, were used for the estimation of Methane emissions from solid waste disposal systems.

(b) Indirect Nitrous Oxide Emissions from Human Sewage

The city of Roseau (including Canefield and Goodwill) and the Jimmit Housing Scheme are the only areas in Dominica with a municipal sewage system. In Roseau, the outfalls of the sewage mains discharge directly into the sea without any treatment.

According to the 1991 Commonwealth of Dominica Population and Housing Census Report, the number of households with pit latrines was 6,851 (35.4%), cesspit/septic tanks 4,637 (23.9%), linked to sewage treatment 2,499 (12.9%), other 449 (2.3%) and none 4.938 (25.5%).

Nitrous oxide (N_2O) emissions from Human Sewage were estimated from country-specific data obtained from the FAO Food Balance Sheets for Dominica.

However, the IPCC Default factors for Fraction of Nitrogen in Protein and Emission of N_2O were used to estimate the emissions of N_2O from Human Sewage.

2.2. GREENHOUSE GAS INVENTORY RESULTS

2.2.1. Sectoral Approach

The use of the Sectoral Approach to determine the carbon dioxide emissions from the energy sector produced total emissions of 76.53Gg of CO_2.

2.2.2. Reference Approach

The use of the Reference Approach to determine carbon dioxide emissions from the energy sector produced total emissions of 75.3 Gg. This compares favourably with the 76.53 Gg calculated using the sectoral approach – a difference of less than 2% and is an indication of the consistency and accuracy of the data and the calculations

2.2.3. Primary Emission Sources

The CO_2 emissions from Energy Sources and Fuel Combustion Categories are shown in **Table 2.2.** The largest emissions of CO_2 result from the combustion of gasoline (45.1%), mainly for vehicular road transport as well as agriculture and fishing. This was followed by gas/diesel oil (37.96%) used almost exclusively in the production of thermal energy. Smaller amounts of CO_2 combustion resulted from the use of LPG (7.08%) in the residential sector. Bitumen which accounted for 31.22% of total fuel imports in 1994 is not combusted for energy and is used mainly in road paving and therefore does not contribute to total CO_2 emissions

Table 2.2: CO_2 Emissions from Energy Sources and Fuel Combustion Categories

FUEL	Gg CO_2	%
Gasoline	33.99	45,1
Jet Kerosene	0	0
Other Kerosene	1.02	1,35
Gas / Diesel Oil	28.59	37.96
Residual Fuel Oil	2.2	2,92
LPG	5.33	7,08
Naptha	3.43	4,56
Bitumen	0	0
Lubricants	0.49	0,65
Other Oil	0.25	0,33
Total	**75.30**	**100**
Memo Items		
International Bunkers	1.13	7,65
Solid Biomass	13.64	92,35

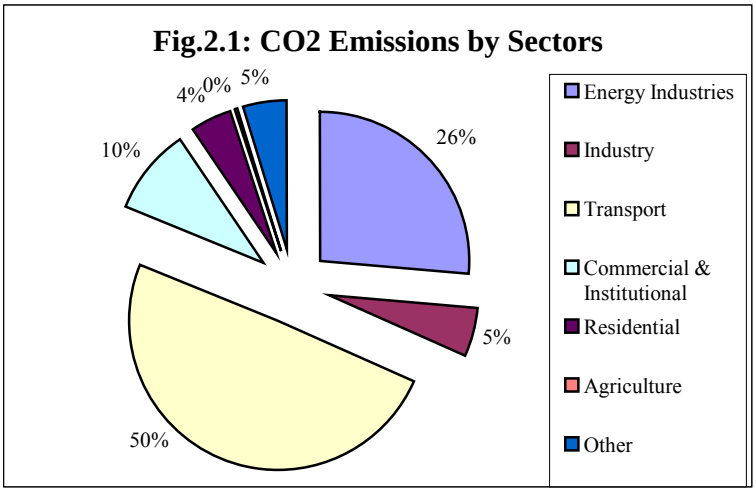
(a) Carbon Dioxide (CO_2)

The carbon dioxide emissions (%) by sub-sectors within the energy sector utilising the Sectoral approach is presented in **Fig 2.1**.

The key sources of carbon dioxide emissions are:

- Transport – 50%.
- Energy Industries – 26%.
- Commercial and Industrial Uses – 10%.
- Industry – 5%.
- Residential – 4%.

Fig.2.1: CO2 Emissions by Sectors



- Other – 5%

There were no CO_2 emissions from the Industrial, Agricultural and Waste Sectors. Total emissions from the Forestry and Land Use Sector were 26.72 Gg consisting mainly of 26.35 Gg (98.62%) from the Forest and Grassland Conversion.

These emissions of carbon dioxide are mitigated by removals from changes in forest and other woody biomass stock and from the abandonment of managed lands. The total removals of CO_2 for Dominica in 1994 were –398.57 Gg. This consisted of –354.92Gg(89.05%) of CO_2 from changes in forest and other woody biomass stocks and –43.65 Gg (10.95%) of CO_2 from carbon uptake from the abandonment of managed lands This resulted in a net CO_2 removal of –371.85Gg.

(b) Other Greenhouse Gases

The Commonwealth of Dominica also had perceptible emissions of three (3) other greenhouse gases:

- Methane – from solid waste disposal, enteric fermentation and manure management;

- Nitrous oxide – from cultivation of histosols, leaching of agricultural fields and sewage; and

- Non-methane Volatile Organic Compounds from road paving asphalt, food production and the production of alcoholic beverages.

Table 2.3 provides a national summary of the Greenhouse Gas Inventory, with the data disaggregated on a sectoral basis.

The data shows that Dominica is a net sink for Carbon Dioxide amounting to net removals of 295.14 Gg of carbon dioxide in 1994. There were also small quantities of methane, nitrous oxide and non-methane volatile organic compounds – 2.97 Gg, 0.042 Gg and 6.26 Gg respectively.

Table 2.3: 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	CO2	CH4	N2O	NMVOC	SO2
Total (Net) National Emission (Gigagrams per year)	**(295.14)**	**2.97**	**0.042**	**6.26**	
1. All Energy	76.53	0.01	0.00		
Fuel Combustion					
Energy and transformation industries	20.21				
Industry	4.10				
Transport	37.68				
Commercial-Institutional	7.33				
Residential	3.41				
Agriculture, Forestry, Fishing	0.10				
Biomass burned for energy	3.70				
Fugitive Fuel Emission					
Oil and natural gas systems	n.a				
Coal mining	n.a				
2. Industrial Processes					
Road paving asphalt				6.13	
Alcoholic beverages				0.06	
Food production				0.07	
3. Agriculture					
Enteric fermentation		0.226			
Leaching of agricultural fields			0.01		
Cultivation of histosols			0.02		
Manure management		0.014			
Grazing animals			0.0015		
4. Land Use Change and Forestry					
Changes in Forestry and other woody biomass stock	(354.92)				
Forest and Grassland Conversion	26.53				
Abandonment of Managed Lands	(43.65)				
Carbon release from agriculturally impacted soils	0.37				
5. Other Sources as appropriate and to the extent possible					
Solid Waste disposal on land		2.73			
Sewage			0.01		

Notes: n.a. – Not applicable.

2.3. UNCERTAINTIES

The calculations of sources and sinks of GHG's for the different sectors, as described above, incorporate several levels of uncertainty with respect to both the country activity data and the various conversion and emission factors.

The ratings of these uncertainties are provided in Table 8A of the IPCC methodology (Revised1996) which is found in Appendix 10 (Table 8: Summary Rating of Uncertainties).

2.3.1. Energy Sector

The main source of uncertainty is the partitioning of the total fuels used in the different sub-sectors. This somewhat limits the results of the Sectoral Approach. However, for the Reference Approach, where the total fuels used are lumped together, there is lesser or very little uncertainty. All activity data has been sourced locally from the Statistical Division of the Ministry of Finance and Planning, which produces annual energy importation data for Dominica. In addition, the sectoral data for energy consumption was obtained from Caribbean Energy Information System (CEIS) studies.

Another source of uncertainty in the Energy Sector, regarding activity data, is with respect to the Memo items. For International Marine Bunkers, for instance, uncertainties exist since the data was partly estimated. Also, country statistics on charcoal and firewood (Biomass) burning were estimated. As for the emission factors for the various greenhouse and other gases (CO_2, CH_4, N_2O, NO_x, CO, NMVOC) the IPCC default values (mostly Tier 1) were used in almost all instances, since country–specific measurements are not available.

2.3.2. Industrial Sector

Greenhouse gas emissions in the industrial sector are restricted to: NMVOC in Road Paving, Alcoholic Beverages and Food Production industries; SO_2 emissions from the manufacture of concrete pumice stone; and HFCs emission from refrigeration and air-conditioning systems. Activity data for these were obtained primarily from the Statistics Division and the ECU, so that uncertainties are minimal.

It must be noted however, that the NMVOC emission factors are based on the IPCC default values, which may be somewhat unrepresentative, based on the age and condition of the factories. Here again, country specific conversion factors are not available.

2.3.3. Agriculture Sector

Government Statistics and expert judgment were used to obtain estimates of the animal population.

2.3.4. Land Use Change and Forestry

There are a number of uncertainties relating to greenhouse gas emissions and removals in this sector. There was a difficulty in assessing the fraction of the forested area which was anthropogenically impacted. In Dominica, selective logging is done mainly for lumber and charcoal production. As such, to determine the actual area disturbed from logging operations was difficult.

There is no recorded data on the exact number of non-forested trees. An estimate was made using pure stand acreages from the 1995 Agricultural Census Report and estimate of crop acreages from the Ministry of Agriculture and the Environment.

With regards to emission and conversion factors, the IPCC default values were used. Given the very general nature of these default values, country-specific values such as

annual growth rate of forests may be quite different and introduce significant uncertainty in the GHG emissions and removals calculations.

Data on the abandonment of managed lands was not readily available and was estimated by the ECU using data obtained from the Dominica Banana Marketing Corporation, the 1995 Agricultural Census and other documents.

2.3.5. Waste Sector

The methodology utilizes population statistics for urban areas and this was used in the calculation of CH_4 emissions from solid waste disposal sites. Under worksheet 6-1C (Supplement), default values for Methane Correction Factor were used. There is high uncertainty, as no data was available for 1994. The calculations were made utilizing data from 1998 –2000 provided by the Dominica Solid Waste Corporation.

In the case of N_2O emissions from human sewage, the IPCC default values were used. This may not be applicable to Dominica and is a source of uncertainty. The per capita protein consumption value used was derived from The FAO Food Balance Sheets for Dominica 1994 – 1996.

Furthermore, although there are both domestic and industrial sources of wastewater, CH_4 emissions were not calculated because there is no anaerobic treatment of wastewater.

2.3.6. Summary of Uncertainties

In summary, the GHG emissions and removals for the different sectors were calculated using available data and expert judgment. However, it must be cautioned that there are uncertainties in these estimates and the degree of uncertainty varies between sectors.

Dominica does not have the expertise or the resources to improve upon these uncertainties. However, with assistance from the UNFCCC, or other funding agencies, the capacity can be improved and studies can be attempted to address these uncertainties.

2.4. RECOMMENDATIONS FOR IMPROVING ACCURACY

Based on the problems encountered in the preparation of the GHG inventory, it is recommended that future efforts focus on training, research and data collection activities. There is need for greater local capacity to undertake future inventory compilations.

There is also need for research in such areas as forest species coverage, using, for instance, remote sensing coupled with GIS methods. But the most pressing need is for obtaining local data on emission factors in the various sectors.

3. VULNERABILITY ANALYSIS

This vulnerability assessment will provide baseline information on Dominica's vulnerability to the impacts of climate change to the year 2050, as can be determined by the available information.

It will use internationally accepted climate change scenarios and examine possible impacts on the coastal zone, forestry, freshwater resources, human settlements, tourism, agriculture, fisheries, and human health.

It will also identify data gaps, capacity building needs and implementation requirements for conducting more in depth vulnerability and adaptation activities.

3.1 CLIMATE CHANGE SCENARIOS

Vulnerability is defined by the IPCC as *" the extent to which climate change may damage or harm a system. It depends not only on a system's sensitivity but also on its ability to adapt to new climatic conditions"*(IPCC, 1995). Vulnerability to climate change can therefore be seen as a complex mixture of ecological, economic and societal factors.

3.1.1. Global Scenarios

The IPCC (2001) in its Third Assessment Report (TAR), pointed out that there was an increasing body of observations providing a picture of a warming world and of other anthropogenic induced changes in the Earth's climate system. Specifically the TAR noted that:

- The global average surface temperature (the average of near surface air temperature over land and of sea surface temperature) has increased since reliable temperature records have been collected since 1861. During the twentieth century the increase has been between 0.2 to 0.6 degrees centigrade with most of this coming during the periods 1910 to 1945 and 1976 to 2000.

- Globally, the 1990s appears to have been the warmest decade and 1998 the warmest year since instrumental records began in the 1860s.

- On average, between 1950 and 1993, night time temperatures over land have increased by 0.2 degrees centigrade per decade: about twice the rate of increase in daytime maximum air temperatures. The increase in sea surface temperatures over the same period has been about half that of the mean land surface air temperature.

- Tidal gauge records for the period since the late 1950s show that global average sea level rose between 0.1 and 0.2 meters during the twentieth century.

- The statistical record indicates that some important aspects of climate appear not to have changed. For example, global changes in tropical and extra-tropical storm intensity and frequency appear to be dominated by decadal and

inter-decadal variations with no significant trends identified in the twentieth century.

- Human influences will continue to change atmospheric composition throughout the twenty-first century. Substantial reductions in emissions of the gases that cause global climate change[18] will be required to mitigate increases in global temperatures.

The TAR goes on to project that by 2100, the globally averaged surface air temperature will warm 1.4 C to 5.8 C relative to 1990 and that globally averaged sea level will rise 0.09 to 0.88m[19].

3.1.2. Caribbean Scenarios

(a) Temperature

The IPCC (1999) indicates that during the twentieth century, Caribbean islands have on average experienced an increase in temperature exceeding 0.5 degrees centigrade.

In view of the dominant influence of the ocean on temperature and climate in the Caribbean and the projected continued warming of the seas, the IPCC is estimating that the region will continue to experience warming in the future. Nighttime temperatures are likely to increase more than daytime, resulting in warmer nights on a proportionate basis. Humidity levels are expected to increase during both day and night periods.

(b) Rainfall

There has also been a significant increase in rainfall variability with mean annual rainfall declining by approximately 250mm. Gray (1993) confirms warming and drying tendencies at stations in Jamaica, Trinidad and the eastern Caribbean during the twentieth century.

Rainfall will be affected by inter-decadal and multi-decadal events such as El Nino Southern Oscillation (ENSO) and this is likely to enhance rainfall, and to a lesser extent temperature, variability by resulting in more periods of drought and floods. If present trends towards greater warming of the eastern Pacific continues, it is expected that drying influences associated with El Nino events are likely to increase in frequency and possibly intensity. Larger year-to-year variations in rainfall can be expected even in those regions that record overall increases in rainfall.

(c) Sea Levels

[18] *The term climate change rather than global warming is used throughout the report since warming represents only one aspect, although a very important element, of the processes associated with human induced changes in the Earth's climate.*
[19] *IPCC: Climate Change 2001: Impacts, Adaptation and Vulnerability, pg. 3*

Future sea levels are predicted using models representing such factors as thermal expansion of the oceans, melting of mountain glaciers and the like. Regional rates of sea-level rise are affected by a variety of factors including the processes of tectonic movement of the Earth. In the Caribbean, the picture in relation to historical trends with regard to sea-level rise is complicated by lack of available data. Hendry (1993) indicates that regionally, relative sea level is increasing at an average of 3mm/yr but with considerable regional variation. The 3mm figure does however indicate a rate of increase quite significantly above the global average.

Sea levels can therefore be expected to continue to rise, resulting in increased erosion in coastal areas. Ocean sea surface temperatures are expected to be higher. Storm surges are likely to increase as sea levels rise and shifts occur in storm activity and ocean currents.

(d) Summary

The overall picture of climate change for the Caribbean emerging from the IPCC's TAR is one of a warmer climate and rising sea levels, with greater variability of rainfall, resulting in more periods of drought and flooding.

3.1.3. Climatic Change Scenarios Used in Analysis

Based on the above analysis, the five scenarios for climate change in **Table 3.1** are used in the assessment[20]. They are based on data developed by various internationally recognized Global Circulation Models (GCMs). Synthetic scenarios, utilized to demonstrate possible levels of sensitivity to climate change, supplement these.

Table 3.1- Summary of Climate Change Scenarios

Climate Change Impact (To 2050)	Low Scenario	Medium Scenario	High Scenario (synthetic)
Mean Annual Temperature (degrees Celsius)	+1.71	+2.5	+3.5
Seasonal Mean Temperature Change (degrees Celsius) - December to February - June to August	 +1.68 +1.71		 +2.0 +2.5
Mean annual precipitation change (%)	- 30	-20	+30
Sea Level Rise (cms)	26	39	50
Tropical Storms/Hurricane Scenario (%)			+20

3.2. SOCIO-ECONOMIC SCENARIOS

Environment, society and economy are not static and consequently environmental, societal and economic changes will occur even in the absence of climate change. Since climate change is concerned with both long and short term impacts and responses it is necessary to attempt to outline what future conditions, independent of climate change, are

[20] *Percentages relate to variations from the present mean averages*

likely to be. As far as possible these projections have been developed in a manner consistent with the IPCC SRES scenarios.

3.2.1. Population

Dominica has maintained a fairly conservative rate of population growth due primarily to high rates of external migration to metropolitan and regional destinations. This growth rate is unlikely to continue indefinitely as a result of the following factors:

- Increasing pressure to reduce immigration in Europe, North America and even the Caribbean.
- Increased life expectancy as a result of improvements in medical science[21].
- Marginal increases in birth rates[22].
- The return of large numbers of Dominican nationals resident in other Caribbean islands escaping the adverse impacts of climate change (e.g. sea-level rise in low lying islands).

The projection is therefore for an increase in the population at a faster rate than has been experienced in the immediate past.

3.2.2. Economic Growth

In it's 2000 Report on Dominica, the Eastern Caribbean Central Bank (ECCB) provides an analysis of economic prospects for 2000 that may be extrapolated as a best indication of future economic direction.

The ECCB notes that prospects for growth are uncertain and that " *in the major export sectors the issue of competitiveness will continue to influence performance. Agriculture is likely to continue to decline in relative importance if banana production fails to recover… [The] government intends to advance its diversification efforts by promoting further development of non-traditional export services, including eco-tourism*".

In the 2000/01 Budget Address the Government of Dominica outlined its future development path as related to the need " *to facilitate the accelerated emergence of modernized, more diversified and resilient economic structures which will be supportive of genuine, profit oriented private sector investment, less reliant on access to guaranteed export markets and more compatible with the realities of the rapidly emerging liberalized global trading systems*".

These proposals point towards an economy where tourism, agriculture and manufacturing are the primary export sectors and sources of employment.

[21] *Chief Medical Officer's Report, Ministry of Health, 2000*
[22] *Chief Medical Officer's Report, Ministry of Health, 2000*

Significantly all have direct linkages to the utilization of natural resources and are in fact heavily natural resource dependent.

3.2.3. Socio-economic Implications

These developments would likely mean that the present stress on Dominica's natural resource base would continue, if not intensify, viz:

- Increased population will mean heightened pressure for land for housing, commercial, institutional, and infrastructural development.

- Increasing pollution of coastal and marine areas from land based sources (manufacturing, agriculture and tourism) with accompanying negative impacts on marine biodiversity.

- Generation of increasing amounts of solid and liquid wastes from domestic, tourism and agricultural uses.

- Other negative environmental trends including deforestation and consequent effects on watersheds and biodiversity.

Projections for impacts arising from global climate change will therefore likely be additional to the existing challenges of sustaining socio-economic progress and environmental integrity.

3.3. VULNERABLE SECTORS

3.3.1. Forestry and Terrestrial Resources

Dominica's 51,752 hectares of forest and vegetation are important as a base for the country's eco-tourism initiative, as a source of economic products and services, as the home for a wide range of the country's terrestrial biodiversity and as the source for the country's water supply and hydro-electric potential.

It is difficult to assess how warmer climatic conditions will affect Dominica's landscape, especially for the mountainous tropical conditions. Research in climate change impacts on these terrestrial ecosystems, as well as on the wildlife present, is still very much in its infancy in the Caribbean and Dominica is no exception. In addition, the data sets and technical expertise required to conduct the detailed analyses are not yet available in Dominica.

Within this context, the key issues regarding the impact of climate change on ecosystems are:

- The faster the rate of climatic change, the higher the probability of substantial disruption of ecosystem structure and function.

- Ecosystems will not react uniformly in response to climate change. Rather, each species will respond differently. Existing species associations will break up and new communities of plants and animals will take their place.

- Ecosystem response to climate change will depend largely on competition between species to maintain themselves in new geographic areas, or under changing conditions. In many cases, pests, parasites, and opportunists species will benefit.

- Ecosystems already stressed by human activities will be more vulnerable to climatic threats and will be among the first to show the effects of climate change. However, the multiple factors affecting these ecosystems will complicate the identification of strictly climatic effects.

- Species adaptive abilities depend not only on genetic variability but also on dispersal and migration capacity. Ecosystem resilience and genetic variability within populations are being reduced through habitat fragmentation. They will be further pressured by climate change.

- For many ecosystems, increases in the frequency and severity of extreme weather events such as drought, storms, and floods will lead to some of the most serious impacts. Changes in seasonal precipitation patterns and weather variability will also be critical.

(a) Temperature Changes

The possible impacts of temperature change on forests and terrestrial ecosystems could be summarized as follows:

- Alteration in the range of species.

- Reduced water flow in watersheds.

- Increase in forest pests and disease.

- Reduced food availability for wildlife.

- Increased species competition for scarce resources.

- Greater vulnerability to extreme events (e.g. hurricanes).

Dominica's vegetation type, especially in its mountainous interior exhibits a pronounced altitudinal zonation due to climate. Any changes in climate are likely to affect these. For example, assuming a lapse rate of 1 ^{o}C per 500 ft, the low scenario of 1.7 ^{o}C would elevate vegetative zones by 850 ft and the high scenario (3.5 ^{o}C) by 1750 ft. Under the high temperature scenarios elfin woodlands could disappear completely, and some species unique to Dominica could be lost. (Parry, 2001. personal communication).

(b) Sea-Level Rise

The threat presented by sea-level rise to the coastal habitats (e.g. coastal freshwater ponds, brackish water systems, mangroves and arable floodplains) is substantial, viz:

- Increasing pressure on forest reserves due to loss of coastal agricultural lands by salinization.

- Loss of coastal forests due to inundation and increasing storm events (e.g. mangroves and low lying tropical dry forests).

- Migration or loss of wildlife species from altered habitats.

(c) Hurricanes and Tropical Storms

With climate change there is also the possible increase in the frequency and intensity of storms in the Caribbean and therefore an increase in the risk of landfall. The terrestrial ecosystems are severely impacted on during the passage of tropical disasters. The main types of damage are windblown trees, damage to soils due to landslides and soil erosion.

- *Wind* – Windstorms result in habitat destruction by breaking branches, defoliation, debarking and complete uprooting of trees. After Hurricane David (1979), at least 50% of all dominant tree species had broken branches and many had lost large portions of their crowns. The resulting openings in the landscape caused the forest to be less resistant to strong winds and therefore less resilient to natural disasters.

  The winds can also have negative effects on wild life as they succumb to extinction with the additional pressure of droughts, floods, or increased hurricane strikes. In addition, they may suffer the loss of feeding grounds, nesting and roosting areas. Hurricane David, for example, caused the devastation of feeding and nesting sites of both of Dominica's endemic parrots. The populations of these two endangered parrots reached critical levels as low as 60 (*A. imperialis)* and 200 (*A. arausiaca)*.

- *Landslides and Soil Erosion* - Dominica's rugged terrain and high precipitation make it prone to major landslides; these cause significant damage to natural eco-systems and major socio-economic infrastructure and facilities as a result of displacement of tons of soil and debris.

Flooding occurs in all the major valleys and villages along the coastal areas of Dominica, particularly during hurricanes and tropical storms. Floodwaters alter stream and river channels and damage stationary vegetation, as well as infrastructure.

The Layou/Carholm landslides in 1997 and 1998 in which approximately 16 ha of land were lost, graphically illustrate the high levels of risk present – **Photo 3.1. and Photo 3.2**.

Photo 3.1 - Flooding in the Layou Valley

The damage caused by the series of landslides and subsequent flooding has had a significant impact on biodiversity in the lower reaches of the watershed, as well as, on marine and coastal ecosystems.

Photo 3.2 - Layou/Carholm *Landslide 1997*

The events also caused social disruption and economic damage to farmers and other property owners in the area. The total damage to the agricultural sector (crops, livestock, equipment and infrastructure) was estimated at approximately US$217,000.00.

The eco-tourism sector was also negatively affected as a result of the destruction of nature trails (paths, signs, benches), with significant reduction in revenue generation.

3.3.2. Coastal Ecosystems

The coastal zone of the island covers both the marine and terrestrial components of the coast. It *"…includes extensive areas of complex and specialized ecosystems such as mangroves, coral reefs and sea grass beds, which are highly sensitive to human intervention" (IPCC 1994).* Since these ecosystems support a wide variety of social and economic activities, including fisheries, tourism, recreation and transportation, the definition can be further broadened to encompass all the man made resources that have been established to support the socio-economic activities identified.

This section will focus on the marine and coastal ecosystems, as the man made components will be dealt with in the other sections of the report, which address the tourism and human settlements issues.

(a) Current Status of Coastal Ecosystems

The coastal zone is characterized by a rich diversity of ecosystems that have become interwoven into the fabric of the socio-economic existence of its population. In addition to providing a livelihood, the coastal zone has been the focal point for settlement, transport and communication and has been actively modified over time to reflect the population's changing customs, traditions and socio-economic aspirations.

The impacts of unrestricted and unsustainable coastal development have already initiated the process of degradation of the natural systems that provide habitats for the diversity of species that inhabit the coastal zone, provide protection from coastal erosion, and provide food for the island's people, viz:

- Problems with over exploitation of species such as lobster, conch and turtles have contributed to the vulnerability of the marine biodiversity. These threats have led to legal provisions being made for their protection and conservation through the establishment of a closed season for lobster fishing and the imposition of a moratorium for conch fishery and harvesting of turtles and turtle eggs.

- Sedimentation, resulting from quarry operations which discharge hundreds of tons of muddy sludge into the sea on a daily basis is the single largest cause of death of coral reefs. Soil erosion caused by bad agricultural practices, poor land management on steep slopes and the construction of feeder roads also along steep slopes, also cause severe sedimentation of coral reefs.

- The disposal of untreated sewerage and other liquid waste into coastal waters that are often utilized for fishing, bathing and recreation is another prime source of marine pollution. The turbidity caused by the suspended solids results in the death of coral reefs, sea grass beds, marine algae and other dependent organisms.

- Other man made causes of vulnerability in the coastal zone include beach sand mining and construction activity in, or too near to, the active beach area. The extraction of beach sand is controlled by legislation, but implementation of the legislation is a major problem.

- Development along the shoreline and the construction of sea defense structures contribute significantly to loss of biodiversity in Dominica. The structures replace valuable habitat (the nesting ground for turtles, for example), obstruct the free migration of species (crabs, iguanas) and may also alter the pattern of sediment and nutrient transport along the coastline.

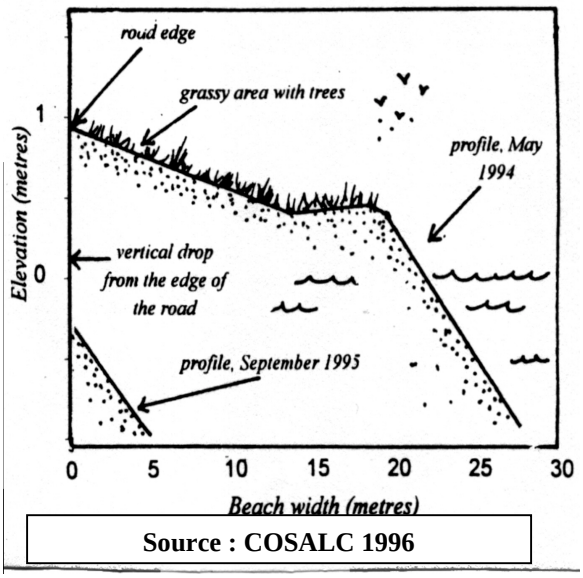
- The activities of the tourism sector also contribute to the existing threats to coastal areas. These include coral reef destruction resulting from anchor damage, as well as coastal and marine pollution and degradation of fresh water swamps as a result of the construction of tourism related infrastructure.

(b) Potential Impacts of Climate Change

The coastal resources of Dominica face a multifaceted challenge, which will become apparent over different time scales.

The IPCC assessments of the vulnerability of coastal zones to climate change and associated sea-level rise clearly indicate that climate related impacts and impacts resulting from present day human activities that affect the coastal zone cannot be separated. In fact, climate change and climate variability are likely to place additional stress on the already vulnerable coastal systems and resources.

Fig. 3.1: Changes to Coconut Beach Before and After the 1995 Hurricanes



Source : COSALC 1996

- *Beaches* - A rise in mean sea level will result in loss of beach area due to erosion and inundation. The main impact of sea-level rise will be reef over topping. For beaches in tropical islands, the possibility is that larger waves will be able to reach the shoreline than at present. This will exacerbate shoreline erosion particularly during storm surges. Generally, beach sediment budgets are expected to be adversely affected by reductions in sediment deposition as higher rates of erosion associated with sea-level rise are experienced - **Fig. 3.1**.

The impacts of fifteen (15) tropical weather systems on Dominica since 1979 have been documented and are illustrative of the typical impacts, which can be anticipated as a result of similar climate change induced events.

Photo 3.3 - Stones deposited on Soufriere Beach by Hurricane Lenny 1999

Most beaches experienced severe erosion, seriously reducing their aesthetic appeal and also resulting in the loss of important recreational space for both local people and tourists. Several sand beaches were replaced by boulders such as Scott's Head Beach, Rock-a way Beach, Belle Hall Beach and Toucarie Beach – **Photo 3.3**.

In the years that followed these events, most beaches have shown signs of only partial recovery. It is also reported that while there is no clear correlation between beach mining and the amount of erosion that has taken place on the

various beaches, most of the beaches, which experience the highest erosion rates, are among those where mining takes place (*Cambers 1997*).

The impacts of tropical cyclonic activity have not always been negative with regards to beach development. There has been some evidence of beach accretion due to hurricane activity. The Batali Beach on the island's west coast for example has widened by about five meters with the passage of Hurricane Hugo. There was also some lengthening of the sand bar on the southern section of the mouth of the Layou River (*Cambers 1997*).

- *Coral Reefs* – While some reefs have the ability to keep pace with the projected rate of sea-level rise, in many parts of the tropics (e.g. the Caribbean Sea and the Pacific Ocean) some species of coral already live near their limits of temperature tolerance. Elevated sea temperature (above seasonal maxima) can therefore result in serious damage to coral due to bleaching. In addition their reproductive functions can be impaired, leading to increased mortality (*IPCC, 1997*).

  Signs of coral bleaching have already been seen in the reefs of Dominica. Studies done by the Fisheries Development Division in 1998, reported that approximately fifteen percent (15%) of the coral shows some sign of bleaching ranging from minor to severe (*Guiste, 2000, personal communication*). High temperatures due to climate change are therefore likely to result in the bleaching of an already stressed ecosystem and subsequently increase the stress factors within the coastal zone of the island.
  After two tropical storms (Iris and Luis) and one hurricane (Marilyn) in 1995, a study was conducted on the damage done to some of Dominica's most prominent coral reefs. The reefs showed signs of both physical and sedimentation damage, including broken barrel (and smaller) sponges, and damage to finger, pencil and brain coral colonies. In one area, overall damage to the reef surface by the storm waves was between 20 and 30%.

  These reefs and sites represent a major component of the eco-tourism product on which the industry is marketed. Any negative impacts on this resource will therefore result in a major loss of tourism revenue and reduce the ability of the tourism sector to contribute to the island's economic and social development.

- *Mangroves* - Mangrove stands are limited in number and extent, and the ecosystem has been rendered vulnerable by anthropogenic stresses such as sedimentation and pollution. Climate change added to the existing stress will therefore further compromise the long-term viability of this important ecosystem.

  Mangroves in Dominica generally occupy low-lying coastal areas. It is expected that as sea levels rise, there will be increased mortality among existing species. This will result from a reduction of the availability of fresh water for the maintenance of salinity balance, as the sea encroaches onto these low-lying areas and into the lower course of river systems.

The shoreline erosion which will result from sea-level rise will induce coastal land loss and in so doing reduce the natural capacity of mangroves to adapt by migrating landwards.

The natural capacity of mangroves to adapt and migrate landwards is also expected to be hindered by land use practices (such as the construction of infrastructure within the coastal zone) that have fragmented existing habitats.

The IPCC (1998) notes that mangroves in the Caribbean are more likely to be affected by changes in precipitation than by higher temperatures and rising sea levels because they require large amounts of fresh water to reach full growth potential. It is therefore hypothesized that a decrease in rainfall in the Caribbean would reduce mangroves' productive potential and increase their exposure to full strength seawater.

- *Sea Grasses* - Sea grass beds which exist in shallow, intertidal coastal environments are among the ecosystems likely to be most negatively affected by climate change effects, particularly as a result of sustained elevation of sea surface temperature, or due to decreases in water salinity resulting from increases in fresh water run off from land which could occur under the high temperature change scenarios. As large volumes of silt are deposited over sea grass beds, the biodiversity of this habitat will be altered. Such changes in biodiversity will affect fish stocks and lead to changes in fish abundance, distribution and/or behaviour.

  There is growing consensus, however, that the main threats to sea grasses will come from existing anthropogenic disturbances such as over-fishing, water pollution, land reclamation and dredging (IPCC 1998). In Dominica water pollution is already causing significant amounts of damage to marine resources.

- *River Estuaries* - The main impact on river estuaries is the inundation of habitats within the estuary due to sea-level rise. This will result in:

  - Increased mortality among existing species from a reduction of the availability of fresh water for the maintenance of salinity balance, as the sea encroaches inland.

  - Loss of habitats for organisms (e.g. anadromous fish and crustaceans) which enjoy brackish water, or water of varying salinities.

  - Loss of biodiversity resulting from above.

  - Threat to the survival of the near shore fisheries

- *Coastal Species Diversity* - There are no studies available to identify the nature of climate change impacts on each specific group of flora and fauna. It must be noted however that past storms and hurricanes have for example, destroyed a variety of shrubs e.g. Hoopwood (*Dalbergia sp*.) and herbaceous plants including Seaside Potato (*Ipomea pes-caprae*).

Coconut trees, Indian Almond (*terminalia cattapa*), Seaside Grape (*Coccoloba uvifera*), Seaside Mahoe (*Thespesia populnea*) and Manchineel (*Hippomane mancinela*) trees are often undermined, uprooted and relocated offshore by waves. These shrubs, herbaceous plants and trees all played an important role in protecting the coast from wind and sea erosion. The impact of their loss is reflected therefore in the loss of the unprotected coastline, which is rendered more susceptible to future tropical cyclonic events (*Cambers 1997*).

3.3.3. Freshwater Resources

The freshwater resources in Dominica are used for domestic purposes (drinking, cooking, bathing and washing), agricultural purposes (farming/irrigation), industrial purposes (bottling and mining), and for the generation of hydroelectric power. This freshwater comes from 10 major watersheds and their accompanying river basins.

The present supply systems are generally adequate to satisfy demands, although intermittent shortages are experienced in a few of the systems during the dry season (*Martin, 1999*). During these dry spells, water consumption increases due to increased watering of lawns and backyard gardens as well as longer, more frequent bathing. The effect of these activities is compounded by a reduction in stream flows. In some streams, dry weather flow has been estimated to drop to as low as 30% of average wet weather flows.

(a) Demand for Freshwater Resources

- *Domestic Supply* - The Dominica Water and Sewerage Company (DOWASCO) currently serves 16,000 customer connections, which represents a population of about 50,000 - 63% of the island population. Standpipe facilities are installed to provide coverage for all major communities with populations in excess of 200 people. The total coverage is estimated at over 90% of the total population. A number of small communities are served by systems built by NGO's (e.g. SPAT, DOMsave and CANsave).

  DOWASCO operates a tariff system for the potable water supply. However, the operating and maintenance costs (average production cost estimated at US$1.13/1000 gallon) for the small scattered water systems around the island are not always recovered from revenue gained through service connections.

- *Hydroelectric Power* – DOMLEC**,** in its hydropower generation system, uses over 6 mgd on average from water catchments in the vicinity of the Freshwater Lake, Laudat and Trafalgar to generate electricity in three power stations**.**

  At the time of establishment in 1952, hydropower met approximately 90% of the energy requirements. With an increased population and growing energy requirements, hydropower currently (2001) supplies approximately 42% of the total demand.

It is estimated that hydro-generated output declines to approximately 25% during the dry season from March-June. This could diminish to a mere 12%, thereby increasing the need to meet growing demand by diesel generation.

- *Irrigation* - Irrigated farmland presently accounts for less than 1% of the estimated 21,156 ha of farmland.

(b) Wetlands

In 1990, a survey classified Dominica's wetlands into "swamps" and "marshes":

- The swamps are dominated by a single tree species (*Pterocarpus officinalis*) and are limited to the northern third of the island.

- A small number of marshes totalling 35 ha are located near the Cabrits. It contains patches of mangrove forest, and a freshwater swamp, which provide habitat for migratory and resident birds. Other important marshes include Indian River near Glanvillia, an area near the estuary of the Layou River and areas in proximity to the Freshwater Lake.

There are three major freshwater lakes protected within the Morne Trois Pitons National Park (Boeri, Freshwater, and Boiling Lakes) – **Photo 3.4**. The Boeri and Fresh Water wetlands provide habitat for migratory and resident bird species. Recently, due to large-scale landslides there has been the formation of natural reservoirs along the Layou-Matthieu Rivers

Photo 3.4 - Freshwater Lake

(c) Potential Impacts of Climate Change

- *Increased Precipitation* – Under an increased rainfall (high temperature change) scenario there is expected to be an increasing direct effect on the volume of surface run-off and thus the quantities of soil being eroded. Where rainfall increases just marginally, river volumes may expand and make more water available for consumptive and non-consumptive uses, but only if suitable management technologies are in place. The following impacts can be expected:

- Landslides: Most of Dominica's soils are easily prone to erosion. Torrential rainfall frequently causes earth movements in the forms of debris flows, rockslides, land slump and landslides. During an inventory conducted in 1987 more than 980 landslides were mapped. It was found that the average slide was about 4 hectares in size and that Dominica has roughly 1.2 landslides per square kilometre (De Graff, 1987).

- Gully erosion: This commonly occurs in Dominica over a wide range of slopes and rainfall conditions especially in areas where no provision for drainage has been made.

- Flooding: It is more than likely that significant increases in rainfall will cause rapid expansion of rivers leading to increased incidents of flash flooding especially in low-lying areas (such as the Layou-Mathieu valleys). Unprotected riverbanks (vegetation has been removed) may collapse, thus leading to the formation of a wider river. Where buildings are located within close proximity to rivers they may be damaged or destroyed. Loss of livestock and crops is also likely.

- Coastal Salinity: Increased freshwater outflows will reduce the salinity of coastal waters. This can have serious consequences for fisheries as coral reefs and sea grass beds may perish or change. Additionally, nursery grounds may no longer support their normal biodiversity and fish stocks with limited salinity-tolerances may move further off-shore to deeper waters while inland brackish-water species may extend their range further offshore and beyond the limits of the river mouths.

- Water Quality: Unless there are changes in agricultural practices, location choices for housing and waste disposal methods currently employed on the island, increased precipitation will undoubtedly result in increased levels of topsoil, increased agro-and industrial chemical concentrations and heightened levels of microbes in the surface waters leading to increased incidence of waterborne diseases. The cost of producing clean water suitable for human consumption is likely to increase.

- Water Intakes and Supply: Increased precipitation during extreme events may lead to heavy rainfall that can damage intakes, supply lines, even treatment plants if they are inappropriately located (that is, if intake pipes are too close to large rivers, or if they are within a flood plain). Municipal water supplies will therefore be threatened.

- *Decreased Precipitation* - During periods of very low rainfall there will be a greater tendency to rely on existing water resources to maintain economic, social and recreational programmes, viz:

- Water abstraction for agriculture will increase as recharge from rainfall dwindles.

- Consumers who normally maximize rainwater stores may need to increase consumption of treated water to meet domestic needs.

- Base flow of rivers will drop significantly as a consequence of the combined impacts of increased abstraction and declining input from rainfall.

- *Increased Temperatures* - Municipal demands are likely to increase as higher temperatures lead to increased water consumption. Use of rivers and streams for bathing and washing may rise as a result of warmer temperatures. There may be some level of concern for aquatic biodiversity if water temperatures increase significantly since this, coupled with dwindling basal flows, may alter the bio-physical parameters of rivers and wetlands sufficiently to affect breeding cycles, offspring and parent fecundity, offspring survival and overall species resistance to environmental stresses such as disease and fishing effort.

- *Hurricanes* – Dominica's water supply is vulnerable to major hurricane impacts. Hurricane Lenny revealed the extent of damage that can occur as a direct result of a storm surge. **Table 3.2** shows the cost to DOWASCO in line repair, maintenance and relocation after Hurricane Lenny. Most of the damage was sustained on the west coast, which rarely sustains a direct hit by a hurricane.

Table 3.2: DOWASCO Estimated Costs after Hurricane Lenny

District	Description	Cost ($us)
Scott's Head	Material, Labour & Equipment	41,561.00
Colihaut	Material, Labour & Equipment	1,798.00
Mahaut	Material, Labour & Equipment	1,023.00
St. Aroment	Material, Labour & Equipment	6,257.00
Toucarie / Cottage	Material, Labour & Equipment	2,138.00
	Pipe relocation to other roadside	6,749.00
Dublanc, Coulibistrie, Campbell, Massacre, Canefield/Fond Cole, Lousiville, Bath Estate, Goodwill, Delices, La Plaine, Pte. Michel, Loubiere, Citronie, Newton, Soufriere	Maintenance	18,403.00
Mero Distribution Line	Relocation of line from bay to the Main Road	42,402.00
Roseau (Goodwill, Canefield)	Sanitation	5,521.000
TOTAL		**$ 125,852.00**

- *Sea-Level Rise* - Sea levels are expected to rise as a direct effect of increasing global temperatures. There is expected to be a corresponding increase in the intertidal range experienced in the coastal zones. Salt-water intrusion will cause salinization of coastal soils and freshwater making them unsuitable for agriculture.

3.3.4. Human Settlements

The character of human habitation in Dominica is largely influenced by the physical makeup of the island. The mountains that dominate the northern and southern sections of the island extend to the coast, leaving the island with an extremely narrow coastal plain.

This narrow, low lying coastal area therefore represents the most feasible location for human occupation, economic activity and infra-structural development and is the site of all major settlements on the island. Much of the critical infrastructure and many of the socio-economic activities are located along the coastline, in many cases at, or close to, present sea level. This makes them vulnerable to flooding and to the impacts of hurricanes and storms.

(a) Main Characteristics

- *Settlement Patterns* - Settlement patterns are influenced by the rugged topography, with major settlements and supporting infrastructure and communications located primarily along coastal areas. In many instances roads and other communications infrastructure pass literally at the water's edge while residential and commercial properties are located within 30 ft feet of the high water mark.

Ninety percent (90%) of the population of Dominica is dispersed among coastal villages, the city and a town –**Photo 3.5**. An estimated seventy percent (70%) of these settlements are located on the leeward (or western) side of the island, which offers greater protection from wind and other climatic extremes.

Photo 3.5 - Settlements on the Coast and Steep Slopes

The country's two main population centres, namely, Roseau, the capital city and the town of Portsmouth, all seaport facilities, one of the airports (Canefield), as well as the majority of the island's road and communication infrastructure are located along the leeward coast.

Most settlements have very little room for expansion except through hillside residential development, or density increases in already built up areas. As a

result, population increase in certain districts is leading to the increasing emergence of hillside developments on the fringes of the existing towns and on small coastal headlands. These areas are highly susceptible to the ravages of extreme events such as hurricanes.

In addition, there is a growing practice among developers to establish developments, which do not comply with the established standards and regulations. A case in point is the practice of developers who, in an effort to maximize the use of limited land space, erect structures without appropriate setbacks. In other instances, construction occurs in close proximity to and/or within a zone of active wave erosion (this is particularly the case with tourism and tourism related developments), while infra-structural developments have in some instances become established in impact prone areas such as the flood plain of rivers.

Given the concentration of population in coastal areas, the anticipated increases will translate into increased pressure on coastal resources, which will in turn increase the vulnerability of these resources to climate change impacts.

- *Roads* – The country is currently served by a main road system, which comprises mainly of a two-lane, narrow asphalt surface that encircles and traverses the island. An extensive network of secondary roads branch off from this main road system to link settlements and the system of agricultural feeder roads and village roads that service the rural communities.

  Most main roads, like other crucial infrastructure, are located in the low-lying, narrow coastal belt, at or near sea level and are readily eroded, or inundated during storm surges.

- *Ports* - Dominica has six (6) major ports of entry into the island and thirty-three (33) designated fish landing sites, eighteen (18) of which are on the West Coast of the island. The major ports of entry comprise two (2) airports (Melville Hall and Canefield) and three (3) commercial seaports (Wood Bridge Bay, Long House and Anse Demai) and the Roseau Ferry Terminal. In addition there are two dedicated cruise ship berths - the Roseau Cruise Ship Berth and Ferry Terminal, on the western boundary of the city of Roseau, and the Cabrits Cruise Ship Berth, located north of the town of Portsmouth. The commercial port at the Woodbridge Bay also provides additional facilities for cruise ships. All of the above facilities are located along the west coast, with the exception of Melville Hall airport, which is on the north east coast.

- *Telecommunications* - Dominica has excellent telecommunication services with two operators providing domestic and international connections.

  Dominica represents an integral component of the Digital Eastern Caribbean Microwave System installed by Cable and Wireless (WI) Limited. The fully digital system has approximately fifteen thousand (15,000) lines in operation.

International direct dialing, telegraph and telex services, Internet services and international database access services are also provided.

- *Electricity* - Services related to electricity supply are well developed and distributed around the island. In 1991, 79% of the households had access to electricity.

  The Medium Term Economic Strategy Paper 2000-2001, states that major investments in electricity generation and distribution are necessary to facilitate the requirements for the further diversification of the economy.

  The utility lines and other network infrastructure associated with these services are installed both below and above ground in the case of telecommunications and above in the case of electricity and are easily displaced and destroyed during hurricanes/storms.

(b) Potential Impacts of Climate Change

Climate change impacts are likely to include:

. Destruction of, or damage to, housing stock, infrastructure and critical facilities in low lying coastal areas, as a result of sea-level rise and the flooding due to storm run off and storm surges. For example, Hurricane Lenny affected one hundred and fifty four (154) homes dispersed among 13 communities on the west coast. Of these 47 were completely destroyed while the remaining 89 experienced varying degrees of damage. Total damage to residential buildings, commercial, tourist (hotels etc), boat houses/storerooms and government public infrastructure was estimated at approximately US$2.91 M. (Damage Assessment Hurricane Lenny 1999)-**Photo 3.6**

Damage to important infrastructure, for example coastal roads, ports, and bridges which severely disrupts several types of economic, social and cultural activities. **Photo 3.7.** Estimated cost for restoration works for sea defenses and associated road works as a result of Hurricane Lenny was estimated at approximately US$1.27 M. The cost of remedial work at five seaports was estimated at US$1.606 M. In addition the recommended permanent works including construction of seawalls, rock armouring and associated road works to protect against wave action was estimated at approximately US$41 M. (Damage Assessment Hurricane Lenny 1999)

Photo 3.6 – Hurricane Damage to Roseau Ferry Terminal

Photo 3.7 -Damage to Deep Water Harbour Port Facilities by Hurricane Lenny

. Elevated mean temperature brought on by climate change could lead to a greater frequency of heat waves. Energy demand would therefore be affected by the anticipated warming. The use of air conditioning which currently contributes to the increased demand for energy for commercial and other types of buildings and in some residences is likely to continue to rise, increasing operating costs for commercial and other related establishments and increased energy bills for residential units.

- Increased cost and reduced availability of insurance coverage for infrastructure and other types of property, as a result of the increased frequency of hurricanes and other extreme events.

3.3.5. Agriculture

It is difficult to quantify the impact of climate change on Dominica's agriculture at this time, as most contemporary crop response studies are being conducted in temperate regions. It is therefore not possible to assess the impacts of carbon dioxide fertilization, changes in temperature and changes in precipitation levels on tropical islands such as Dominica, where other variables are also of major significance. In addition, the data sets required for such analysis are not available.

(a) Main Characteristics

Agriculture is the leading economic activity in Dominica, contributing 22% of GDP in 1994. The majority of Dominica's agriculture is rain-fed with irrigated farmland accounting for less than 1% of the estimated 21,148 hectares of farmland.

- *Land Use* - Limited land resources and the demands of a growing population have placed pressure on Dominica's productive agricultural lands. Seventy percent (70%) of Dominica's land resources have been classified as unsuitable for agriculture, mainly because of erosion risks, water saturation due to heavy rainfall, or poor soils (GOCD, 1985) – **Table 3.3**

Table 3.3 - Agricultural Suitability of Land

Category	Area (ha)	National Park/Forest Reserves (ha)	Percent of Total Land
Moderate Erosion Risk	16,098	3,810	20
Waterlogged	10,734	1,760	13
Good Agricultural Land	23,211	145	30
TOTAL	**79,000**	**15,573**	**100**
Very High Erosion Risk	28,957	9,858	37

A comparison between the 1961 and 1995 Agricultural Censuses reveals a number of interesting shifts in the number of farms, the total area cultivated, the acreage under permanent cultivation and forest - **Table 3.4.**

Source: Dominica Environment Profile 1991

The amount of land in productive agriculture has also undergone some changes. The 1995 agricultural census conducted by the Ministry of Agriculture indicated that 13,036 ha (61.7%) of total land area enumerated under farms (21,134 ha) were cultivated. Of this, the land found to be under permanent cultivation was 11,862 ha (56.1%), and 5,992 ha (28.4%) in forest.

There was an approximately 11% increase in the number of farms during the period from 9,109 farms in 1961 to 10,100 farms in 1995.

Similarly, the area under permanent cultivation increased by 30.5%, moving from approximately 10,000 ha in 1961 to approximately 13,000 ha in 1995.

However, there was a 55.80% decrease in the area under forest (6,640 ha) in 1995, compared to the 1961 census (15,020 ha). This was due to the fact that land reported as farm land in 1961 (29,231 ha compared to 23,428 ha in 1995) was found only as forest in the 1995 Census.

The 6.5% increase in cultivated land has come with serious environmental consequences. Some of the most visible environmental effects include soil erosion and landslides, as most of the newly converted lands were located on slopes. The situation is worsened when bananas are planted in inappropriate areas with poor land management practices.

Table 3.4 - Land Use 1961/1995

Land Use	1961	1995	1995*	% Change
Number of Farms	9,109	9,170	10,100	10.88
< 1.98 ha	6,847	6,130	6,696	-2.2
2.02-20.20 (ha)	2,087	2,187	2,448	17.3
20.24-40.08 (ha)	78	53	61	-21.8
>40.48 (ha)	97	63	71	-26.8
Farm Lands (ha)	29,231	21,134	23,482	23.98
Land cultivated (ha)	13,644	13,036	14,494	6.2
Permanent Cultivation (ha)	10,081	11,862	13,158	30.5
Temporary cultivation (ha)	3,563	931	1,296	-63.63
Forest (ha)	15,020	5,992	6,640	-55.8
Other (ha)	2,186	2,105	2348	7.41

Source: Adapted from Dominica Agricultural Census (1995)-
**** Adjusted for comparison with 1961***

- *Farm Size* - The average farm in Dominica is small, with an average size of 2 ha. Of the 10,100 farms in Dominica in 1995, approximately 67% (6,696) were less than 1.98 ha in size and 24% between 2.02 and 20.2 ha.

- *Land Tenure* – According to the DAC (1995), the main land tenures were ownership with 13,765 ha (65%) and family land with 2,308 ha (10.9%). The amount of land listed as rented farms and communal had similar relative importance - 1,174 ha (5.6%). Squatting Farmers represented 1.7% (364 ha) of the total acreage under farms. This represents a great structural change in land tenure from 1961, when ownership represented 95.5% (29,474 ha),

rented for money 4.2% (1296 ha) and the remaining 0.3% (981 ha) was rented for free. The Land Reform Programmes conducted in the 1980s and 1990s, on 7 estates of about 2065 ha, had distributed land to an estimated 860 farmers.

- *Topography* - It is estimated that on a national scale about 50-55% of the cultivated land has a moderate to steep slope and many of the farms are not easily accessible.

- *Farming Enterprises* - The major enterprises include banana, vegetables (including greenhouses), root crops, tree crops and small live stock production. However most farmers cultivate bananas. In 1994, four thousand eight hundred and forty (4,840) farmers were involved in banana production.

- *Technology* – Most on-farm operations are labour intensive and there is little development in mechanization (partially explained by topography). Although there are frequent and severe problems with soil moisture levels, especially in coastal regions, there is no significant use of irrigation technology (*FAO, 1998*).

- *Irrigation* - With the exception of the Grand Savanne area on the west coast where irrigated vegetables have been cultivated since the early 1980's, irrigation has not been widely practised in Dominica.

  The Ministry of Agriculture and the Dominica Banana Marketing Corporation (DBMC) plan to place some 405 ha of land under irrigation in an effort to boost productivity. The main source of irrigation water is expected to be surface water either pumped, or gravity fed, from streams or rivers. Currently there are no measures in place with respect to drainage linked to irrigation schemes (*ECU 2001*).

(b) Sensitivity to Precipitation

Banana is the most significant crop and the production is very sensitive to levels of precipitation. **Table 3.5** illustrates the differences in production experienced between years of low rainfall and years with excessive rainfall.

It shows that banana production fell below the mean production level of the 1970's by 12% in 1973 and 15% in 1975 due to drought conditions. Similarly in the 1980's, there was a 26% fall from the average production in 1983 and 13% drop in 1985 due to drought.

Conversely, production seems to respond favourably to above average, fairly distributed rainfall. An example of this is the banana production for 1970, which rose by 28% above the average for the 1970's due to good rains. There were exceptional years during the 1980's when production rose to 45% above average, e.g. in 1988 due to high rainfall.

A stark contrast in optimal productivity is observed when the above average rainfall production is compared to drought production levels. There was a 17-37% difference in the 1970's and a staggering 53-60% difference in the 1980's.

Table 3.5: Influence of Rainfall on Banana Production (Tonnes) in Dominica.

Decade	Average Production	Drought Years	Rainfall (mm)	Drought Production	Excess Rainfall	Rain fall (mm)	Excess Rain Production
1970's	32,301	1973 1975	1,657.87 2,278.38	28,375 27,435	1970 1976	2909.64 2638.14	45,130 32,818
1980's	39,042	1983 1985	1,974.69 2,415.21	28,671 33,827	1981*! 1988	2860.75 2918.19	26,888 71,473
*1990's	41,580	1994	1,950	42,781	1993	3,050	55,486

** Market decline and instability should be factored in.*

**! Indicate recovery after Hurricane David*

In addition, crops such as vegetables are extremely sensitive to the fluctuations in precipitation. Excess rainfall tends to increase the incidence of pest and diseases leading to declining productivity, whilst drought conditions lead to reduced yields.

(c) Sensitivity to Extreme Events

Extreme events inflict damage directly on food systems through the destruction of crops and livestock and the erosion of farmlands. At the community level, there is the loss of life and property, flooding, damage to roads and bridges, along with the decline or complete loss of water supply. Poor water quality may be responsible for plant, animal and human health problems, including diseases associated with pathogenic organisms.

Soil erosion poses significant problems to the agriculture sector. The two significant processes of soil loss occur as surface wash and landslides. Landslides generally remove all buried seeds, advanced vegetative regeneration, stumps and other organic matter and leave exposed mineral soil material or bare rock in the area of denudation. The direct impact of rains on exposed soil surface causes the loss of topsoil through surface wash.

(d) Potential Impacts of Climate Change

Given Dominica's economic dependence on agriculture, climate change poses a substantial threat to the economy. It also poses a threat to the nation's food security, given the percentage of food produced for national consumption. The situation becomes even more serious when climate change forces are combined with existing socio-economic and environmental pressures on the agricultural sector.

The effects on crop agriculture will vary depending on the nature of the climate change impact, viz:

- *Tropical cyclonic activity*- unfortunately Dominica has not been spared the ravages of hurricanes strikes. Some of the major hurricanes and Tropical Storms to hit the island in recent times include Hurricane David (1979), Allen (1980), Hugo (1989), Tropical Storm Iris, Hurricane Luis and Marilyn in

1995, and Lenny (1999). These have all inflicted tremendous damage to the Agricultural sector and more specifically the banana production – **Photo 3.8**.

Photo 3.8 - Banana Plantations Devastated by Hurricane Lenny

Estimated losses to the agricultural sector caused by Hurricane Lenny were over US$ 3,860,000.00. This includes damage inflicted to crops (banana and non-banana), losses due to left back bananas on the ports and infrastructure- **Table 3.6**.

Table 3.6: Estimated values of Non Banana Crop losses from Hurricane Lenny

CROP	ESTIMATED ACREAGE (HA)	DAMAGE DESCRIPTION	ESTIMATED AFFECTED ACREAGE	TOTAL PRODUCTION LOSS (US$)
Plantain	242.92	Broken Stems	60.73	668,843.30
Tannia	141.70	Topples/damaged trees	7.09	103,171.64
Dasheen	323.89	Erosion/removal by raging waterways	16.19	149,253.73
Yams	242.92	Drainage failure/removal by raging waterways	4.86	83,731.34
Grapefruit	808.72	Toppling Fruit loss	32.39	29,850.75
Oranges	546.56	Toppling Fruit loss	27.32	100,746.26
Cocoa	101.21	Broken branches	2.02	2,091.42
Avocado	141.70	Broken branches	7.09	32,649.25
Nutmegs	1.62	Fruit loss	n.a	n.a
Vegetables	141.7	Crop loss/drain bed failure	16.19	298,507.46
Total	**2692.94**		**173.88**	**1,468,844.90**

Source: Commonwealth of Dominica Provisional Assessment Task Force Report to the Ministry of Agriculture (1999)

- *Sea-Level Rise* – This can have a variety of impacts on the agricultural sector including:
  - Salinity of coastal agricultural zones.
  - Salinity creating marginal lands, or making marginal lands unsuitable for agriculture.
  - Loss of freshwater due to salt-water intrusion.
  - Physical loss of agricultural lands.
  - Susceptibility to flooding.
  - Loss of pasture for livestock.

- *Temperature Increase* - Some of the projected impacts for crops are:
  - Drought, causing heat stress on plants.
  - Loss of soil moisture.
  - Alteration of soil microorganism balance.
  - Increase of agricultural pests due to increasing life cycles.
  - Weakened crops prone to insect attack and disease.
  - Alteration of soil physical structure.
  - Loss of soil nitrogen due to high ambient temperatures.
  - Loss of irrigation efficiency.

- *Changes in Precipitation* - The threat of reduced, or increased rainfall is of great significance to Dominica's agricultural sector. Some of the potential problems under a scenario of > 20% increase in rainfall are:
  - Flooding of agricultural lands
  - Reduced hours of sunshine
  - Excessive soil erosion
  - Loss of water quality
  - Changes in soil Ph
  - Leaching
  - Silt deposition on agricultural lands
  - Loss of soil nutrients
  - Damage to farm infrastructure
  - Increased incidence of pests and diseases

  There are also many potential problems which will result under a scenario of > 20% decrease in rainfall. Such a scenario would be associated with an increase in ambient temperatures resulting in:
  - Drought causing heat stress on plants
  - Loss of soil moisture
  - Alteration of soil microorganism balance
  - Increase of agricultural pests due to increasing life cycles
  - Weakened crops prone to insect attack and disease
  - Alteration of soil physical structure (e.g. creation of soil pans)

- The *livestock sub-sector* is also likely to be negatively affected. Changes in precipitation are likely to have a great ecological and socio-economic impact on the industry. High daytime temperatures are likely to stress limits for livestock production and higher temperatures at night may cause heat stress in animals.

  Possible effects are as follows:
  - Loss of bodyweight
  - High percentage of increase in both external and internal parasites,
  - Predisposition to and increase in diseases
  - Low fertility and reproductive rate for male and female
  - Late maturation of offspring and increase in mortality.

3.3.6. Fisheries

The fishing sub-sector, although considered artisanal (1.8% of GDP), is important to Dominica in many respects. It is an important source of protein especially in low-income coastal communities; provides an important contribution to gross domestic product; is a major part of Dominica's eco-tourism package; and is an important source of employment. In addition, the coastal habitats associated with fisheries, particularly coral reefs, mangroves, and beaches, also perform other important economic, environmental, and ecological functions.

(a) Main Characteristics

The fishery resources of Dominica reflect the variety of ecological and environmental habitats and features that are present and can be divided into at least four major categories – near shore reef fisheries, deep slope fisheries (generally at depths of 200m to 300m), coastal pelagic, and migratory pelagic (*Guiste, 2001*).

Evans (*1997*) points out the rich biodiversity that can be found in the islands coral reefs particularly along the west coast. This includes not only demersal species, but also a number of coastal pelagic such as jacks, snappers and hamlets as well as species more generally found in open waters (such as stingrays and manta rays).

(b) Potential Impacts of Climate Change

The fisheries sub-sector is vulnerable to the projected impacts of climate change through the impact of higher sea temperatures on the coral reefs and the impact of sea-level rise on the mangroves and sea grass beds.

Hurricanes also have major social and economic impacts on the fisheries sector. Hurricane David in 1979 virtually wiped out Dominica's fishing fleet. About twenty years later, damage to the fishing industry caused by Hurricane Lenny was valued at US$2,827,238.80 (EC$7,577,000.00). This was due to damage to coral reefs and sea grass beds, beach landing sites, fishing gear and equipment and associated infrastructure.

3.3.7. Tourism

Dominica, "*The Nature Island of the Caribbean*", is a newly emerging tourist destination, still in the relatively early stages of development of the sector.

(a) The Tourism Product

Dominica's tourism is focused mainly on the eco-tourism product rather than the traditional SSS (sun, sea and sand) image of the other Caribbean islands. The tourism base is therefore the natural resources.

The cultural and heritage resources of the island are also an important component of the tourism package. This is centered on the indigenous Carib (Kalinago) culture and historic buildings of Roseau and the ruins of Fort Shirley. In recent years Dominica's

World Creole Music Festival and Dominica's carnival celebrations have also formed important components of the cultural package.

In addition to the above, the island has a small number of sandy beaches that are also a part of its tourism product even though it does not promote itself as a beach destination.

The tourism industry is also highly dependent, though not exclusively, on activities in, or close to, coastal areas. Most of the major hotels are located along the coastal strips south of Roseau, along the west coast and in the Picard area along the northwestern coast. In addition, all major air and seaports with the exception of the Melville Hall airport are located along the western coast of the island.

(b) Potential Impacts of Climate Change

The vulnerability of Dominica's tourism to climate change comes from three (3) sources, viz:

- *Eco-tourism* – the increasing reliance on eco-tourism means that the vulnerabilities of the forestry and the terrestrial and coastal eco-systems are also vulnerabilities of the tourism sector. The vulnerabilities and potential impacts discussed in those sections are therefore applicable to the tourism sector.

- *Coastal Vulnerability* – The location of Dominica's tourism infrastructure along the coast make them highly vulnerable to hurricane/storm and sea surges. Hurricane Lenny in 1999 caused approximately US$250,000.00 damages to tourism infrastructure mainly along the west coast.

- *Competition From Other Destinations* - If winter temperatures are to rise as the IPCC predictions suggest this may have serious implications for tourism in the Caribbean as a region, as milder winters will reduce the inducement for tourist to travel during this period and higher temperatures will reduce levels of human comfort in Dominica.

3.3.8. Human Health

It must be noted here that efforts to assess the likely impacts of climate change on health have not been as well developed as in some other fields of climate change research. A primary area of concern to date has been the likely spread of disease vectors into higher latitudes as warming extends the habitats for many of these vectors. Uncertainty surrounding health impacts of climate change is therefore conditioned by the level of knowledge of impacts on other sectors, as well as by uncertainty relating to actual changes of climate.

Within this context, climate change is likely to present a special set of challenges for the health sector in Dominica, which in many instances already experiences health impacts associated with present day climate variability.

(a) Main Characteristics

The health sector in the country is one of the largest recipients of government expenditure, with operations of the Ministry of Health annually amounting to 14% of total recurrent expenditure and 5% of GDP. This reflects the priority assigned to advancing health care in line with national and international goals for improved levels of health.

The Chief Medical Officers' Report (2000) highlights the following significant features related to health care in Dominica:

- *Life Expectancy* - has increased quite significantly over the years and now stands at 71 and 74 years for males and females respectively.

- *Chronic Diseases* - such as diabetes and hypertension are leading contributors to both morbidity and mortality figures. This trend has significance for climate change in that those elements of climate that influence these medical conditions (for example psychological and nutritional stresses) will impact on the overall health situation. The CMO's report indicates that asthma is also emerging as a leading cause for hospital and clinic visits.

- *Infant Mortality Rate* – This has remained fairly stable since the 1980s at approximately 14– 16/1000.

- *Malnutrition* - has been virtually disappearing, although there remain important needs for greater appreciation of nutrition and lifestyle choices particularly in poorer rural communities.

- *Tuberculosis* - Small pockets have been reported for the Carib Territory and inner city neighbourhoods of Roseau.

- *Typhoid* - remains a lingering problem, with nine cases recorded in 1998.

- *HIV/AIDS* – This is one of the major heath concerns. Generally, sexually transmitted diseases constitute a principal source of morbidity.

- *Pipe Borne Water* - An estimated 94% of the population has access to pipe borne potable water with the main concerns relating to quality and availability of the supply particularly during periods of prolonged reduced rainfall.

- *Sanitary Excreta* - An estimated 20% of the population is, without access to sanitary excreta disposal facilities, particularly in villages and communities along the island's west coast where it is difficult to construct pit privies or install effective septic tank systems where the ground is very rocky. However these households are served by public conveniences, which in most cases are erected on the shoreline or close to the coastline and are damaged with every passing storm or hurricane. Particular problems also exist in Portsmouth where high water tables limit the effectiveness of these methods.

The most common forms of disposal are septic tanks, pit latrines, and communal facilities/public conveniences. During Hurricane Lenny a large number of the community facilities along the west coast were destroyed by the storm surge.

- *Aedes Aegypti Infestation* continues to be a serious problem, although some progress has been achieved by efforts to control dengue and other mosquito borne diseases - the household index has declined from 34% in 1991 to 17% in 1998. Principal receptacles for this vector in Dominica (which is expected to breed favourably under a number of the elements associated with climate change) include water drums, discarded tyres, and vases. Areas scoring highest on both the household and container indices for the vector were Marigot, Roseau, and La Plaine.

- *Gastroenteritis* - for the under 5-age group declined from 587 cases in 1995 to 70 in 1998.

- *Leptospirosis* - has dropped from 12 cases in 1995 to 0 in 1998, while *dengue*, endemic to the region, continues to show considerable annual variability.

(b) Potential Impacts of Climate Change

The effects on health of the extremes in precipitation and other weather patterns deriving from the strong 1997/98 El Nino in the Pacific region has heightened interest in the possible impacts of changes in weather and climate on small island States. A difficulty in identifying such impacts is that the cause of many human health disorders is often influenced by a range of socio-economic, demographic and environmental factors so that it may be difficult to separate the changes deriving from alterations in climate regimes from other "background" influences (IPCC, 2000).

In Dominica extreme weather events such as hurricanes and droughts, as well as longer-term alterations in weather patterns are likely to have significant implications for those sections of the population already exhibiting vulnerability either by virtue of medical predisposition (e.g. cardiac and sickle cell patients) or by virtue of socio-economic and environmental conditions.

Additionally many health impacts are likely to provide new challenges for public health arising out of complex interrelationships among numerous epidemiological, environmental and socio-economic factors. Nevertheless, using available data it is possible to identify certain likely impacts of climate change based on the scenarios:

- *Drought* - Dominica is dependent on rain fed rivers and streams for its potable water supply. These sources are climate sensitive and are adversely affected by major reductions in precipitation. Presently communities without reliable supply or independent storage as well as communities at higher elevations face reductions in water quality during intensified drought conditions. The type of forecasts for increasing rainfall variability projected by the IPCC and other models suggests that such problems could be intensified**.**

Other potential drought related impacts include: increased risks associated with dengue arising from enhanced opportunities for breeding of the Aedes Aegypti mosquito with significant implications for national productivity, health care costs, eradication activity, and even tourism development; increased incidence of gastroenteritis, a "dry season" affliction affecting particularly poorer sections of the community; intensification of scabies and other "water wash" diseases associated with the absence of adequate water supplies for personal hygiene; increasing incidence of asthma and other respiratory diseases caused by rising air pollution as a result of air-borne movement of bacteria and other pathogens and brush and forest fires

Drought can also have negative impacts on agricultural production of domestic and export food crops (especially bananas) affecting farm incomes and the availability of fresh foods; decreasing productivity of offshore fisheries through reduced nutrients from land based sources as well as stresses to mangrove habitats. This would affect the nutritional levels of many coastal communities dependent on free access to near-shore and estuarine species for protein intake.

- *Hurricane* - While there is still fairly substantial uncertainty as to the impact that climate change will have on the frequency of hurricanes and other tropical storm systems, there is more agreement that increased ocean temperatures can be expected to increase the intensity of storms and hurricanes.

  The potential health impacts could be significant, especially on vulnerable groups living along the coast, persons living in sub-standard housing, persons with pre-existing health or physical disabilities or conditions, and persons with already limited food and water sources.

  Among the expected impacts are:

  - considerable damage to health infrastructure already inadequately maintained particularly in rural areas;
  - water and food borne diseases such as typhoid, shigella, and hepatitis A and E arising out of contamination by floodwaters;
  - acute and/or chronic health problems from chemical contamination of water by agrochemicals and other hazardous wastes;
  - increases in vector borne diseases.

  One potentially significant problem in this regard is leptospirosis, a potentially fatal disease spread through the urine of rodents.

  Another is the spread of malaria and dengue by mosquitoes. In this regard, the rates for Aedes Aegypti infestation in some communities are already substantially in excess of international guidelines so that efforts will have to be made to ensure that shifts in climate and weather will not result in the enhancement of breeding conditions.

Other impacts of hurricanes indirectly affecting health include loss of shelter and population displacement, contamination of water supplies, loss of food production and storage and increased risk of infectious diseases.

- *Temperatures* - The most direct effect of global warming on human health is that of heat stress. This usually affects the young, the very old, and people engaged in manual labour or prolonged outside exposure, such as farming, or fishing. Individuals with chronic illnesses, such as heart disease, are also at increased risk of complications from heat exhaustion or heat stroke.

  Presently there are no regular reported cases of heat related morbidity or mortality in Dominica. However given the importance of cardiac related disease as a leading cause of both morbidity and mortality in Dominica, it can be envisaged that a warmer climate will nevertheless have significant impacts on health. In addition persons living in densely settled low income communities are particularly at risk and are of course often least likely to be able to afford air conditioning and other artificial cooling. Differences in the diurnal temperature range are also likely to be reduced, meaning that there will be less respite than present from high daytime temperatures.

  Other possible implications of higher temperatures include increased spoilage of food, enhanced breeding conditions for mosquitoes and other disease vectors, and effects on food production. In terms of food spoilage this will pose challenges for already stretched resources for inspection and monitoring of food establishments.

  Adaptive responses to ameliorating higher air temperatures may themselves have health implications. Greater use of air conditioning will have health implications particularly in terms of the maintenance and monitoring of air conditioning ducts and systems to ensure that mould spores and other pathogenic materials are not able to thrive and pose health risks. Additionally the insulation of air-conditioned buildings, in order to enhance energy use, accompanied by the use of indoor carpeting, cleaning agents and solvents, and the presence of other chemical agents will increase the risks of "sick building syndrome ". These will represent additional areas of responsibility for the health care system.

  There are also concerns as to the health impacts that might be associated with warming of the oceans. While cholera is not endemic to Dominica, evidence from the Pacific suggests that rising sea temperatures may increase the risk of cholera spreading beyond areas of endemism.

- *Sea-level Rise* - Sea-level rise is not expected to have any direct health impacts in Dominica but will likely result in the displacement of persons, damage to housing (and possibly health infrastructure) and consequent indirect health impacts in terms of physical and psychological effects.

Other impacts of sea-level rise on fishery and agricultural productivity can be expected to have impacts on food availability and therefore possibly nutritional levels. Specific health hazards could arise from heightened storm surges and from damage to coastal infrastructure, including wastewater and sanitation systems.

- *Integrated impacts of climate change*- Efforts at forecasting the health impacts of climate change require utilizing the knowledge of environment- health relationships gained from limited past experience and applying this to future environmental changes involving high degrees of uncertainty and which will probably far exceed the range of past variation. This necessarily poses difficulties for assessment of projected impacts.

  Nevertheless, taken together the combined effect of the projected impacts of the climate change scenarios outlined above would be to place additional stresses on a health care system which is recognized as already under strain in dealing with existing health concerns. As noted above, the health sector already annually accounts for approximately 14% of budgetary resources, an extremely high proportion for any country.

Climate change will likely affect the prevalence and patterns of many of the existing health concerns facing Dominica, while also superimposing new and additional levels of stress arising from changes in environmental parameters.

3.4. SUMMARY

It is clear from the foregoing, that all of the principal social and economic sectors in Dominica are vulnerable to the potential impacts of climate change.

4. INSTITUTIONAL FRAMEWORK

4.1. ENVIRONMENTAL RESPONSIBILITY

The Environmental Coordinating Unit in the Ministry of Agriculture and the Environment is charged with the responsibility for coordinating all environmental activities on the island. It also serves as the focal point for the multilateral environmental agreements to which Dominica is a party.

At the sectoral level, the responsibility for environmental conservation and management is dispersed among a number of government agencies, non-governmental organizations, statutory bodies and other interest groups.

There is often overlap between the roles played by these bodies/organizations even if they all have a different focus and different jurisdiction over the same resource base. A case in point is the responsibility relating to sand mining and the removal of stones from beaches, a responsibility which falls under the jurisdiction of the Ministry of Communications and Works. While this ministry grants permission to the public for the removal of sand and stones from the beach, its portfolio does not cover biodiversity conservation despite the fact that the mining activities for which it grants permission has serious negative impact on the biodiversity there. The responsibility for biodiversity conservation and management rests with the Forestry and Wildlife Division and Fisheries Development Division of the Ministry of Agriculture and the Environment.

There is therefore an urgent need for strengthening partnerships between institutions, for developing clearer definitions of responsibilities and for strengthening of the capacity for implementing environmental conservation and management measures.

4.2. ENVIRONMENTAL REGULATIONS

4.2.1. Coastal Regulations

Dominica has no comprehensive coastal zone management regulations. A number of laws have been enacted which address issues of environmental management which are applicable to the coastal zone. These include:

- *Beach Control Act (1966, 1990)* – Protects beaches, controls the mining of beach material and requires that a permit be obtained for removal of beach material.

- *Public Health Act (1968)* – Provides general authority to maintain environmental health and control sources of pollution. Does not establish criteria for water quality, or standards for industrial wastewater discharges and for solid/hazardous waste management.

- *Pesticides Control Act (1974, 1987)* – Controls the importation and use of pesticides. There are no regulations specifying environmental protective pesticide management practices or imposing restrictions on its application.

- *Litter Act (1990)* – provides general authority for the control and abatement of nuisances caused by litter on public and private lands.

There are also other Acts specific to the forestry and fisheries sector which are also applicable to the management of the coastal zone, but which will be discussed in their sectoral context.

Despite the absence of an integrated approach, Guiste (2001) states that these laws have been useful in enabling, for example, the government to declare marine protected areas long before habitat degradation, or biodiversity loss, became a problem in particular locations.

He points out however, that while the existing laws have provided a sound basis against which resource management can be implemented, they fall short in some respects. Most of the legislation addresses the protection of commercial species and fails to address the problems associated with interactions between the various ecosystems, or to consider the source points of land based marine pollution that have a number of adverse impacts on the coastal zone.

In addition to the national legislation that has been enacted to address environmental issues, Dominica is a member of the International Maritime Organization and has ratified the Cartegena Convention on marine pollution and prevention. Unfortunately however, most of the international maritime and environmental treaties and conventions to which Dominica is a party do not have their provisions implemented in national legislation, a factor which restricts the progress that could be made in efforts to strengthen coastal zone and marine management.

Despite these shortcomings with national legislation, Dominica continues to build its legislative/regulatory framework for environmental management and to strengthen existing authority for the protection of its natural resources.

4.2.2. Forestry

The main legal instruments governing forest use and management are the following:

- *The Forest Act (1959)* - This legislation empowers the Minister of Agriculture to establish Forest Reserves on Crown Lands as well as Protected Forests on private lands. It stipulates the conditions for timber harvesting, makes provision for the control of squatting, and defines various other offences.

- *The Forestry and Wildlife Act (1976)* makes provisions for the conservation and management of wildlife, through the listing of species, the establishment of reserves, and the setting of fines for a variety of offences.

- *The National Parks and Protected Areas Act (1975)* provides for the establishment of National parks and a protected area system.

- *The Water and Sewerage Act* 1989 states the Government's water policy. It addresses the need for orderly and coordinated development, use and conservation of Dominica's water resources. It also makes DOWASCO responsible for the supply of water to all residents of the country.

Policy guidance is also provided by other plans that are directly related to the forestry sector. A *Biodiversity Action Plan* has been developed with funding and technical assistance from the United Nations Environment Program (UNEP), within the framework of the Convention on Biodiversity. A *National Environmental Action Plan (1994)* sets out programs to be conducted to achieve sustainable development in the use of natural resources.

4.2.3. Fisheries

Various legislative and regulatory instruments govern management of Dominica's fishery resources. Principal of these is *the Fisheries Act of 1987*, which requires the preparation of a Fisheries Management Plan for the development and management of the country's fisheries.

The Act provides an umbrella authority for efforts to promote sustainable management of fisheries, including the establishment of protected areas. Another important legislative instrument impacting on the management of fisheries is the *Territorial Sea, Contiguous Zone, Exclusive Economic and Fishery Zones Act of 1981*, which establishes the extent of Dominica's maritime areas. Other legislative instruments directly affecting fisheries are legislation pertaining to development control and forestry and wildlife.

Principal responsibility for the management of fisheries and their habitats is distributed among an array of government ministries and departments. These efforts are spearheaded by the Fisheries Division of the Ministry of Agriculture as the principal agency responsible for management of marine fisheries in Dominica.

Other government ministries and departments with interests in the sector include:

- The Ministry of Health and Social Security with responsibility for monitoring of coastal water quality.

- The Ministry of Communications Works and Housing with the portfolio for sand mining and removal of stones from the shore.

- The Ministry of Tourism involved in the promotion and regulation of tourism in coastal and marine areas.

- The Coast Guard responsible for enforcement of maritime and marine law.

- The Forestry Department responsible for management of rivers, wildlife (including Turtles) and mangroves.

A number of non-governmental and community based organizations are also involved in activities often directly, or indirectly, related to fisheries. These include the National Development Corporation, which promotes investment activity, the various fishermen's cooperatives, and private sector tourism operators involved in dive and whale watching activities.

Given the number of agencies involved and their differing sectoral emphases, problems of inadequate coordination and communication can negatively affect the fishery resource particularly in terms of terrestrial activities impacting on the fishery habitat.

4.2.4. Physical Planning

Physical Planning is the responsibility of the Physical Planning Division (PPD). This Division is responsible for, *inter alia,* the administration of *the Town and Country Planning Act* 1975, enforcement of land sub-division and building regulations and providing advice to local and central government authorities on issues of land use and building control.

The Town and Country Planning Act is the substantive planning and development legislation of the island. Dominica is currently reviewing the OECS Draft Planning Legislation with a view to its adoption and implementation. The island is also presently implementing an integrated planning process, which has the potential to increase the coordination of strategies, which respond to development issues.

The aforementioned Act covers all types of development and authorizes the formulation of a national development plan that is expected to provide a coherent and comprehensive land use policy that assesses special development needs. To date, neither a national physical development, nor land use plan has been adopted, approved or legislated (except for a land use plan that pertains specifically to the National Park).

The Act also provides a framework for managing, guiding and coordinating public and private sector developments in accordance with overall development policy. The Act therefore empowers the Division to exercise planning control over all development activities.

4.2.5. Environmental Impact Assessments

In keeping with continued efforts to enhance the legislative/regulatory frame, Dominica is presently considering enacting into law (under the Physical Planning Act) an established policy, which seeks to ensure that an Environmental Impact Assessment

(EIA) precedes all major national development projects that are likely to have negative environmental impact.

It is however reported that the policy is not always enforced, particularly for projects such as the construction of sea defense works and quarry operations.

4.2.6. Enforcement

The enforcement of legislation is a problem throughout all sectors. Some of the constraints being experienced are linked to the lack of financial and human resources necessary for the implementation of the task. There is also what has been described as the absence of political will to enforce and enact certain legislation, e.g. to ensure that Environmental Impact Assessments are conducted for coastal and land based development projects.

Additionally, as the legislation that exists is scattered over various government ministries, the degree of enforcement depends on each ministry's primary area of focus and responsibility.

5. NATIONAL RESPONSE MEASURES

Dominica joined the international response to climate change when it ratified the United Nations Framework Convention on Climate Change.

This Initial National Communication represents the start of the national process of responding to climate change, within the framework agreed upon by the Conference of Parties (COP).

In developing this national response strategy, Dominica is guided by the principles of Article 4 of the Convention, and subsequent COP decisions, wherein the developed country parties have committed to assisting the developing country parties in the implementation of response measures to combat the negative effects of climate change.

The preceding sectoral analyses indicate the wide-ranging nature of the potential adverse impacts that anthropogenic climate change can have on Dominica, notwithstanding the high levels of uncertainty as to the timing, nature and extent of these possible changes in climate parameters and consequently their impacts.

Dominica, however, fully subscribes to the Precautionary Principle enshrined in the Convention and does not believe that one has to await full scientific certainty before initiating measures to combat climate change.

Given the scarcity of resources however, Dominica's approach will not be based on climate change considerations only. The measures to address the likely, or potential, impacts of climate change would be linked to wider considerations and would be directed in the first instance, towards reducing existing vulnerabilities and risks to present day weather and climate extremes, as well as advancing wider development objectives.

The measures will address all the main aspects of climate change i.e.

- Reduction in emission of greenhouse gases.

- Adaptation to the many sources of vulnerability that have been identified.

It must be noted however that given the low levels of greenhouse gas emissions, the emphasis will be placed on the adaptation aspects, as this is the area where Dominica will experience the most serious adverse impacts.

5.1. REDUCTION OF GREENHOUSE GAS EMISSIONS

The Greenhouse Gas Inventory has shown that the major GHG's emissions are generated by the transport sector (50% CO_2), the energy industries (26% CO_2), and Commercial and Industrial Uses (10% CO_2). There are also smaller quantities of methane emissions from the solid waste disposal sites, as well as manure management and enteric fermentation in the agricultural sector; and of nitrous oxide from agricultural activities.

Efforts to reduce GHG emissions will therefore be targeted at the three (3) main sources i.e. the transport sector, the energy sector and the commercial and industrial sector.

5.1.1. Transport Sector

The transport sector comprises of vehicles used by private individuals and by commercial entities. It is the least flexible to changes, because it is heavily dependent on petroleum-based fuels, and entrenched lifestyles. Emissions from these sources could be expected to increase over time under a Business as Usual scenario, as the population increases and the economy continues to grow.

The options for reduction of emissions from this sector will be developed in the context of a comprehensive transportation plan for Dominica, both to better regularize and minimize traffic flow and consequently reduce the emission of greenhouse gases. This plan will consider, *inter alia*:

- The provision of a reliable and efficient public transportation system in Dominica.
- Special fiscal and licensing incentives to encourage people to keep their cars for longer periods, since resale and purchase of another car, very likely new, only increases the number of cars on the road with consequent increases in GHG emissions.
- Legislation of fuel economy standards, including compulsory fitting of speed limiters.
- The greater use of more efficient and less-polluting engines, such as conversion from 2-stroke to 4-stroke engines and greater use of electronic engine systems.
- The mandatory installation of pollution removal devices such as catalytic converters in vehicular exhaust emission systems and the implementation of tougher legislation relating to exhaust emissions.
- Energy use efficiency improvements through the use of less carbon emitting fuels, such as natural gas, as well as unleaded fuel.
- The use of alternative energy sources, for instance switching to diesel from gasoline. It must be noted however that this may increase emissions of NOx and particulates.

- Proper maintenance and overall servicing of vehicles, which will likely lead to both reductions in fuel use and carbon emissions.

- Improvements in tire performance and lubricants and other accessories such as transmission improvements.

- The use of light-duty road vehicles in urban traffic and heavy-duty vehicles for freight traffic.

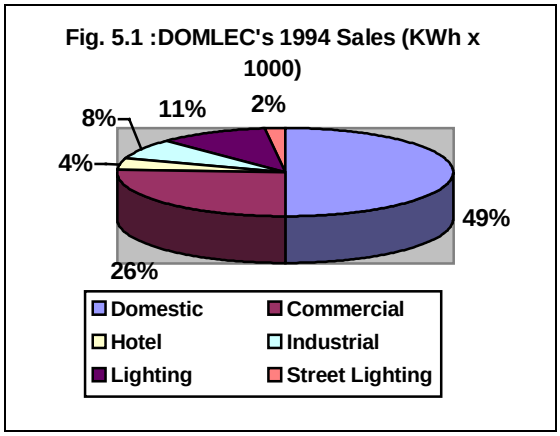
- Restrictions on the importation of older foreign used vehicles. Ideally, the first approach to controlling or reducing CO_2 emissions from exhausts pipes is to restrict the age of the vehicles on the roads to those that meet better emission standards. Consequent with this approach, will be the reduction in consumption of fuel, since older cars are generally less fuel-efficient than new cars.

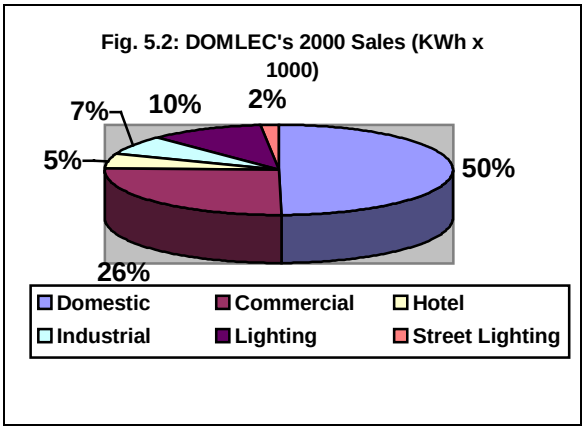
5.1.2. Energy Sector

In 1994, Dominica derived about half (52%) of its power supply from the generation of electricity by thermal power plants fed by carbon-rich fossil fuels, the rest (48%) coming from hydro-electric power plants.

This represented a significant shift from the early 1950's and 1960's when hydropower met approximately 90% of the energy requirements. This shift has continued and current operations show an increasing dependence on diesel generation as a result of demand growth.

In 2000, electricity sales increased by approximately 46.5% over 1994 from 42,343 to 62,005 KWh x1000. The sectoral distribution of sales remained very similar during the period with the Domestic sector accounting for 49% and 50% of the sales in 1994 and 2000 respectively. This was followed by the Commercial sector (26% in 1994 and 2000) and Lighting (11% and 10% of the total sales in 1994 and 2000 respectively). Sales to the Hotel sector increased by 1% of the total sales, whilst there was a 1% decrease in sales to the Industrial sector over the period. **Fig 5.1 and 5.2**





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In 1994 hydro generation accounted for approximately 56% of total power generated and diesel accounted for 44%. In 2000, diesel accounted for 59% of the power supply generated and hydro production for 41%. In 2000, 12,075,795 litres of diesel was consumed in the production of electricity. This represented an increased of 101.7% over 1994 in which 5,987,425.5 litres of diesel were consumed.

This trend is expected to continue under a Business as Usual scenario due to the unusual prolonged drought conditions being experienced over the last three years and as demand in the Domestic sector increases significantly, once Government implements its plans for electrifying the rural areas that are currently without electricity and new private housing development programmes are completed. The 1991 Census reported that 76% of the population has electricity.

This scenario points to the potential for significant increases in GHG emissions from this sector. It is therefore necessary to put measures in place to manage the emissions. These will include, *inter alia*:

- The modernization of existing power plants through the use of energy efficient technologies or the retrofitting of existing plants with modern efficient technologies such as decarbonization of flue gases and fuel.

- The use of less carbon-intensive fuels, such as switching from liquid fossil fuels to natural gas, or simply the use of cleaner liquid fuels where costs can be justified.

- Greater use of renewable energy technologies for power generation such as solar, micro-hydro and wind energy. DOMLEC has made a commitment to increase the use of alternative power sources in the future.

- Further development of hydropower, which may not be cost-effective in the short-term because of the technology limitations, but is a viable short-to-medium term mitigation option.

- Providing of incentives for investment in renewable energy and the removal of policies that hinder the application and use of renewable energy.

- Involving local communities, mainly in small-sized energy supply projects.

5.1.3. Commercial, Residential and Industrial Sector

This sector uses energy to operate machinery and equipment, cool buildings, provide lighting, and provide other services ranging from cooking to the use of home appliances including computers.

The emissions from these sectors could also be expected to increase under Business as Usual scenarios, as a result of economic growth and population increases. It is therefore necessary to put measures in place to manage these emissions. These include:

- The use of more energy efficient and less environmentally harmful building materials. For instance, high quality durable hardwoods which have a much higher thermal retention capacity than brick or concrete, not to mention the lower energy use in the production of wood as opposed to brick or concrete and the carbon sequestration potential of wood, may prove to be an attractive building material alternative for Dominica. Upgrading the national building code of Dominica to include energy conservation in building designs may facilitate this technology option.

- The Government of Dominica may enact regulatory measures relating to mandatory energy-efficiency standards, within the context of a national building code. The Government may also move to alleviate hindrances to these measures, including defining these standards and ensuring their cost effectiveness. Voluntary standards and measures, as a good will gesture on the part of manufacturers and builders, would greatly help to make these policies more effective.

- Improvements in the thermal integrity of buildings aimed at reducing cooling energy losses.

- The regulatory enforcement of energy conservation labels on equipment and appliances.

- The introduction of tax concessions and incentives for the adoption of energy-efficient products. This could include the acceleration of depreciation taxes on the acquisition of equipment that are less GHG intensive.

5.2. NATIONAL ADAPTATION STRATEGY

Increased variability in rainfall, coastal erosion and inundation, changes in frequency and strength of tropical storm systems, and warmer temperatures can be projected to result in complex and often widely variable impacts, straining already limited financial, human, and natural resources. Thus in the Dominica context, the challenge for effective adaptation to a changing climate will be the extent to which the country is able to integrate concerns for climate change into decision making at all levels.

The role of the Government of Dominica would be to facilitate the adaptation process towards ensuring that obstacles to effective adaptation are removed, or reduced. This will include:

- Integrating climate change into development policies, plans and projects and incorporating appropriate adaptive responses.

- Ensuring that adaptive responses are consistent with national social, economic and environmental development goals.

- Taking adaptive action where State property, resources and services are likely to be adversely affected by climate change.

- Fostering awareness and providing information to decision makers, at all levels, about climate change, climate change effects and possible adaptive actions.

- Providing assistance to individuals and groups vulnerable to the potential impacts of climate change, with insufficient resources for effective responses.

It must be emphasized that although the public sector will have a crucial role, adaptation to changing climate will require actions and changes in behaviour by stakeholders at all levels.

5.2.1. Sectoral Adaptation Options

There is a wide range of adaptation options that can be developed for the vulnerable sectors.

(a) Forestry and Terrestrial Resources

The strategies and actions available for adaptation to climate change are also suitable for coping with many other environmental pressures that currently exist. These include:

- Development and implementation of a land use policy.

- Strengthening of legislation and regulations governing forest management on government and private property.

- Agro-forestry - There is the need to prevent land degradation and rapid soil erosion while providing land for agricultural production. Due to the rugged terrain it is absolutely essential to maintain tree cover on slopes 30° and over.

- There is a need to find creative fiscal measures to encourage private lands to remain under forest cover.

- Reforestation of critical watersheds. Many of the watersheds have been partially deforested largely under the pressure of conventional/intensive agriculture. It may not be feasible to reforest certain areas with indigenous forest cover due to the level of degradation. In such circumstances, certain fast growing exotic species may be utilized

- Strengthening the existing Wildlife Protection Act and develop, adopt and implement a Wildlife Farming Policy. This should also make provision for ensuring the security of habitat.

- Protecting wetland ecosystems. These sites are important habitat for migratory and resident wildlife.

- Urban Forestry - sites should be developed incorporating meaningful "green spaces". Aside from aesthetic considerations, this would help alleviate some of the common urban environmental stresses, particularly heat intensity, and noise pollution.

- Public education/awareness on ecosystem threats and applicable conservation strategies.

- A regional approach to critical habitat management and research in order to develop an understanding of how tropical ecosystems respond to climatic changes. This could be done in collaboration with the Caribbean Foresters Society, CARICOM, and OECS/NRMU.

- Trials of forest species suitable for (a) + 2 ^{o}C environments, (b) reduced rainfall and varieties es less prone to wind damage

- Implementation of model-based climate and adaptation impact assessment following IPCC Guidelines and climate scenarios.

(b) Coastal Ecosystems

Integrated Coastal Zone Management (ICZM), (which involves cooperation among all the responsible stakeholders) has been identified as the most appropriate process to address current and long-term coastal management issues.

While there is no set procedure for the ICZM process it is an effective tool for reducing vulnerability, encouraging sustainability and maximizing the options for future generations in the face of global climatic change. The discussion, which follows, offers a range of adaptation measures that can be implemented or explored within the framework of ICZM to provide responses, or adaptive strategies to coastal ecosystem problems resulting from climate change.

- *Use of Traditional Knowledge and Skills* - In planning for adaptation, efforts should be made to maximize the use of traditional knowledge and skills that island people have used in the past to cope with the variety of environmental stresses they have faced, even if these measures have no scientific basis, (*IPCC, 1998*). Often the use of these traditional knowledge and skills results in the implementation of more cost effective and efficient measures to address problems of coastal erosion.

  Nunn et al (*1999*) argues however, that adaptation efforts require more than just the use of traditional management strategies as over the years the overwhelming demands on coastal areas have changed so significantly that this alone would not be appropriate. It is suggested therefore that adaptation strategies should apply a mix of traditional and modern practices, which aim at satisfying both the subsistence and commercial demands on coasts.

Shore Protection Measures – Recently, major construction projects have been implemented on the west coast. This involves the construction of artificial shoreline protection structures (mainly seawalls) as sea defences – **Photo 5.1**.

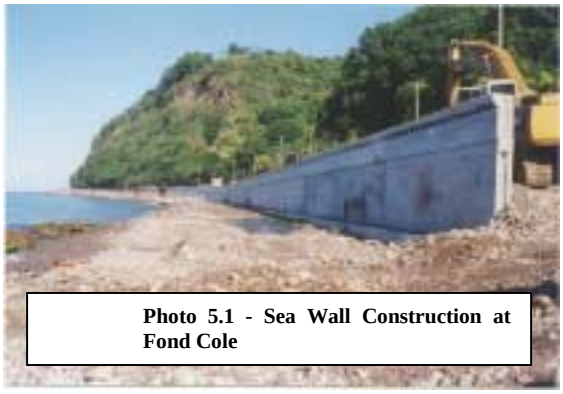

Photo 5.1 - Sea Wall Construction at Fond Cole

However detached offshore breakwater (above and below) should be considered as an alternative to seawalls in areas in which conditions are favourable.

Properly constructed and oriented detached underwater breakwater share the same function as a coral reef dissipating wave energy and promoting sediment accumulation in their lees. (Juillerat 2001 personal communication)

Coastal re-vegetation provides yet another type of option and represents a strategy, which can be adopted by both local communities and governments to reduce problems of shoreline erosion. Local species such as Seaside grapes (*Cocoloba unvifera*), seaside mahoe (*Thespesia populnea*), West Indies almond (*Teminalia catappa*), coconut palm (*Cocus nucifera*) and Casuarina (*Casuarina equisetfolia*), a variety of trailing vines and grasses such as seashore dropseed (*Sporobolis virginicus*), beach morning glory (*Ipomea per-caprae*) and sea purslane (*Sesuvium portulacastrum*) could be planted. (Juillerat 2001 personal communication)

The lack of understanding of shoreline processes has been catastrophic in many cases. This implies a significant commitment to specific research and development programmes, in finding the best solutions, which could be conducted at both the national and regional levels. This requires a comprehensive understanding of the ways the various factors interact. Without the basic knowledge, solutions proposed may be misguided and inappropriate

- *Setback Strategies* - Options such as setback and "set up" strategies can also be utilized to reduce direct human impact on the coast, particularly when implemented in collaboration with the re-vegetation of coastal fringes. This can be implemented in collaboration with the enforcement of development controls such as building codes that take into consideration environmental characteristics and other design and construction standards.

- *Public Education* - Public education processes to sensitise the local population, especially school-aged children, on the issues of climate change are also needed.

In addition, it is also important to enhance the understanding of local non-governmental organizations (NGOs) concerning climate change issues. NGOs can play a critical role in raising awareness about sustainable coastal adaptation.

Awareness building is also crucial among public and government officials, as the common complaint concerning the absence of political will to drive the implementation of necessary measures, may be the result of a lack of awareness and/or understanding of the issues.

- *Environmental Impact Assessments* - the conduct of EIA's should be mandated for all recommended adaptation measures to be implemented. In that regard, training in the use of environmental management tools relating to EIA and economic tools such as natural resource accounting, provide a good starting point.

- *Legislation* - There is also a need to review and where necessary update legislation and regulations with a view to developing an appropriate legislative and institutional framework for dealing with the impacts of climate change.

- *Databases* - The establishment of a reliable qualitative and quantitative database in support of widespread observations of the impacts of current climate variability. In addition to the above, baseline information on coastal resources, coastal oceanography, shoreline profiles and historical shoreline erosion rates are also some of the many types of data that are vitally important.

  Since data collection is often expensive and difficult, it is necessary therefore to identify the most relevant information required to feed the ICZM process and to assist managers and decision makers. This information is also important to the creation of a factual understanding of climate change issues in the Dominican context.

- *Hazard Mapping* - The creation of new, or revision of existing, hazard maps which will define the extent of impact prone areas and inform strategies for sustainable land use.

- *Research* - The initiation of research activities in support of some of the above options. This research will address the appropriate traditional knowledge and skills, which can be utilized in identifying cost effective, flexible and easily replaceable adaptations to climate change impacts.

(c) Freshwater Resources

The adaptation options for this sector include:

- *Refurbishment of DOWASCO Facilities* - catchments, transmission and treatment facilities need to be refurbished to increase quality of product, reduce wastage of treated and untreated water and facilitate or accommodate increased water storage during times of heavy rainfall.

- *Revision of the Pricing Mechanism* - to accurately reflect the value of the water resource. The valuation of the water resource must incorporate costs of producing (this is done by protecting watersheds), accessing, treating and delivering water that complies with international health standards. It is often forgotten that water plays an important role in supporting a wide range of ecosystems and that unregulated removal for municipal purposes can jeopardize these ecosystems. Water is therefore abstracted at a price to the environment. A small levy may thus also need to be included in the final price charged for water in order to reflect this, or through fiscal taxes on non-healthy activities (so called "sin tax").

- *Restoration and Rehabilitation of Watersheds, Riverbanks and Wetlands*. Wetlands especially must be allowed to perform their functions as water quality and flood regulators.

- *Establishment of a National Water Commission*- that will oversee the development of "code of conduct" for the responsible use of fresh water. This code should include amongst others, strong provisions for:

    - Compulsory construction of rainwater storage facilities for all homes and businesses above a certain size, seeking Ministry of Planning and Ministry of Health approval.

    - Application of price rates that decrease with decreasing consumption.

    - Implementation of special tax concessions for commercial enterprises involved in successful wastewater recycling programmes.

    - Adoption of water conservation plumbing measures. These can include the restricted importation of large toilet tanks, the compulsory use of automatic stops on all public pipes/taps, the use of low water use fittings and appliances.

    - Provision of water meters to all consumers.

- *Implement Structural Improvements Along All Watercourses* based on sound engineering and environmental principles. These include the raising of all bridges well above the maximum recorded flooding levels, and construction of levees along rivers that threaten adjacent communities. The raising of bridges is especially important in order to maintain road communications. Currently, bridges are heavily damaged during extreme rainfall events. The need to widen and keep storm drains clear of garbage is also necessary.

- *Development Of Public Awareness And Education Programmes* for persons (water consumers) of all age groups to sensitize the public to ethical water consumption practices.

- *Strict Management Of Existing Forest Reserves* - This should include the establishment, where necessary, of other protected areas to include sensitive and highly vulnerable wetlands for the safeguarding of water supplies.

- *Zoning Of Certain Agricultural Lands* prohibiting the use of specific agro-chemicals and farming practices must be expanded and strictly enforced.

- *Strengthening Monitoring Programmes* that will facilitate:

  - Collections of baseline data e.g. stream flow and other relevant research through a department of Hydrology.

  - Studies that will quantify the response of surface run-off to rainfall

  - Development of flood maps for all coastal and other vulnerable areas on the island.

- *Provision Of Economic Incentives* for the establishment and maintenance of forests on private lands.

- *Integrate Watershed Conservation Into National Planning And Decision-Making* on land use, river basin, coastal zone planning and all other environmental planning.

- *A National Water Resource Management Plan* which will address:

  - Human and Institutional capacity for the monitoring, assessment and management of water resources in the context of climate change.

  - Intensive impact assessments on water resources in relation to all planned and ongoing activities and projects on the island.

  - Awareness raising programmes at school, community and club levels.

  - Incentive programmes geared towards aggressive change of attitude towards water use targeting major users - the hotels, business houses, farm operations.

  - Appropriate investment programmes that promote innovative natural resource exploitation in economic development.

  - Community projects to address the restoration of degraded aquatic ecosystems.

  - Legislative changes to more effectively manage water resources.

  - Enforcement mechanisms that are practical, effective and sustainable.

- Implementation of a model-based climate impact and adaptation assessment using IPCC Technical Guidelines and climate change scenario.

(d) Human Settlement

The adaptation options here include:

Photo 5.2 Vulnerable Coastal Settlement at Massacre

- *Relocation* - the gradual relocation of housing and infrastructure to non-impact locations at the end of their design life, where this proves practical. With regards to infrastructure related to communications and utilities, consideration should be given to the relocation of existing lines to safer locations. New lines may be installed underground as already is the case with some utilities, but away from the near coastal locations where there is evidence that network infrastructure and equipment have already been dislocated by wave action.

- *Setbacks* - The implementation of existing mandatory setbacks in coastal and other impact prone areas is also essential but requires better surveillance on the ground by the Planning Authority to ensure that approved setbacks are maintained during implementation of development projects. In addition, a review and upgrading of all physical planning law and regulation is recommended with a view to developing an appropriate legislative and institutional framework for dealing with the impacts of climate change.

- *Effective Enforcement* of existing policy and/or legislative and regulatory measures pertaining to the building code, zoning of land use and Environmental Impact Assessment (EIA) are critical.

  The enforcement of the building code for example, will encourage the use of design standards for new construction that provide suitable resistance to above normal winds and flooding. The building code will also address ways to improve building sites, and advance standards and guidelines to reduce damage to existing structures. These adaptations include *inter alia*, retrofitting of structures to better withstand hurricanes and other hazards and the addition of appropriate structural improvements such as drainage channels to assist in alleviating existing flooding problems.

- *Environmental Impact Assessments* - Measures should be taken to ensure that climate change considerations are integrated into the EIA process. In conjunction with the above, strengthening of hazard mapping and risk assessment capabilities are also important. By creating new, or revising of existing hazard maps that define the extent of impact prone areas, comprehensive hazard information will become available for use by private

and commercial/industrial developers to inform strategies for sustainable land use and economic development.

- *Physical Planning* - There is also the need to strengthen the physical planning agency to enable it to carry out forward planning, development control and land use practices which are oriented towards the objectives of national development plans for the island. These should also be in line with measures for sustainable management of the island's resources and incorporate climate change considerations.

- *Use of Traditional Knowledge* - Adaptation strategies should maximize the use of traditional knowledge and skills as the local people have had valuable experience in dealing with a variety of environmental stresses. This is not, however, to suggest that decision makers should rely solely on traditional management strategies. It is therefore recommended that adaptation strategies should apply an appropriate mix of both traditional and modern practices that aim to satisfy both the subsistence and commercial demands on the physical environment.

- *Education and Public Awareness* - Public education programmes will prove useful in, for example, developing strategies for housing sector adaptation. Given the anticipated impacts, an effective public education programme could focus on, for example, protecting housing and other structures against hurricane damage or promoting the acceptance and adoption of appropriate disaster preparedness and management strategies and plans.

  Within the formal education system, an important adaptive strategy would be to incorporate climate change issues into the school curricula at all levels including the infant and adult education programs, with the aim of increasing the awareness and understanding of climate change issues and the potential repercussions and impacts.

  From the point of view of education and awareness, it is also important to enhance the understanding of local non-governmental organizations (NGOs) concerning climate change issues. This is particularly important with those agencies that provide financial services. This approach can create opportunities to develop partnerships, which can, for example, ensure compliance with the building code and other standards/regulations for development control. Partnerships between insurance agencies and enforcement agencies provide a good starting point to ensure compliance. Therefore, a prerequisite for the provision of insurance coverage could be tied to the need for prospective clients to meet the requirements set out by, for example, the Government planning authority.

- *Public Participation* - Another critical consideration, whatever the response strategy, is to ensure acceptance by the local population, and in this regard therefore, the promotion of public participation in the development process is critical.

- *Insurance* - In 1994, the CARICOM Heads of Government commissioned a Working Group study of insurance in the Caribbean. The report of the working group which was adopted by the CARICOM Heads of Government in 1996, though not specifically concerned with climate issues, proposes practical strategies for adaptation to anticipated climate change impacts which are applicable to the SIDS. The following proposals, drawn largely from the conclusions of the CARICOM Working Group, are recommended:

  - Collaboration of insurance companies and government and non-governmental agencies in the development and promotion of public awareness activities aimed at sensitizing insurance policy holders to risk reduction and mitigation options for their properties, including the adoption of more proactive measures to promoting vulnerability reduction.

  - The review of existing legislative and regulatory instruments pertaining to insurance with a view to strengthening those.

  - Collaboration of government and the insurance industry to identify practical mechanisms for the expansion of available and affordable catastrophic insurance to vulnerable groups and communities traditionally excluded from the insurance markets (e.g. low income households, farmers and fishermen).

  - Discriminatory premium pricing by insurance companies based on vulnerability reduction and risk assessment including the use of hazard and risk mapping tools as well as building codes and other development control procedures.

- *Research* - Successful implementation of any of the adaptation strategies/options recommended must be preceded by appropriate research and documentation aimed at establishing a factual understanding of climate change issues in the Dominican context. In that regard the following types of research activities are recommended:

  - Data collection that will facilitate the establishment of a reliable quantitative database in support of widespread observations of the impacts of current climate variability e.g. whether existing requirements provide the recourse intended for the problems thy aim to address.

  - The identification of appropriate traditional knowledge and skills, which can be utilized in identifying cost effective, flexible and easily replaceable adaptations to climate change impacts such may be created by for example, the projected temperature increases.

  - The identification of flexible, cost-effective and easily replaceable measures for coastal protection that would reduce vulnerability through

better incorporation of the long-term environmental consequences of resource use.

- The identification of appropriate adaptation strategies aimed at reducing the potential social dislocation that may result from climate change related damage.

- Implementation of a model-based climate impact and adaptation assessment using IPCC Technical Guidelines and climate change scenario.

(e) Agriculture

The Adaptation options for the Agricultural sector include:

- *Enforce Legislation And Policy Concerning Land Use* - Enforcement of existing legislation and land use policies are of paramount importance given the vulnerabilities identified.

- *Food Security and Health* - Efforts should be made to ensure food security by promoting agricultural diversification, employing appropriate research and technology to meet adequate production targets in the face of the threat of climate change. These include drought-resistant crops, greenhouse technology, and crop pest and disease management.

- *Large Scale Watershed Management Projects* - Efforts should be continued to maintain the integrity of the forest reserves. Reforestation should be carried out for areas where squatting remains a problem. Agro-forestry programs should be targeted at private lands within watershed areas. These should address soil conservation techniques (particularly for slopes over 30°), appropriate vegetative cover, contour drainage, terracing, and riverbank protection.

- *Education / Public Awareness* - The public needs to be aware of the issues arising from climate change and the need to adopt appropriate strategies to cope.

- *Technology* - There is the need for applied research to generate appropriate technologies. Technologies such as greenhouses, drip irrigation and hydroponics have the potential to increase crop productivity on a per acre basis, thereby increasing effective use of limited arable land.

  Investigations may be necessary on the use of drought resistant or saline resistant crop strains depending on the impact of drought and sea- level rise in the future.

- *Relocation of Farms* - This approach may be necessary if current conditions are drastically altered by climate change. An example may be the increasing levels of salinity in coastal agricultural lands due to sea-level rise and tidal intrusion. Such an occurrence would create marginal lands. Agricultural production may have to retreat inland and an alternative use found for formerly productive sites (e.g. service sector infrastructure- commercial, tourism).

- *Pest and Disease Management* - Climate change may produce ideal conditions for some agricultural pests to thrive. Insect pests may be able to produce multiple breeding cycles given higher temperatures and drier conditions.

  Drought stricken crops may be weakened and therefore vulnerable to attack by pests. International cooperation along with local research efforts should be made to study possible sources of pest introduction, and methods of biological or chemical control for pests of our region. Growing pest resistant crop strains, or altering cropping patterns according to the pest cycle may be necessary.

- *On Farm Water Storage Capabilities*- Efforts should be made to introduce and to encourage appropriate technologies of water storage facilities on farmers holdings for irrigation and livestock purposes. Similarly existing technologies, e.g. Ferro-cement tanks, should be encouraged and supported by the Ministry of Agriculture and the Environment.

- Implementation of a model-based climate impact and adaptation assessment using IPCC Technical Guidelines and climate change scenario.

(f) Fisheries

Adaptation options for the fisheries sector are required at a number of levels:

- *Responding To Changed Sea Conditions And Targeting Offshore Species* - This would require:

  - Encouragement of use of fishing boats able to target offshore fisheries.

  - Enforcement of fishing controls within the country' exclusive economic zone.

  - Raising the level of coastal structures (docks and piers).

  - Implementation of sea-worthiness and safety programmes for fishermen.

  - Provision of support to fishermen to promote access to larger fishing boats better able to target offshore pelagic, as well as withstand rougher seas.

  - Provision of facilities, where possible, for removal of vessels of all sizes from the sea to sites above the reach of storm surges.

- *Public Awareness* to sensitize stakeholders as to the types of impacts that can be expected. This will allow for planning to better respond to these impacts and is important at all levels. Public awareness programmes are needed, targeted at all stakeholder groups involved in exploitation and management of the fisheries resource.

- *Fisheries Plan* - The number of responses necessary, and their linkages to other sectors, means that it is essential that these take place within the context of an overall integrated plan for development of the country's fisheries resources.

  The important element is to ensure that knowledge related to climate change is incorporated into planning for all aspects of fisheries management and development.

  This points towards the need for strengthening the capacity of fisheries personnel to assess climate change impacts and plan as best as possible for adaptation. Such strengthening should involve exposure to the general science of climate change, and training for technical personnel in climate modelling. Additionally, resource managers will have to continue data collection efforts with a view to now also identifying any links between the fisheries, and weather and climate-related phenomenon.

(g) Tourism

The adaptation options for the tourism sector include:

- The establishment of a reliable quantitative database in support of widespread observations of the impacts of current climate variability. This is important to the creation of a factual understanding of climate change issues in the Dominican context and for determining and planning for the potential impacts of future climate change.

- The conduct of research into appropriate traditional knowledge and skills, which can be utilized in identifying cost effective, flexible and easily replaceable adaptations to climate change impacts.

- The creation of new, or revision of existing, hazard maps which will define the extent of impact prone areas and inform strategies for sustainable land use and tourism development.

The conduct of research on the use of appropriate multi purpose, cost effective and easily replaceable measures for coastal protection, which would reduce vulnerability through, better incorporation of the long term environmental consequences of resource use.

(h) Health

The following adaptive responses have been identified as initial actions for promoting health sector adaptation in Dominica. They are not intended as a comprehensive list, but

rather, are intended to serve as guidance. They will require consultations and discussions with stakeholders to further refine the needs and response actions.

- *Public Awareness* - This will be key to all efforts since changes in behavior will in many instances be required. Efforts should include sensitization for key community educators in government and non-governmental organizations, as well as the media and should include material in Kweyol. In view of the importance of the activity a survey should be conducted to assess present needs. The Phase 2 financing for GEF Climate Change Enabling Activities provides an opportunity to develop, and possibly implement, a pilot public awareness programme that might incorporate health sector priorities.

- *Building Capacity For Climate Change Response* - This focuses on building capacity at technical levels within health management. This includes developing mathematical models specifically oriented for assessing vector potential, strengthening linkages between climate early warning systems and the health management systems, and training health planners in risk and vulnerability assessments relating to climate change.

  Bertollini and Menne's chart of adaptive actions notes the importance of inter-agency coordination. Establishment of a multi-sectoral mechanism, including health sector representatives, allowing for prompt exchange of information and coordinated and joint action among stakeholders should therefore be a central part of capacity building measures.

- *Surveillance And Monitoring* - Surveillance and monitoring of health/environment parameters requires certain levels of capability including systems for capturing data, trained personnel, and equipment for processing and use of information generated.

  The CMO's Report identifies a number of data gaps that presently constrain improved health management and such gaps will need to be filled to enable full and timely flows of health data among authorities of any trends associated with changes in climate and weather. Efforts should be directed towards establishment of information management systems that are capable of timely capture and distribution of data.

- *Strengthened Environmental Health* - Many of the impacts associated with climate change are linked to management of the environment. Existing problems with solid and liquid wastes are likely to be exacerbated by such impacts as hurricanes and higher temperatures projected with climate change. Vector control, environmental engineering and public awareness will be central elements of environmental health programmes.

- *Development Control* - Damage associated with hurricanes and storm surge already contributes to health sector vulnerability by increasing the risk of death and injury. Additionally improper development heightens vulnerability to soil erosion and land slippage, as well as a host of other adverse negative impacts.

Efforts must be made to promote development activity that mitigates disaster and health risks that may be associated with, or enhanced by, climate change.

- Implementation of a model-based climate impact and adaptation assessment using IPCC Technical Guidelines and climate change scenario.

5.2.2. Priority Action Plan

The large number of adaptation options that are possible (**see Appendix 11**) points to the need to focus limited resources on core issues that have multi-sectoral and multiplier benefits.

The following six (6) priority areas have been identified as being central to enabling meaningful adaptive response measures to anthropogenic climate change in Dominica. Successful implementation of the actions proposed here, will establish a strong foundation from which Dominica can continue to strengthen it program of response to climate change.

(a) Public Awareness

In order for action and resources to be directed to a problem, it is first necessary for there to be awareness of the issue. This is particularly true for an issue such as climate change that is relatively complex and technical, and where the science is still evolving. All of the sectoral analyses indicate the importance of public awareness as a tool for adaptation.

Awareness of climate change needs to exist at two inter-related levels. The first of these is at the level of the general public that needs to be aware of certain basic features of climate change, as it is likely to interact upon them. The second is at the more technical level – this latter level is dealt with below in relation to requirements for Capacity Building.

The ultimate objective of the public awareness programme is to sensitize stakeholders to the likely impacts of climate change and the measures that can be taken to ameliorate adverse impacts.

Creating mass awareness of climate change should be focused on imparting practical information that is necessary for responding to existing weather/climate stresses in a manner that will not compromise the long-term sustainability of the resource base.

This will require a carefully developed information programme that incorporates and utilizes latest available data as a guide for decision-making at household, enterprise, community, sectoral and national levels. The *Phase Two funding from the Global Environment Facility (GEF) for Enabling Activities under the UNFCCC will be used to initiate a comprehensive climate change public awareness project.*

Public awareness will also be instrumental in creating a supportive political environment for adopting the type of long-term responses necessary for ameliorating some of the impacts of climate change. Themes for the campaign should revolve around practical

knowledge that will inform school aged children, farmers, tourism investors, fishermen, and other stakeholders of anticipated changes in weather patterns, and the type of measures to be taken to reduce their vulnerability to climate change and to promote adaptation.

(b) Sustainable Coastal Resource Management

Strategies for coastal protection on climate change would encompass efforts at enhancing natural resources such as mangroves and coral reefs. They would also be targeted at land-based sources that negatively impact on the long-term sustainability of coastal ecosystems.

This will require the type of holistic and integrated management approaches articulated in the Coastal Zone Management concept[23]. Critical to the success of this type of programme is the involvement of a wide range of stakeholders in the development and implementation of these activities.

Opportunities would also be sought for enhancing information exchange and training of coastal managers in relation to climate change, as the aim would be to sensitize coastal resource user and managers to the possible impacts of climate change and the short, medium and long term measures are needed to facilitate adaptation to climate change.

As the sectoral assessments point out, a critical factor in coastal zone management in Dominica is the need for strengthening of institutional frameworks and capacities.

The significance of Dominica's coastal areas also suggests the need for stepped up monitoring of the health of various coastal resources as an information tool for assessing whatever changes might be occurring in these systems in response to climate change. Regional and international cooperation would be sought in this regard.

(c) Strengthened Disaster Management Capabilities

Dominica already presents high levels of disaster risk to weather related events and has suffered recent major disasters associated with hurricanes. Due to its physical location, the country is affected by frequent hurricanes and is also susceptible to volcanic and seismic activity.

Present national disaster response capabilities are coordinated by the Office of Disaster Management that is responsible for coordination of the various inputs required. While these efforts have proven successful in responding to a wide range of disaster situations it is recognized that there is need for strengthening the agency.

In the context of these risks and the experience of past disasters, Dominica has developed disaster preparedness and response capabilities, including Early Warning Systems (EWS). In terms of hazard monitoring and forecasting, EWS capabilities for hurricane warning are well developed and tested. However projections for climate change would

[23] *A useful introduction to coastal zone management of relevance to island States is " A Workbook of Practical Exercises in Coastal Zone Management for Tropical Islands", Commonwealth Science Council, Bacon et al, 1998*

clearly place additional stresses on the disaster response capabilities as presently structured.

An important element of Dominica's response to climate change would be to strengthen its disaster management and response capabilities. In addition to measures for further strengthening the national disaster unit, particularly important will be the need to strengthen telecommunication links and to enhance even further the role of local response units to coordinate local level response.

Given the high degree of disaster risks that exist in certain areas consideration would also be given to including the disaster management office in the physical planning and development approval process. This is to enable disaster risk considerations to be factored into decision making from an early stage.

(d) Integrated Water Resource Management

Dominica presently depends virtually exclusively on rain-fed surface water for its freshwater supply thereby making it vulnerable to variations in rainfall.

A combination of resource enhancement activities (reforestation, agro-forestry, land acquisition) and management measures (water conservation, land use policy, legislation) are advocated as adaptive measures to promote adequacy of water supply. In view of the centrality of water to all development activity – health, agriculture, tourism, industry – the government will put in place the necessary technical and institutional capabilities that will allow for sustainable use of Dominica's water resources in a context of increased rainfall variability.

Both projected population growth and plans for economic development are likely to lead to intensified demands for freshwater and therefore accelerate pressure on occasionally already stretched freshwater resources. Such pressures are likely to be intensified by projections for anthropogenic climate change.

It will therefore be critical that future water resource assessments go beyond traditional engineering notions of return periods for extreme weather events, such as droughts and floods, in order to be better prepared for increased rainfall variability expected to be associated with anthropogenic climate change.

Additionally, given the role of the country's forestry resources in serving as a watershed, it will be necessary to undertake the policy, administrative, public awareness, and enforcement measures required to ensure that these resources are not degraded by unsustainable activities, particularly deforestation, that would restrict the ability of the forests to continue to meet this essential function. Additionally, the country's forestry forms an increasingly important part of a diversified tourism product so that it's preservation is likely to have significant cross sectoral benefits.

(e) Strengthened Physical Planning

Many of the sectoral recommendations point either directly, or indirectly, at the need for strengthening physical planning and development control functions so as to reduce existing pressures on climate change sensitive sectors and resources.

Anthropogenic climate change requires that governments and communities have the legal and regulatory power and capabilities to monitor and control land use. This would be both proactive in the sense of forward planning capacities and regulatory in the sense of the ability for monitoring development and identifying risks and hazards associated with the physical planning process. Strengthening of physical planning and development control will have beneficial cross sectoral impacts with significant effects for example on coastal areas, human settlements, agriculture, health, forestry and water sectors.

Particular challenges are posed to human settlements in coastal areas. The relocation or abandonment of these communities would be problematic in Dominica given the nature of the topography. The cumulative effect of increased flooding, salinization, coastal land loss and infrastructural damage may mean that some resettlement ("*retreat" in IPCC terminology*) may be necessary.

In light of the above, the following initiatives will be taken with respect to the physical planning and development control process:

- Strengthening of these agencies to enable them to adequately carry out forward planning, development control, and monitoring functions necessary for ensuring that development activities do not heighten vulnerability to climate change.

- Greater use of hazard mapping and risk assessment technologies as tools for enabling decision making in physical planning.

- Encouragement of retrofitting in old buildings to facilitate compliance with relevant building guidelines, particularly so as to increase resistance to storm conditions.

- Incorporating parameters of climate change into the development control decision-making process. This would include consideration of temperature increase, flooding, and enhanced storm surge and wave action in coastal areas.

  This will be relevant to situations where new development projects are being considered, as well as to those projects that may be developed to promote adaptation to climate change.

  The South Pacific Regional Environmental Programme (SPREP) has developed a set of guidelines for assisting planners in incorporating climate change considerations into development control and this serves as a useful and practical tool that can assist planners in this new and complex area of environmental concern.

(f) Capacity Building for Climate Change

"Capacity" refers to *the ability of individuals and institutions to make and implement decisions and perform functions in an effective, efficient and sustainable manner (UNDP, 2000).*

Underlying all of the identified areas for priority action is the need to develop the national capacity within Dominica to respond to the challenges presented by changes in weather and climate parameters associated with anthropogenic climate change.

As noted above, there will be a number of critical roles for government as it attempts to respond to the national challenges posed by climate change. This makes it imperative that there be a clearly defined framework for coordinating and guiding the effort. In line with the UNDP definition of capacity, there is the need for adequate level of expertise in terms of individual skills, an appropriate institutional focus for leading action on climate change, and a wider socio-political environment that is supportive of efforts to enable adaptation to climate change.

As such, the first requirement in enabling sustainable adaptation responses is for the identification and empowerment of an agency charged with responsibility for promoting adaptation to global climate change. To a great extent, this mandate already rests with the Environmental Coordination Unit of the Ministry of Agriculture and Environment. The need at this time is to further strengthen the Unit's capabilities as it pertains to climate change. This requires additional training, legal empowerment, and full-time staffing allocations and budgetary resources for climate change.

Given the multi sectoral and cross sectoral nature of the responsibilities it will be necessary for inter-agency networks to be strengthened to allow for coordination and exchange of information among stakeholders. Other enabling elements for the focal point(s) include the strengthening of its role in the development planning and approval processes. It is also important that structured exchanges of information and coordination involving key agencies responsible for natural resource management and climate be institutionalised.

It is important that measures for responding to climate change take place within a wider national framework for sustainable development and of reducing climate and weather associated vulnerability and risks. This is aimed at ensuring that adaptation measures are complimentary to other goals such as poverty reduction and sustainable use of natural resources.

It will therefore be necessary to develop a national climate change strategy aimed at providing the policy framework for infusing climate change concerns into development planning. In this regard international cooperation would be sought for developing a Climate Change Action Plan, an element of which should be establishing the framework for the operation of the focal point (s) and building capacity in priority agencies and sectors. This would also form one of the areas to receive attention during the *Phase 2 Enabling Activities being supported by the Global Environment Facility under the UNFCCC process.*

The need to strengthen technical capabilities at the sectoral level in agencies such as those involved with freshwater and coastal resource management has already been noted. In this regard, a UNDP report on capacity building in Small Island Developing States notes the importance of training in vulnerability assessment and the need to strengthen climate observation systems and networks as among areas requiring priority attention.

This is relevant to Dominica and a training programme will be organized using available climate simulation models (for example MAGICC/SCENGEN or VANDACLIM) targeted at transfer of technology/training to key resource management agencies, as well as to relevant stakeholders in the public sector, NGOs and the business community.

This will be a part of a larger effort to upgrade skills relevant to assessing the impacts of climate change. Related to this is the need to strengthen data collection of climate parameters. Regional and international cooperation would also be pursued with regard to Dominica's participation in climate observation networks such as those spearheaded by the WMO. These would all form elements of the national climate change strategy noted above.

Tab. 5.3 Summary of Selected Adaptation Options for Dominica

COASTAL ZONE
Relocation and retreat of structures and activities
Restrictions on future development
Sea-walls, levees etc
Reinforcing existing structures e.g. docks
Flood plain management plan
Building codes
Mangrove habitat protection and reforestation
Raising coastal bridges and roads
Guidelines and restriction of sand mining

HUMAN SETTLEMENTS
Inland relocation (particularly for future developments)
Upgrading planning legislation (building codes, EIA etc)
Public awareness
Use of traditional knowledge
Development of climate change database
Hazard mapping
Coastal protection measures

FRESHWATER
Reductions in line losses
Accurately reflecting costs of water
Restoration of riverbanks and wetlands
Water conservation
Public awareness
Improved management of forest resources including private forests
Strengthening data collection
Development of a multi-sectoral national water management plan

AGRICULTURE
Introduction of salt tolerant species
Hydroponics
Public awareness
Introduction of heat and drought tolerant crops
Crop research
Use of greenhouses
Protection of forested areas
Farm relocation
Improved pest and disease management
Restoration of degraded lands
Agricultural diversification
Reduced livestock stocking rates

FORESTRY

Development and enforcement of land use policy
Legislation and regulations
Promoting agro-forestry
Preservation of watersheds including compulsory acquisition
Reforestation
Public awareness
Wetlands protection
Urban forestry

FISHERIES

Resource and ecosystem monitoring
Public awareness
Strengthening environmental legislation
New fishing technologies
Efficient processing facilities
Regional and international cooperation
Development of a Fisheries Management Plan incorporating climate change

TOURISM

Relocation of structures
Strengthened development controls
Economic diversification
Hard and soft coastal engineering protection measures
Flood control

HEALTH

Public awareness
Surveillance and monitoring
Infrastructure development
Engineering and technological responses
Medical interventions

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