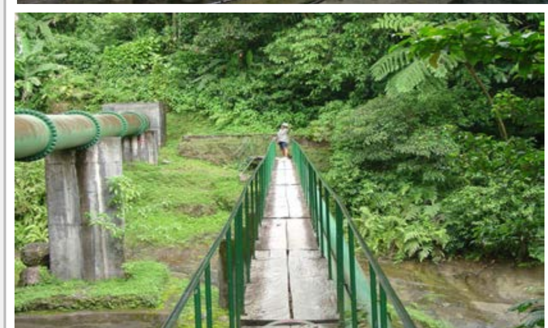
# COMMONWEALTH OF DOMINICA

# SECOND NATIONAL COMMUNICATION ON CLIMATE CHANGE

Under the United Nations Framework Convention on Climate Change

Environmental Coordinating Unit,
Ministry of Environment, natural Resources, Physical Planning and Fisheries



# SECOND NATIONAL COMMUNICATION OF THE COMMONWEALTH OF DOMINICA UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

## 2012

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## I. FOREWORD

The Commonwealth of Dominica ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1994, as a recognition of the importance of climate change as a major environmental phenomenon with serious ramifications for all nations especially resource poor most vulnerable developing countries and Small Island Developing States (SIDS) of which Dominica is a member.

As one of the obligations under Article 12 of the UNFCCC, Dominica committed to the production of regular National Communications to the Conference of the Parties (COP).

This Second National Communication (SNC) on Climate Change is in compliance with Dominica's obligation to the UNFCCC. Chapter 1 sets the National Circumstances, and in particular the aspects of development policies related to the major components of climate change process. Chapter 2 is devoted to Greenhouse Gases Emissions and Inventories, carried out for the period 2000 – 2005, in accordance with the methodology recommended by the Convention Secretariat and the IPCC. Chapter 3 deals with Vulnerability to climate change and its variability. The capacity for mitigating the effects of Greenhouse Gas (GHG) Emissions is presented in Chapter 4. It is followed by chapter 5 in which all other information related to achievement of the Convention objectives is presented.

For the first time, in inclusive account of GHG Emissions Mitigation across various sectors, technologies and scenarios confirms the key role and need for renewable sources, irrespective of any tangible climate change mitigation agreement.

The SNC has successfully provided policymakers and partners over the ensuing period with the most authoritative and objective scientific and technical assessments, which while clearly policy relevant, never claimed to be policy prescriptive. Moreover, the SNC should be considered especially significant at a time when the Government of the Commonwealth of Dominica is pondering the role of the SNC in the context of its respective climate change adaptation and mitigation efforts.

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 and implement appropriate solutions to the global climate change challenges, with the view of integrating climate risk and resilience into core development planning, while complementing other ongoing activities.

It is my greatest pleasure to present this SNC to the Conference of Parties (COP) of the UNFCCC. Such report aims to contribute to achieving transformational changes in integrating consideration of climate change into national development planning consistent with poverty reduction and sustainable development goals.

....................................................
Honourable Dr. Kenneth Darroux

Ministry of Environment, Natural Resources, Physical Planning and Fisheries

## II. ACKNOWLEDGEMENTS

The Ministry of Environment, Natural Resources, Physical Planning & Fisheries wishes to acknowledge individuals, agencies and organizations for their efforts towards the completion of Dominica's Second National Communication on Climate Change (SNC).

Appreciation must go first and foremost to the leadership and staff of the Environmental Coordinating Unit, particularly to Mr. Lloyd Pascal- Director and Mr. Collin Guiste – Climate Change and Second National Communications Project Coordinator.

Appreciation is also extended to the project team:
Dr. Claude Davis, International Consultant, Greenhouse Gas Emissions and Inventory
Mr. Brian Challenger, International Consultant, Vulnerability and Adaptation Assessment
Mr. Albert Bellot, Consultant, SNC compilation
Ms. Allisa Bellot, Consultant, Education Training and Public Awareness
Dr. Michael Taylor, Consultant, Climate Trends and Projections
Mr. Ted Serrant, Consultant, Greenhouse Gas Emissions and Inventory
Ms. Kimisha Thomas, Consultant, Greenhouse Gas Emissions and Inventory
Mr. Nigel Lawrence, Consultant, National Circumstances
Mr. Camille David, Consultant, Vulnerability and Adaptation Assessment
Mr. Minchinton Burton, Consultant, Systematic Research and Observations

Appreciation to the members of the National Climate Change Steering Committee, the Permanent Secretary and Staff of the Ministry of Environment, Natural Resources, Physical Planning and Fisheries, other government agencies and institutions, other stakeholders and the media who participated in the consultations and made valuable contributions towards the development of the SNC.

Thanks to the UNDP/GEF for providing the funding and the guidelines for the project.

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| | |
|---|---|
| ACCC | Adaptation to Climate Change in the Caribbean |
| APF | Adaptation Policy Framework |
| BDD | British Development Division |
| BPoA | Barbados Programme of Action |
| CARIBISS | Caribbean Business Information System |
| CARICOM | Caribbean Common Market |
| CDM | Clean Development Mechanism |
| CEIS | Caribbean Energy Information Studies |
| CER | Certified Emission Reductions |
| $CH_4$ | Methane |
| CMO | Chief Medical Officer |
| CO | Carbon monoxide |
| $CO_2$ | Carbon dioxide |
| CPACC | Caribbean Planning for Adaptation to Climate Change Project |
| CSO | Central Statistical Office |
| COP | Conference of Parties |
| DAC | Dominica Agricultural Census |
| DBMC | Dominica Banana Marketing Corporation |
| DNA | Designated National Authority |
| DOC | Degradable Organic Carbon |
| DOMEX | The DOMinica EXperiment |
| DOMLEC | Dominica Electricity Company |
| DSWMC | Dominica Solid Waste Management Corporation |
| 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 |
| FAD | Fish Aggregation Devices |
| FAO | Food and Agricultural Organization |
| GCM | Global Circulation Models |
| GCOS | Global Climate Observing System |
| GEF | Global Environment Facility |
| GDP | Gross Domestic Product |
| GHG | Greenhouse Gases |
| GNP | Gross National Product |
| GOCD | Government of the Commonwealth of Dominica |
| GWP | Global Warming Potential |
| HFC | Hydrofluorocarbons |
| ICZM | Integrated Coastal Zone management |
| IPCC | Intergovernmental Panel on Climate Change |
| IMF | International Monetary Fund |
| IUCN | International Union for Conservation of Nature |

| | |
|---|---|
| LEAP | Long-Range Energy Alternatives Planning System |
| LPG | Light Petroleum Gas |
| MACCC | Mainstreaming Adaptation to Climate Change in the Caribbean |
| MEA | Multilateral Environmental Agreements |
| MoAFF | Ministry of Agriculture, Fisheries and Forestry |
| MOCW | Ministry of Communication and Works |
| MOFP | Ministry of Finance and Planning |
| NBSAP | National Biodiversity and Action Plan |
| NCSA | National Capacity Self Assessment (NCSA) |
| $NH_3$ | Ammonia |
| NGO | Non Governmental Organization |
| $NO_x$ | Nitrogen Oxides |
| $N_20$ | Nitrous Oxide |
| NMVOC | Non - Methane Volatile Organic Compounds |
| PPD | Physical Planning Department |
| PRECIS | Providing Regional Climates for Impact Studies |
| ODM | Office of Disaster Management |
| OECS | Organization of Eastern Caribbean States |
| OECS/NRMU | Organization of Eastern Caribbean States Natural Resource Management Unit |
| RAF | Resource Allocation Framework |
| RCM | Regional Circulation Models |
| SAR | Second Assessment Report |
| SIDS | Small Island Developing States |
| SLM | Sustainable Land Management Programme |
| SNC | Second National Communication |
| SWDS | Solid Waste Disposal Sites |
| $SO_2$ | Sulphur dioxide |
| SPACC | Special Programme for Adaptation in the Caribbean |
| SPAT | Small Projects Assistance Team |
| SRES | Special report on Emission Scenarios |
| SSMR | Soufriere Scotts Head Marine Reserve |
| TAR | Third Assessment Report |
| UNDP | United Nations Development Programme |
| UNEP | United Nations Environment Programme |
| UNESCO | United Nations Education, Scientific Cultural Organization |
| UNFCCC | United Nations Framework Convention on Climate Change |
| VER | Verifiable Emissions Reductions |
| WMO | World Meteorological Organization |
| WWF | World Wildlife Fund |

# VIII. EXECUTIVE SUMMARY

The Commonwealth of Dominica ratified the UNFCCC in 1994, as recognition of the importance of climate change as a major environmental phenomenon with serious ramifications for all nations especially resource poor developing countries and Small Island Developing States (SIDS) of which Dominica is a member. As one of the obligations under Article 12 of the UNFCC, Dominica committed to the production of regular National Communications to the COP. The first such report, the Initial National Communication was submitted in 2001

This Second National Communication is compliance with Dominica's obligation to the UNFCCC. Chapter 1 sets the National Circumstances, and in particular the aspects of development policies related to the major components of Climate Change process. Although the baseline year for the report is 2000, Chapter 2 is devoted to Greenhouse Gases Inventories, carried out for the period 2000-2005, in accordance with the methodology recommended by the Convention Secretariat and the IPCC. This inventory is complemented by tables providing details on calculations carried out. Chapter 3 deals with Vulnerability to climate change and variability.. The Capacity for mitigating the effects of GHG emissions is presented in Chapter 4; this capacity is related to social and economic development policies of the country. It is followed by chapter V in which all other information related to achievement of the convention objectives is presented. It gives a detailed assessment of Dominica's ongoing efforts and requirements to efficiently implement the Convention.

## 1 NATIONAL CIRCUMSTANCES

### 1.1 Country Profiles

Dominica is an island among the Windward Islands in the eastern Caribbean Sea. It is located between 15º 12' and 15º 39' N Latitude and 61º 14' and 61º 29' W Longitude. It is 48 km long and 24 km wide at its widest point with an area of 75,000 hectares (ha). Dominica is mountainous with flat land that is limited to coastal areas in the northeast, in river valleys and in certain areas in the centre of the island. Sixty-nine percent (69%) of island is forested ranging from dry scrub woodland on the coast to lush, tropical forest in the interior.

Dominica has no known petroleum energy resources but makes use of some of its hydroelectric energy resource. It has extensive geothermal energy potential in addition to solar, wind and biomass resources.

### 1.2 Biodiversity

Notwithstanding its small size, Dominica possesses an extensive range of terrestrial and marine biodiversity. In terms of terrestrial flora, some 155 families, 672 genera and 1226 species of vascular plants have been identified on the island. A number of plant species are considered endemic to the island. Seven (7) distinct vegetation communities are present ranging from montane rainforest to coastal swamp and dry scrub woodland. Fumarole vegetation associated with volcanic activity is also present. In terms of terrestrial fauna Dominica contains the most diverse stock of wildlife species in the eastern Caribbean. This includes some 175 species of birds, 18 species of wild mammal, 15 reptile species, amphibians, and various species of freshwater and estuarine fish and crustaceans.

### 1.3 Protected Areas

Twenty-five percent of Dominica's forest lands are legally protected either as forest reserves or National Parks. Dominica has two (2) declared Government Forest Reserves namely the Central Forest Reserve (410 hectares) established in 1951 and the Northern Forest Reserve (5,475 hectares) established in 1977. These two Forest Reserves in the north-central part of the island cover over 11% of Dominica's land area. Three National Parks have been designated. The Morne Trois Pitons National Park (6,872 hectares) was established in 1975, the Cabrits National Park (5,388 hectares), which includes a marine component, was established in 1986, and the Morne Diablotin National Park (3,335 hectares) was established in 2000. The Morne Trois Pitons National Park was officially declared a UNESCO World Heritage Site in 1998.

### 1.4 Climate

The combination of its size and location results in the climate of Dominica being strongly influenced by features of the north tropical Atlantic. The climate of Dominica is classified as "humid tropical marine"

- ***Rainfall:*** The bulk of the rainfall occurs between June and November, which are the peak months for cyclonic activity. The drier period extends from January to May. Because of the island's elevated and rugged topography, micro-climatic variability can exist over very short distances and is influenced by the high moisture content of the air masses (the northeasterly trade winds) that enter from the Atlantic Ocean and the Caribbean Sea. Average annual rainfall over the island ranges from just above 2,000 mm (79 in) along the west coast to in excess of 7,620 mm (300 in) in the interior. High rainfall makes the island susceptible to landslides particularly in mountainous areas. Dominica's rugged topography results in considerable amount of orographic rainfall
- ***Temperature:*** Dominica has an average temperature of $27^{o}$C ($80^{o}$F). The annual range is small for the mean temperature (~3 degrees), with peak temperature values occurring between July and August. Maximum temperature values may reach as high as $31^{0}$C and peak slightly later in the year, while minimum temperature values may drop to less than 22 $^{O}$C in the mean in January/February. Diurnal ranges are usually no greater than 3°C in most places.
- ***Natural Hazards*** :The primary natural hazards affecting the island are tropical storms and hurricanes and their attendant impacts, which include erosion, landslides and floods. The Commonwealth Vulnerability Index rates Dominica as having the sixth (out of 111 countries evaluated) most vulnerable economy (to external shocks and natural hazards) in the world, and the most vulnerable in the Caribbean. The island is located within the Atlantic hurricane belt. The island is impacted (brushed or hit) approximately once every four years. Over the period 1987 to 1997, Dominica was affected by nine tropical cyclonic systems which ranged in intensity from localized wind blows to intense hurricanes. Tropical systems of note which have impacted Dominica include David (1979), Gert (1981), Gilbert (1988), Hugo (1989), Iris

(1995), Marilyn (1995), Hortense (1996) and Lenny (1999) and Dean (2007). These tropical systems severely impact infrastructure, agriculture, transport and fisheries sectors. Seismic activity in Dominica is frequent. It is estimated that over 90% of the population live within 5 kilometres of seismic activity zones.

## 1.5 Demography

The island was originally populated by Amerindian peoples, known as Caribs and is the only island in the Caribbean still to possess distinct communities of these indigenous people of the Caribbean.

Population estimates for 2001 indicate that Dominica had a population of approximately 71,000[1] persons. This reflects a decline from 74,750 in 1994. Topographic conditions have forced human settlements onto narrow coastal areas particularly in the south and west with approximately 44,000 persons (62%) living along the coast. The largest community is Roseau (the capital city) and its environs with 14,847 persons representing almost 21% of the total population.

## 1.6 Economy

Dominica's economy has traditionally been dominated by agricultural production and export. Dominica's agricultural sector is composed primarily of a large number of small farmers cultivating less than 10 hectares of land and with minimal technological and scientific inputs. By the 1970s, banana production and export, based on a preferential access regime for bananas in the UK, was the principal source of foreign exchange and employment. The collapse of protected markets for the fruit in the latter half of the 1990s has been catastrophic for the industry in Dominica as well as having major adverse impacts on other sectors of the national economy.

Dominica possesses a relatively small but developing tourism sector based on the country's natural attractions - particularly its forests and marine resources. A primary obstacle to the growth of Dominica's tourism industry has been the lack of adequate facilities for direct international air travel from the major tourism markets in Europe and North America. Dominica's manufacturing sector consists primarily of a number of light industries producing for the domestic and regional market.

## 1.7 Energy Use

Electricity constitutes the primary source of commercial energy for industrial and other uses in Dominica. The country presently has an installed capacity of 21 megawatts consisting of 6MW (28.5%) of hydropower and 15MW of diesel powered units. The main end users of electricity are domestic, commercial and institutional customers and the pattern of consumption demonstrates the low energy use of industry and other non-domestic consumption at this time

[1] *It is believed that recent economic difficulties have resulted in fairly extensive migration from Dominica as well as increased seasonal and other movement.*

The other main source of energy use in Dominica is in the road transport sector. As in most other developing countries road transport consumes an increasing amount of petroleum. In the case of Dominica this has economic, environmental and health implications.

### 1.8 Renewable Energy thrust

The Government's objectives for the energy sector among other things highlights minimizing of the cost of energy, diversify energy sources, reduce the reliance on fossil fuels, and conserve energy, while at the same time, reducing emissions of Greenhouse gases. The short-term goal is to have at least 25% of all electricity generated in Dominica from renewable sources by the year 2010, while encouraging and promoting the need for energy efficiency and energy security.

## 2. GREENHOUSE GAS INVENTORY

This report presents the inventory of GHG emissions and sinks for the years 2000 to 2005 inclusive as a component of Dominica's Second National Communication (SNC). The SNC inventory includes that for the year 2000 in accordance with the convention requirements. Unfortunately, sufficiently detailed records of the information used to compile the 1994 GHG inventory for the INC were not available to allow a complete update of the 1994 inventory but the 1994 estimates were compared with those for the later years.

The greenhouse gas (GHG) inventories were compiled using the Intergovernmental Panel on Climate Change (IPCC) guidelines for the Energy, Industrial, Solvent and Other Product Use, Agriculture, Land Use & Forestry and Waste sectors. The gases included in the current inventories are the direct GHGs namely, carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), and partially fluorinated hydrocarbons (HFCs) and the indirect GHGs - non-methane volatile organic compounds (NMVOC), carbon monoxide (CO), sulphur dioxide ($SO_2$) and nitrogen oxides ($NO_x$).

### 2.1. GREENHOUSE GAS INVENTORY RESULTS

Estimates of the GHG inventories for 1994 and 2000 to 2005 are summarized in Table 2-1 (for all GHGs) and Table 2-2 (for $CO_2$ only).

**Table 2-2 Comparisons of GHG Emissions (Gg) for 1994, 2000 to 2005**

| | $CO_2$ | $CO_2$ | $CH_4$ | $N_2O$ | NOx | CO | NMVOC | $SO_2$ | HFCs |
|---|---|---|---|---|---|---|---|---|---|
| | Emissions | Removals | | | | | | | |
| 1994# | 72.8 | 170 | 0.968 | 0.0946 | 0.432 | 4.45 | 2.43 | 0.105 | NA |
| 2000 | 106 | -138 | 1.57 | 0.118 | 0.595 | 6.32 | 1.64 | 0.177 | 0.0046 |
| 2001 | 118 | -137 | 1.57 | 0.108 | 0.676 | 6.86 | 3.85 | 0.213 | 0.0050 |
| 2002 | 113 | -133 | 1.56 | 0.101 | 0.673 | 7.06 | 2.77 | 0.190 | 0.0017 |
| 2003 | 111 | -131 | 1.55 | 0.107 | 0.614 | 6.13 | 2.30 | 0.202 | 0.0019 |
| 2004 | 111 | -130 | 1.56 | 0.076 | 0.577 | 5.75 | 3.22 | 0.186 | 0.0027 |
| 2005 | 119 | -128 | 1.56 | 0.097 | 0.630 | 6.06 | 2.30 | 0.218 | 0.0030 |

# Estimates for 1994 were updated in this report.

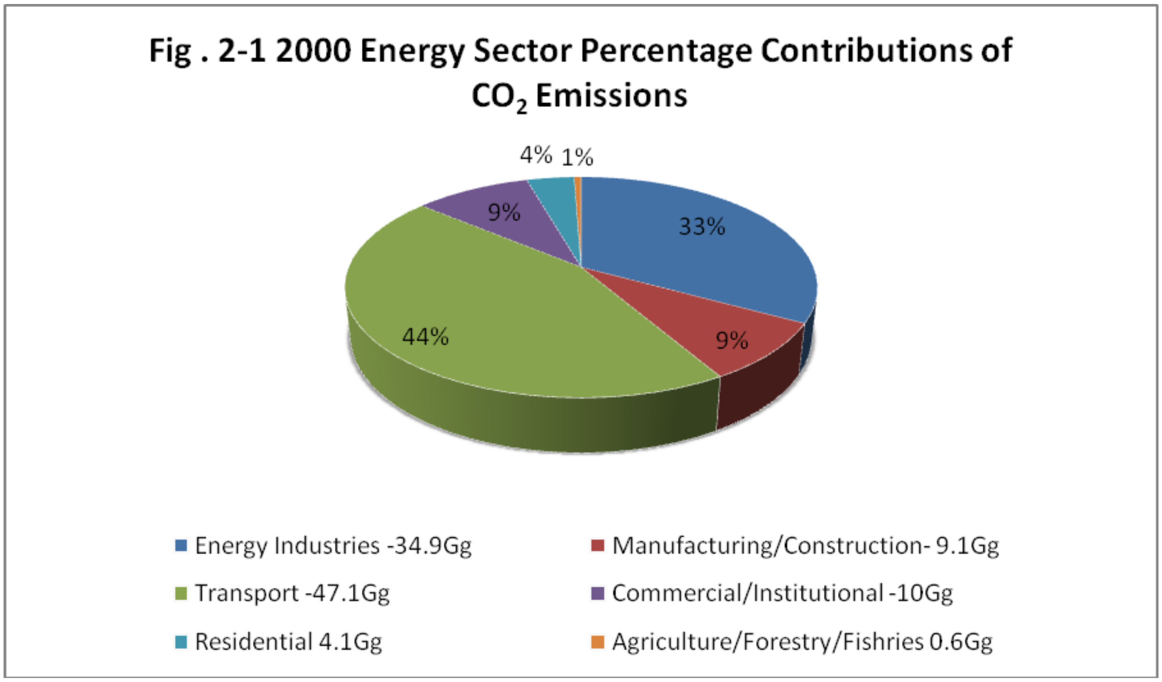
**Table 2-3 Comparisons of $CO_2$ Emissions (Gg) for 1994, 2000 to 2005**

| | 1994# | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|
| **1 Energy** | 72.8 | 106 | 118 | 113 | 111 | 111 | 119 |
| A Fuel Combustion (Sectoral Approach) | 0.0 | 106 | 118 | 113 | 111 | 111 | 119 |
| 1 Energy Industries | 20.2 | 34.9 | 40.3 | 33.1 | 36.1 | 34.1 | 41.8 |
| 2 Manufacturing Industries & construction | 4.10 | 9.10 | 10.1 | 10.5 | 13.2 | 11.6 | 11.0 |
| 3 Transport | 37.7 | 47.1 | 53.7 | 55.4 | 46.8 | 42.9 | 46.8 |
| 4 Other Sectors | 10.8 | 14.7 | 13.8 | 14.3 | 15.0 | 22.3 | 19.5 |
| a Commercial/Institutional | 7.33 | 10.0 | 9.43 | 9.91 | 10.7 | 18.4 | 15.4 |
| b Residential | 3.41 | 4.07 | 3.67 | 3.59 | 3.42 | 3.08 | 3.29 |
| c Agriculture/Forestry/Fishing | 0.100 | 0.631 | 0.721 | 0.766 | 0.856 | 0.811 | 0.766 |
| **5 Land-Use Change & Forestry (2)** | | | | | | | |
| A Changes in Forest & Other Woody Biomass Stocks (Removals) | -355 | -198 | -198 | -193 | -192 | -190 | -188 |
| B Forest and Grassland Conversion | 26.5 | 60.4 | 60.4 | 60.4 | 60.4 | 60.4 | 60.4 |
| C Abandonment of Managed Lands## | -43.7 | 0 | 0 | 0 | 0 | 0 | 0 |
| D $CO_2$ Emissions & Removals from soil## | 0.37 | 0 | 0 | 0 | 0 | 0 | 0 |

# Updated estimates from this study. ## No data available for 2000 to 2005 but assumed data for 1995 presented in the INC

The percentage contributions of $CO_2$ emissions by subsectors within the energy sector for the base year 2000 utilizing the Sectoral Approach is presented in Figure 2-1. The Energy Industries (33%) and Transportation (44%) subsectors are the main contributors accounting for 77% of total emissions from the sector. The contributions are similar in the other years assessed and account for between 70% and 80% of the $CO_2$ emissions while the Manufacturing Industries & Construction and Other (residential, commercial and forestry and fishing subsectors) respectively account for the remainder There is no consistent trend in the total emissions or in the subsector emissions over the period 2000 to 2005.

The transport sector has the largest $CO_2$ emissions (43 to 54 Gg) and accounts for 39 to 49% of the emissions between 2000 and 2005.




## 2.3 . UNCERTAINTIES

Uncertainties in the inventory arise from both emission factors and the activity data. Since default emission factors were used their uncertainties are those recommended in Table A1-1 of the IPCC Reference Manual Volume 1.

Uncertainties in the activity data were due mainly to the unavailability of some data either because records were not maintained or not compiled at all. In such cases best estimates were made or estimates were based on surrogate data.

## 2.4 CONCLUSIONS

Two methods are used to calculate the $CO_2$ emissions for the energy sector. These are the Reference Approach and the Sector Approach. The percentage contributions of $CO_2$ emissions by subsectors within the energy sector for the base year 2000 utilizing the Sectoral Approach shows that the Energy Industries (33%) and Transportation (44%) subsectors are the main contributors accounting for 77% of total emissions from the sector. The contributions are similar in the other years assessed and account for between 70% and 80% of the $CO_2$ emissions while the Manufacturing Industries & Construction and Other (residential, commercial and forestry and fishing subsectors) respectively account for the remainder . The transport sector has the largest $CO_2$ emissions (43 to 54 Gg) and accounts for 39 to 49% of the emissions between 2000 and 2005.

Non- $CO_2$ ( $N_2O$, $SO_2$ and HFC) emissions for the period are relatively small (less than 0.2 Gg) while the average annual $CH_4$, NOx, CO and NMVOC emissions were respectively 1.56 Gg, 0.63 Gg, 6.37 Gg and 2.68 Gg.

The use of Solvents and Other Products use can result in emissions of NMVOCs. Estimates of the emissions are based the amounts of products used and the percentage of NMVOC or $N_2O$ that evaporates during use. During the period 2000-2005 NMVOC emissions ranged between 0.284 – 0-275 Gg. This was mainly attributed to emissions from personal care products.

As per the Agricultural Sector, there were no $CO_2$ emissions. Total annual $CH_4$ emissions for the period 2000-2005 (0.748 Gg) showed an increase over the year 1994 (0.226Gg). This is primarily a result of a larger number of cattle and an accompanied increase in enteric emissions which accounted for over 90% of total $CH_4$ emissions from the agricultural sector.

An average of 0.75 Gg of methane was emitted due to enteric fermentation while 0.03 Gg emitted as a result of animal manure management. Nitrous oxide emissions from manure management and agricultural soils ranged from 0.06 to 0.10 Gg annually.

Despite the progressive decline in $CO_2$ removals during the period 2000-2005 (-138Gg to -128Gg), Dominica's Land Use Change and Forest Sector represents a net sink of $CO_2$. The releases (emissions) due to conversion from forested areas to settlements remained constant over the period, but this is far outweighed by the sink changes due to woody biomass stocks (removals).

Emissions from the Waste Sector arise from the treatment and disposal of municipal or industrial solid waste and from the treatment and disposal wastewater from domestic and industrial sources. $CH_4$ emissions from the sector for the period 2000-2005 ranged from 0.679 to 0.673 Gg. Total $NO_2$ emissions for the same period remained constant at 0.015 Gg and was only due to waste handling

The data show that $CO_2$ emissions from mobile combustion sources (i.e., on road transportation) followed by energy industries (electricity generation) in the energy sector are the two largest overall contributors to $CO_2$e emissions. The next largest source is direct and indirect $N_2O$ emissions in the agricultural sector. Dominica is a net sink for $CO_2$ amounting to a net removals of 31.60 Gg of $CO_2$. Similar results are obtained for the years 2001-2005.

The GHG inventory data for the years 2000 to 2005 have large uncertainties. Uncertainties in the activity data were due mainly to the unavailability of some data either because records were not maintained or not compiled at all. In such cases best estimates were made or estimates were based on surrogate data. The total uncertainty in the $CO_2$ equivalent emissions in 2000 was 82%. Similar uncertainties were assumed to apply for the other years.

An assessment carried out for the preparation of the INC Phase II Report indicated a number of shortcomings with the various Ministries/ Institutions responsible for collecting/processing specific sectoral data required for calculating GHG Inventories. There is a need for developing the capacity of these Ministries/Institutions to adequately carry out their function and to make the preparation of the GHG Inventory a continuous process. While the various Ministries/institutions should be responsible for the collection and processing of specific sectoral data, the ECU should be responsible for the coordination of annual GHG Inventory. In this regard there is an urgent need for developing the capacity of the staff at the ECU to coordinate this process.

# 3 VULNERABILITY AND ADAPTATION ASSESSMENT

Vulnerability is defined by the IPCC as the combination of sensitivity to climatic variations, the probability of adverse climate change, and adaptive capacity. Generally it refers to a system's is is susceptible to, unable to cope with the adverse effects of climate change. .The IPCC defines adaptation to climate change as "adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities". Closely aligned to this is the concept of adaptive capacity, which the IPCC refers to as "the ability of a system (ecological and/or socio-economic systems) to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences".

## 3.1 METHODOLOGY

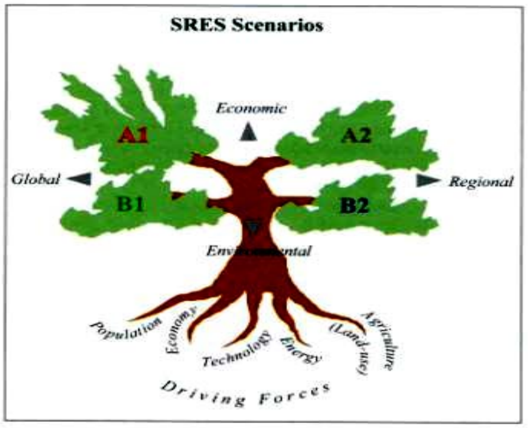
Various methodological approaches exist for assessing climate change impacts and adaptation requirements and range from highly sophisticated climatological modeling to information based on local expert opinion[1]. Most of the approaches are generally based on variants of the IPCC Basic Methodology which utilizes a seven step approach[1].
For this report the assessment will utilize a modified version of the Adaptation Policy Framework (APF), developed by the United Nations Development Programme (UNDP) as a tool for climate change impact and adaptation assessment.

## 3. 2 CLIMATE SCENARIOS TRENDS AND PROJECTIONS

Global Circulation Models (GCMs) are useful tools for providing future climate information. GCMs are mathematical representations of the physical and dynamical processes in the atmosphere, ocean, cryosphere and land surfaces. Their physical consistency and skill at representing current and past climates make them useful for simulating future climates under differing scenarios of increasing greenhouse gas concentrations

### 3.2.1 Scenarios

The GCMs, RCM, and statistical downscaling model are run using the Special Report Emission Scenarios (SRES) (Nakicenovic et al., 2000).[1] Each SRES scenario is a plausible storyline of how a future world will look. That is, the scenarios explore pathways of future greenhouse gas emissions, derived from self-consistent sets of assumptions about energy use, population growth, economic development, and other factors. They however explicitly exclude any global policy to reduce emissions to avoid climate change. Scenarios are grouped into families according to the similarities in their storylines as shown in **Figure 3.1.**




- A1 storyline and scenario family: a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and rapid introduction of new and more efficient technologies.
- A2 storyline and scenario family: a very heterogeneous world with continuously increasing global population and regionally oriented economic growth that is more fragmented and slower than in other storylines.
- B1 storyline and scenario family: a convergent world with the same global population as in the A1 storyline but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies.
- B2 storyline and scenario family: a world in which the emphasis is on local solutions to economic, social, and environmental sustainability, with continuously increasing population (lower than A2) and intermediate economic development.

**Figure 3.1**Special Report on Emission Scenarios (SRES) schematic and storyline summary (Nakicenovic et al., 2000).

## 3.2.2 Climate

### 3.2.2.1 Temperature

Irrespective of scenario, model or methodology used, there is a projected annual mean temperature increase for Dominica. Figure 3.3 gives the range of increase projected for each time slice above as gleaned from the GCMs and RCM.

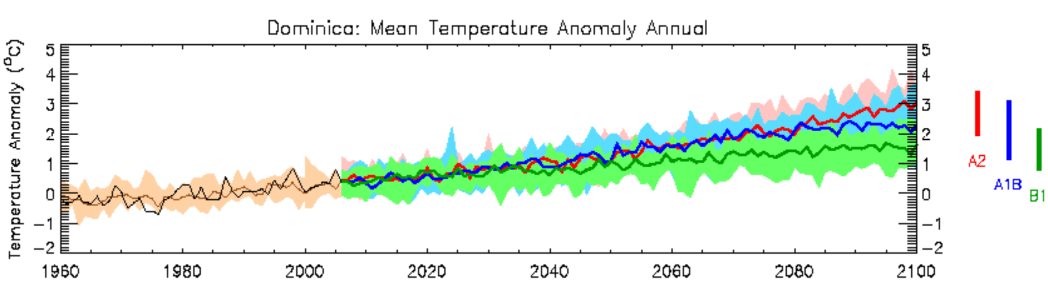
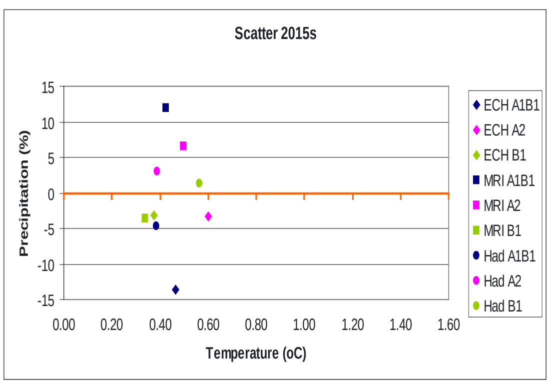


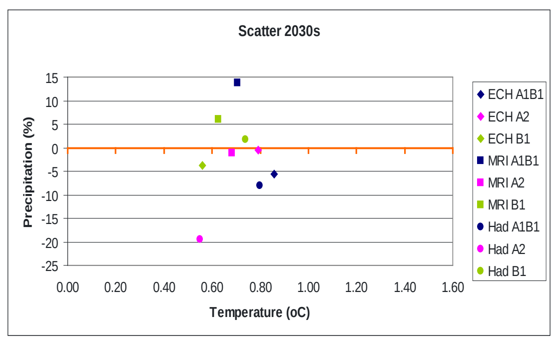

**Figure 3-3** Annual mean temperature anomaly 1960-1990. Units are $^{O}$C. Black line: Average of observational datasets for current climate. Brown line and brown shading: Ensemble median and range for model projections of recent climate. Coloured lines and shading: Ensemble median and range of projections under 3 emissions scenarios. Bars at the far right demonstrate the change by 2080-2100 under each emissions scenario. All values are given as an anomaly from 1971-2000 mean climate. ( Taylor et al 2009)

The GCMs suggest that the mean annual increase in temperature will be between 0.4°C and 0.5°C by the 2015s, 0.6°C - 0.8°C by the 2030s, 0.9°C - 1.3°C by the 2050's and between 1.5°C (B1 scenario) and 3°C (A2 scenario) by the end of the century (2100) . The RCM shows a similar rate of increase with an annual temperature change of 1.8–2.3°C by the 2090s. These projections are consistent with IPCC projections for the Caribbean which show annual mean temperatures increasing by 1.4°C to 3.2°C, with a median increase of 2.0°C by 2100. The increases are however slightly less than the anticipated global average warming.

### 3.2.2.2 Rainfall

There are fewer consensuses in the projected rainfall for Dominica than for temperature. Figure 3.4 shows the annual percentage change for three GCMs running a variety of scenarios. There is a clear tendency toward drier in the annual mean, with greater consensus toward the end of the century. For the 2015s, the models project changes ranging from -15% to +13% (dependent on scenario and model), with 5 of 9 model runs indicating a decrease in the annual mean rainfall  For the 2030's the range is from -20% to +15% and 6 of 9 runs indicate a drier Dominica. By the 2050's the range is -21% to +10% and 7 of 9 runs indicate drier conditions than the present. The RCM captures the same drying trend but is more drastic. It projects the annual rainfall to be 30%-50% less than present day amounts by the end of the century. This is consistent with the IPCC projections of a drier Caribbean by the century's end.



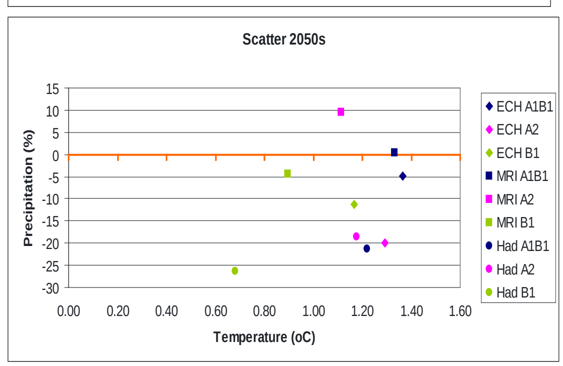




**Figure 3.4** Scatter plot of projected change in mean annual rainfall and temperature for 3 GCMs (Had, MRI and ECH) run under A2, B1 and A1B SRES scenarios. Each marker indicates the change produced for a model run under a different scenario. Diagrams are for the 2015s, 2030s and the 2050s. Markers below the orange line indicate a projection of drier conditions. (Taylor et al 2009)

### 3.2.2.3 Seasonality

In general the seasonality of Dominica (Fig.3-5) remains the same in the future i.e. the pattern of cooler dry winter-hot wet late summers will still prevail, though monthly temperatures will be on average 2 degrees higher by the 2050's (as indicated by the rightward shift of the polygons). Other discernible changes in the polygon shape are accounted for by the aforementioned drying tendency as the century progress, which is captured by the polygon progressively becoming shorter.

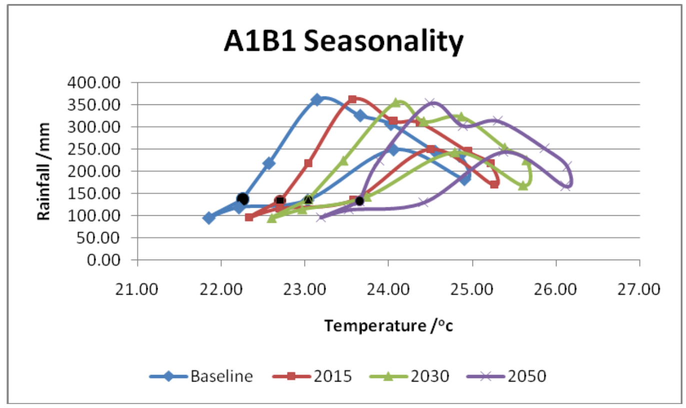



**Figure 3.5** Seasonality diagrams for Dominica. Polygons show the variation in mean rainfall and temperature for a given year. Plots are for current climate (baseline), and the 2015's, 2030's and 2050's, under the A1B1 scenario. The black dot indicates January. Each year follows counter clockwise. (Taylor et al 2009)

### 3.2.2.4 Hurricanes

Since the models examined do not explicitly model hurricanes, it is the IPCC's projections which are relied on. Based on a range of models, the IPCC suggests that future hurricanes of the north tropical Atlantic will *likely*[2] become more intense, with larger peak wind speeds and heavier near storm precipitation.

There is however less confidence in model projections of (i) a *decrease* in the *number* of relatively *weak* tropical cyclones, (ii) *increased numbers* of *intense* tropical cyclones, and (iii) a global *decrease* in the *numbers* of tropical cyclones. Some modelling studies attribute any possible global decrease in the number of cyclones to increased stability of the tropical troposphere (due to differential warming in the vertical in a warmer climate) which compensates for the impact of the warmer ocean temperatures.

### 3.2.2.5 Sea Level Rise

Ocean expansion (due to warming) and the inflow of water from melting land ice have raised the global sea level over the last decade. Large deviations among the limited set of models addressing the issue, however, make future estimates of sea level change uncertain, including for the Caribbean.

[2] In the IPCC Summary for Policymakers, the following terms have been used to indicate the assessed likelihood, using expert judgement, of an outcome or a result: *Virtually certain* > 99% probability of occurrence, *Extremely likely* > 95%, *Very likely* > 90%, *Likely* > 66%, *More likely than not* > 50%, *Unlikely* < 33%, *Very unlikely* < 10%, *Extremely unlikely* < 5%.

As with hurricanes, it is the IPCC's projections which are relied on. Whereas it is not presently possible to project sea level rise for Dominica, changes in the Caribbean are projected to be near the global mean. Under the A1B scenario, sea level rise within the Caribbean is projected to be between 0.17 m and 0.24 m by 2050 (IPCC 2007). For comparison, global sea level rise is projected to average 0.35 m (0.21 to 0.48 m) under the same scenario by the end of the century (relative to the period 1980-1999). It is important to note, however, that changes in ocean density and circulation will ensure that the distribution of sea level rise will not be uniform across the region.

#### 3.2.2.6 Climate Summary

In summary the following is noted about the climate of Dominica:

- There is evidence to suggest that the climate of Dominica is changing. Both maximum and minimum temperatures have increased in the recent past.
- The warming trend is expected to continue. The country is projected to be warmer by up to 1.3$^{o}$C by the 2050s, and between 2 and 3 degrees by the end of the century.
- Winter months will see marginally larger increases in temperature than summer months.
- The frequency of very hot days and nights will increase, while the number of very cool days and nights will decrease.
- The country is likely to be drier in the mean. Projections are for up to 20% drier by mid century when models show more consensuses about the trend, and up to 50% drier by 2100.
- July-August will likely be drier.
- The seasonality of Dominica will be largely unchanged. The cooler (with respect to late season temperatures) dry early months and wet hotter late months will still prevail.
- Hurricane intensity is likely to increase (as indicated by stronger peak winds and more rainfall) but not necessarily hurricane frequency.
- Caribbean sea levels are projected to rise by up to 0.24 m by mid century.
- Sea surface temperatures in the Caribbean are projected to warm, up to approximately 2$^{o}$C by the end of the century.
- ENSO's impact on Dominican rainfall (early and late season) will likely continue, given projections of the phenomenon's continued occurrence in the future.

## 3.3 ASSESMENT OF SECTORAL IMPACTS OF CLIMATE CHANGE IN DOMINICA

This section covers the assessments of impacts of climate change on various sectors in Dominica as well as identifying adaptation options.. These sectors include Forest, Fresh Water Resources, Agriculture, Human Settlements, Coastal Zones and Fisheries. The sectoral chapters utilize the same basic structure consisting of:

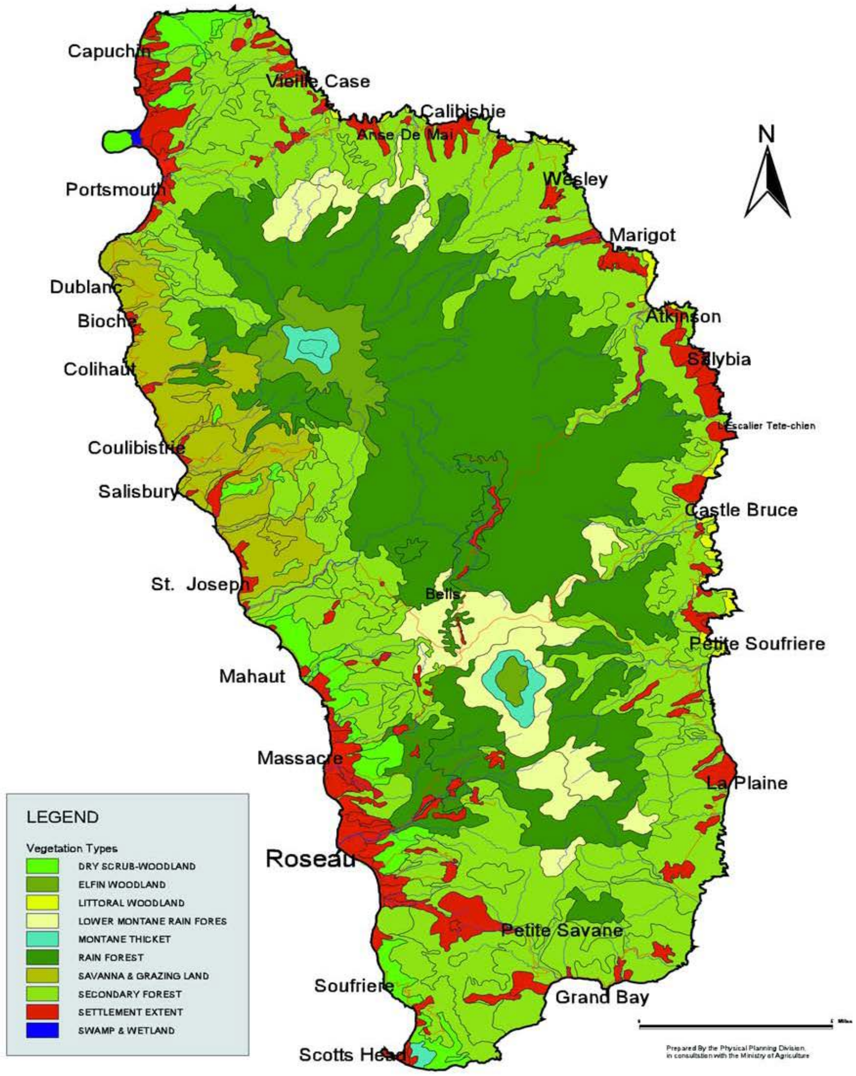
- An overview of the sector – including climatic conditions, geography, historical development, major issues facing the sector at present.
- Current stresses and trends. Identification of local factors affecting vulnerability to existing climate.
- Current adaptive capacity and strategies
- Socio-economic scenarios.
- Future scenarios of climate change. Potential/likely impacts on the sector.
- An identification of Adaptation strategies and measures.

### 3.3.1 FOREST VULNERABILITY AND ADAPTATION TO CLIMATE CHANGE

#### 3.3.1.1 Overview

Dominica's topographical diversity has produced a rich array of flora and fauna with extensive rainforests, a multitude of rivers and stream and cascading waterfalls all of which contribute to Dominica's reputation as "The Nature Island of the Caribbean". Forests dominate the island's landscape and they have been a key geographic determinant in shaping the island's history and development. Sixty six percent (66%) of the land area (51,752 ha) was estimated to be covered by vegetative cover of various types (Initial National Communication, 2001).

**Figure 3.2 Generalized vegetation map of Dominica**




Source: Commonwealth of Dominica Biodiversity and Action Plan 2001-2005

#### 3.3.1.2.1. Climate Change Impacts

##### 3.3.1.2.1.1 Increased Temperatures

Projected increases in temperature will take place against a background of overall drying trends. Some of the possible impacts of temperature change on Dominica's forests and terrestrial ecosystems are likely to be:

- Alterations in the species diversity of many forested ecosystems.. Examples of this already exist with the gradual shift into higher elevations of invasive drought tolerant lemon grass species.

- Reduction in flow volumes of streams and river due to longer drier period. This is already a seasonal phenomenon in Dominica in the dry season and will likely be exacerbated by higher seasonal temperatures and increasing drought conditions.

- Increase in the incidence of higher pests and diseases occurrences associated with changing temperate and rainfall patterns could affect many wild species.

- Higher pest related problems, droughts, variable rainfall as well as more frequent hurricanes and storms, could lower recovery periods of disturbed ecosystems and food availability for wildlife[1].

##### 3.3.1.2.1.2 Hurricanes and Tropical Storms

Climate change impacts from projected changes in storm intensity, and possibly frequency, are likely to have very significant implications for Dominica's forests. Hurricanes and tropical storms adversely impact forests through wind and water damage. Damage may include defoliation, breaking of stems, breaking of branches and crowns, and uprooting and toppling of trees. In the longer term as trees recover, changes occur in species dominance and composition

### 3.3.1.3 Recommendations for Adaptation

The significance of Dominica's forest resources has resulted in the identification of a wide range of recommendations for strengthening management of these resources. These recommendations have been most comprehensively brought together in the Policy on Planning for Adaptation to Climate Change prepared by the Government of Dominica under the regional Caribbean Planning for Adaptation to Climate Change (CPACC) project

## 3.3.2. FRESHWATER RESOURCES VULNERABILITY AND ADAPTATION TO CLIMATE CHANGE

### 3.3.2.1. Overview

Dominica is one of the wettest islands of the Eastern Caribbean due to high rainfall in the interior (up to 7600mm) arising from the influence of its topographical nature and the North East Trade Winds. The eastern Atlantic coast receives an annual average rainfall averaging 4445mm. 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 1250mm (Canefield Meteorological Office, 2007)

Rivers are the main source of potable water in Dominica. The main uses of water in Dominica are domestic supply, hydropower, and export. The abundance of surface water has minimized the need to explore for groundwater and hydrological studies have indicated only limited aquifers with low yields. Generally available water resources are adequate to supply domestic requirements except during extended drought periods. DOWASCO provides services to an estimated 90% of the population with 16,000 connected customers in 2003.

### 3.3.2.2. General Impacts of Climate Change on Freshwater Resources

The impacts of climate change will not occur in isolation but will represent a combination of environmental impacts. Within Dominica the general impacts are likely to include:

- Changes in temporal and spatial distribution due to increased climate variability. Total annual rainfall between the east and west coast may vary with more serious water shortages on the drier west coast.
- Contamination of ground water and surface flows due to increased soil erosion and nutrient losses arising from the greater frequency of extreme rainfall events in various localities across the island. This will in turn increase water treatment costs which are likely passed on unto consumers. There is also likely to be an increased incidence of water borne diseases.
- Salinisation of groundwater recharge near the coast due to salt water intrusion and marine inundation.
- Increased hurricanes, storms and extreme rainfall events are likely to damage water distribution lines as a result of mudslides. This may have implications for water availability.
- Changes to surface hydrology due to drought related conditions will affect both humans and aquatic organisms.

#### 3.3.2.3. Adaptation Measures

The following overarching policy measures will be required:

- Promotion and strengthening of collaboration between local communities, DOWASCO, Ministry of Health, Ministry of Agriculture, Forestry and the Environment and other stakeholders to develop sound and workable management strategies to protect the island's water resources.
- Development of a long term national water management plan that incorporates climate change concerns.
- Reforestation and other watershed management practices to increase the ability of watersheds and catchments to maximize water availability, as well as to reduce soil erosion and sedimentation including water conservation and restoration of degraded river banks, wetlands and water catchment sites.

## 3.3.3 AGRICULTURE SECTOR VULNERABILITY AND ADAPTATION TO CLIMATE CHANGE

### 3.3.3.1 Overview

Seventy percent (70%) of Dominica's land resource has been classified as unsuitable for agriculture due to the topography, the erosive nature of the soil, high erosion risk from water saturation, or the stony nature of the land itself.

In Dominica, agriculture is mainly rain fed. Precipitation and water availability influences the type of crops, farming technologies, and the season for cultivating crops. Given Dominica's topographic and climatic conditions as well as the country's principal agricultural products where precipitation is extreme there is also potential for soil loss. Conversely, drought conditions seriously affect crop development and yields.

### 3.3.3.2 Summary of Impacts of Climate Change on Dominicas Agricultural Sector

The assessment looks at five major components of projected changes in climate: warmer temperatures, intensified tropical storm activity, greater rainfall variability, sea-level rise, and increased $CO_2$ atmospheric concentrations

Agriculture in Dominica remains vulnerable to a number of existing climatic conditions: many of these are likely to worsen with a changing climate. Projections for more intensified storm conditions, rainfall variability and higher temperatures are likely to present significant challenges for the sector. Historically, hurricanes, floods and other natural disasters have crippled agricultural production many times in the past requiring recovery periods to regain productivity. Adverse impacts from climate change can be expected to exacerbate soil loss, damage farm infrastructure and cause ecological disturbances which are crucial to sustaining agriculture development

A changing climate can be expected to have significant impacts on conditions affecting agriculture, including temperature and, precipitation. These conditions determine the carrying capacity of terrestrial ecosystems to produce food for the human population and domesticated animals.

#### 3.3.3.3 Adaptation Measures

Two main types of adaptation can be identified i.e. autonomous adaptation and planned adaptation. Within the agricultural sector autonomous adaptation would involve for example farm level changes to precipitation patterns by changing crops or choosing different varieties or technologies. Planned adaptation measures involve conscious policy options or response measures aimed at altering the adaptive capacity of the agricultural system

### 3.3.4 HUMAN SETTLEMENTS VULNERABILITY AND ADAPTATION TO CLIMATE CHANGE

#### 3.3.4.1. Overview

Dominica's human settlements have been influenced by the country's rugged topography which has forced human settlements into the narrow coastal areas and along river valleys. Dominica's mountainous terrain means that 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 at risk to soil loss and land slippage and are generally more vulnerable to the ravages of extreme events such as hurricanes and to coastal processes

#### 3.3.4.2. Climate Change Impacts

In the case of climate scenarios these are based primarily on the results of the PRECIS model. Projected changes in climate affecting Dominica as a result of global climate change can be expected to have significant impacts on human settlements

Vulnerability of human settlements in Dominica to existing weather and climate can be viewed in terms of risks from coastal processes, inland flooding, and landslides. A consistent feature of human settlements in Dominica is the vulnerability of roads and buildings to storm surge flooding. Inadequate planning controls are apparent in the continuing construction of buildings and other facilities in active wave inundation areas

#### 3.3.4.3Adaptation Frameworks for Risk Reduction in Human Settlements

For human settlements, adaptation to climate change refers to efforts aimed at minimizing adverse impacts of climate change and if possible to exploit any beneficial side effects of a changing climate. Generally speaking, in many ways man-made systems are likely to be better able to adapt to changes in climate than are natural systems. Climate change considerations will require that Dominica seek to strengthen existing approaches as well as devise new ones to meet the new challenges likely to arise from the type of impacts identified above. Both hard technologies such as infrastructure and soft technologies such as regulation and awareness are likely to be required.

### 3.3.5 COASTAL ZONE CLIMATE CHANGE VULNERABILITY AND ADAPTATION

#### 3.3.5.1. Overview

The coastal zone – that area where the marine and terrestrial environments are in direct contact – is of great significance to an island State such as Dominica. Dominica has 153 km (95 miles) of irregular coastline adjoining a 715 sq .km coastal shelf. The west coast of the island is bordered by the Caribbean Sea, with the Atlantic Ocean on the east. Dominica's narrow coastal plain extends from the coastline to form a narrow continental shelf that measures less than 1 km in width except in the area of Marigot on the east coast where it increases to approximately 5 km.

#### 3.3.5.2 Existing Vulnerabilities

Dominica's coastal ecosystems are among the most productive and diverse habitat on the island. The communication infrastructure is concentrated within the coastal zone together with its major urban centers, key institutions, and commercial activities. Its naturally deep coastal waters support its vital water borne commerce including cruise ship and cargo vessel trade.

Population and development trends in Dominica indicate a continued coastal orientation in human settlement. Policy regulating coastal development is largely sectoral and in some cases nonexistent. There is no national development plan for Dominica. Consequently development along the coast has been haphazard and unregulated.

#### 3.3.5.3 Climate Change Impacts

All of Dominica's important coastal resources will be severely impacted from climate change. Natural stress factors, disasters, storm surges and the anticipated rise in sea level and increased variability in temperature are likely to exacerbate the problem and increase the stress on these coastal environments and ultimately diminish their natural resilience.

#### 3.3.5.4 Adaptation Measures

While adaptation to climate related stresses in the coastal zone has taken place over the years, the continuing damage sustained by natural features such as coral reefs and beaches, as well as the high levels of vulnerability experienced by human settlements and infrastructure in coastal areas, indicates that considerable weaknesses continue to exist
Adaptation measures possible are wide ranging and span a variety of hard and soft technologies. Underlying all of these measures is the need to enhance resilience of the natural systems as a first line of defense against climate change effects. Additionally important is the need to implement sound planning for coastal areas.

Ultimately, the sustainable development of the coastal zone will be a critical component of Dominica's efforts to respond to the immense challenges presented by global climate change.

## 3.3.6 FISHERIES VULNERABILITY AND ADAPTATION TO CLIMATE CHANGE

### 3.3.6.1 Overview

Historically Dominica's topographical features have been a constraining factor to its physical development concentrating human settlements primarily into coastal areas. However the resultant strong community coastal interface which exists has helped to sustain a small fisheries sector for many years. The responsibility for the management of fisheries and their habitats falls within the domain of several ministries. However the principal agency charged with the responsibility for the management of fisheries and marine resources is the Fisheries Division

### 3.3.6.2. Impacts of Climate Change

At least five elements of a changing climate may be expected to impact on Dominica's fisheries. These are:

- Increased sea temperatures
- Intensified hurricane activity
- Changes in oceanic circulation
- Acidification of the oceans
- Sea-level rise.

Dominica's fisheries are likely to display a number of vulnerabilities to some of the projected effects of climate change. Nearshore fisheries, already stressed by pollution and over-fishing, will be impacted in a number of areas by warmer seas, intensified hurricane activity and other impacts. At the same time Dominica's migratory and pelagic fisheries, also at risk globally from over fishing and other anthropogenic impacts, will also be affected by shifts in currents, impacts on food supply, warmer oceans and other direct and indirect impacts from a changing climate.

These changes will present challenges for fisheries stakeholders – fishermen and women, resource managers, and consumers – as they seek out ways of promoting he sustainability and viability of the resource in the context of a rapidly changing global climate.

### 3.3.6.3 Recommendations for Adaptation and Risk Reduction

Efforts for risk reduction and adaptation of the fisheries sector to respond to adverse effects are complicated by the fact that the primary habitat for Dominica's fisheries resources – the ocean – is a global common property resource and therefore effectively outside of the management capability of Dominica's fisheries stakeholders. At the same time it is clear that a number of anthropogenic impacts are already adversely affecting the sustainability of Dominica's fisheries. These impacts threaten many of Dominica's fishery resources and can be expected to intensify many of the impacts of climate change.
A further complicating factor in devising adaptation or risk reduction measures for fisheries is the level of uncertainty that exists as to the dynamics of the fisheries, the specifics of the impacts likely from climate change, and the effects of a changing climate on the fishery resource

## 3.4 CONCLUSION

### 3.4.1. Adaptation and Risk Reduction

A review of the potential impacts of climate change reveals that a number of Dominica's existing vulnerabilities to current climatic conditions are likely to be exacerbated by many of the projected changes in regional and global climate. Across all sectors, a number of adverse impacts are likely to be felt, influenced by such critical climatic parameters as temperature, rainfall, and extreme events.

Dominica's history, its economic structures, patterns of human settlement, and other aspects of its socio-economic development have been profoundly influenced by the country's mountainous topography. In particular the country's rugged terrain has resulted in population centres and economic activity being located in coastal communities. Agricultural and other encroachment into forested interior lands tends to result in soil erosion, land slippages and other disturbances to the country's rich forest resources. Other human impacts including solid and liquid waste disposal, quarrying, and fisheries directly and indirectly affect the country's fragile marine ecosystem resulting in degradation of habitats and loss of species diversity.

### 3.4.2Priorities for Adaptation and Risk Reduction

In many cases autonomous adaptations will take place requiring very little intervention by governments. However there are also likely to be many instances where autonomous action will not occur.. Against this background, governments will have a critical role in:

1. Providing information to decision makers at all levels.
2. Providing technical and financial resources for adaptation and risk reduction efforts.
3. Ensuring that adaptation and risk reduction policies and measure are consistent with wider social, economic and environmental goals, and
4. Actions to protect government investments in infrastructure, buildings etc.

### 3.4.3 Incorporating Risk Reduction and Adaptation into Development

The pervasive nature of the likely impacts of climate change means that the optimal adaptation approaches are likely to be those that are anticipatory and facilitate inclusion of adaptation. In this regard three strategies can be identified to enable integration of climate change adaptation concerns into development activities;

- Incorporating climate change concerns into new development proposals;
- Developing proposals that are specifically aimed at climate change risk reduction and adaptation.
- Developing proposals for strengthening institutional and technical capacity for climate change response.

Incorporating climate change considerations into development activity is critical for a number of important reasons. Firstly, there will be continuing pressure for development activity. An important consideration is to recognize the urgency for immediate action.

Climate change is not a future scenario but a current event with almost daily scientific reassessments of the immediacy of the risks presented. Adaptation policies and measure must therefore be viewed as a priority and therefore integrated into decision-making at virtually all levels.

# 4 GREENHOUSE GAS MITIGATION ASSESSMENT

## 4.1 INTRODUCTION

This chapter provides the greenhouse gas mitigation assessment for Dominica by presenting a national-level analysis of the impacts of various technologies and practices that affect greenhouse gas emissions. The assessment provides policy makers with an evaluation of those technologies and practices that can a) affect GHG emissions, b) identify policies and programs that could enhance their adoption, and c) contribute to national development objectives.

The scope of this assessment covers projections of GHGs for the period 2009 to 2030 and uses historical data for the period 2000 (the base year) to 2008 in order to calibrate where feasible, the bases for the projections. Three scenarios are developed to project emissions – a Reference Scenario and two other scenarios (Scenario 2 and Scenario 3) characterized primarily by increasingly aggressive mitigation measures. The Reference Scenario only includes activities and projects that are currently under way and does not include any additional GHG mitigation.

## 4.2 GHG EMISSIONS AND MITIGATION OPPORTUNITIES

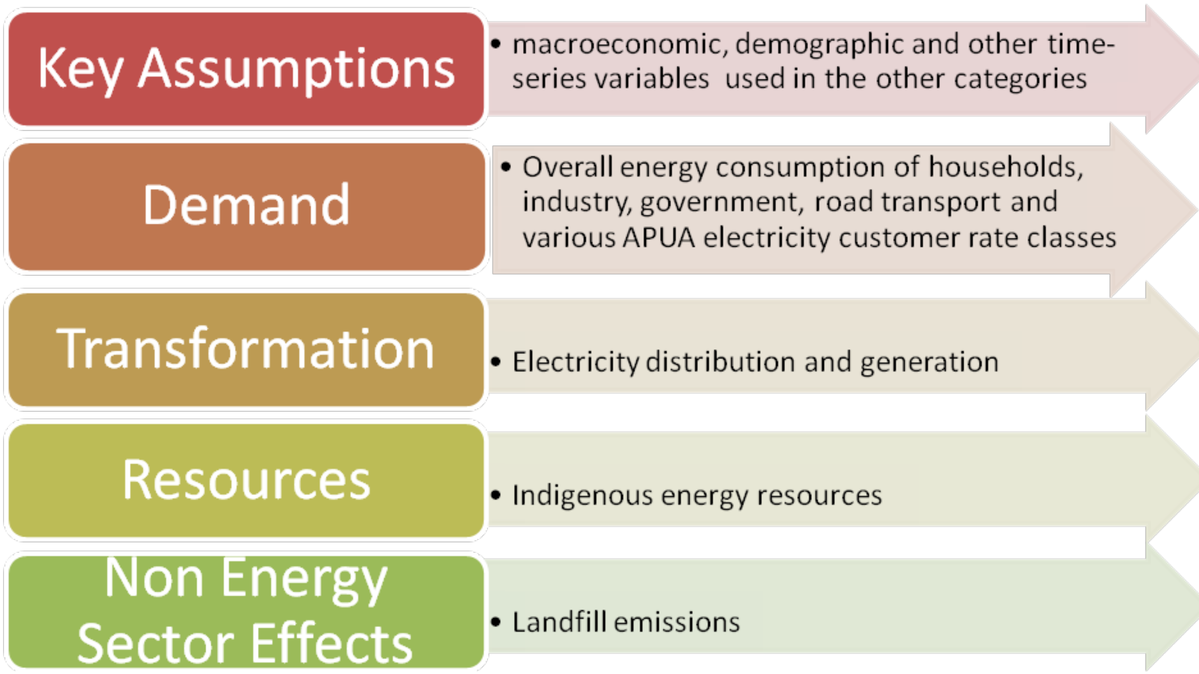
The potential opportunities for reductions in Dominica's GHG emissions in part can be determined by examination of the GHG emission inventory. The GHG emissions for 2000 to 2005 show that $CO_2$ dominated the emissions (383 Gg). Most $CO_2$ emissions (~97%) were from the energy sector. Emissions of methane ($CH_4$) were 1.6 Gg or 33.0 Gg $CO_2$ equivalents ($CO_2e$) when the global warming potential for $CH_4$ is taken into account. $CH_4$ emissions are from agriculture (50%), the waste sector (43%) and the remainder from forestry and energy sectors. In view of the dominance of $CO_2$ emissions from the energy sector mitigation opportunities will be examined only for the energy sector but it will be also equally important to maintain the sinks (forestry) in Dominica.

The $CO_2$ emissions between 2000 and 2005 from the energy sector (Chapter 2) show that emissions from transportation range from 39 to 44% while that from electricity generation ranges from 29% to 35%. Between them transportation and electricity generation account for just over 69% to 80% of the $CO_2$ emissions.

## 4.3 METHODOLOGY FOR THE MITIGATION ASSESSMENT

The mitigation analysis used the Long-Range Energy Alternatives Planning System (LEAP) model[i] and examined the demand, transformation, resources and non-energy sector emissions and effects. LEAP is a scenario-based energy-environment modeling tool based on comprehensive accounting of how energy is consumed, converted and produced in a given region or economy under a range of alternative assumptions. The base year used in this analysis is 2000 - the same year used for compilation of the national GHG emission inventory and is the year preferred by UNFCCC for reporting Second National Communications. The first projection year for all scenarios was 2009 and the last 2030. The input data for the LEAP model are grouped into five categories called modules (see Figure 4-1).

**Figure 4-1 Modules in the LEAP Model**



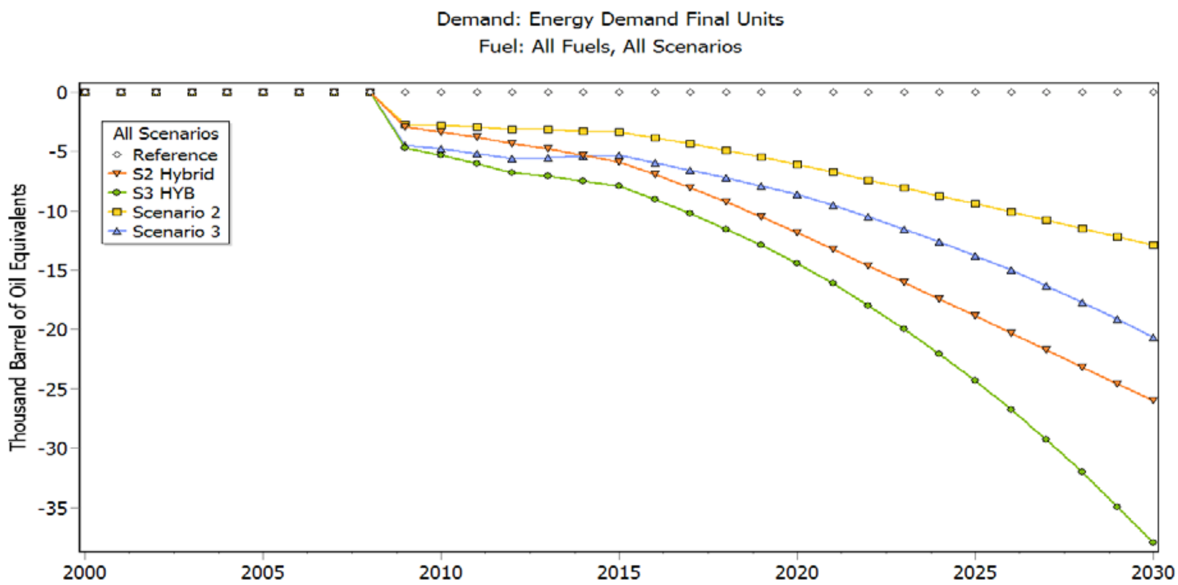

The subcategories or branches in each of these modules were determined by the level of detailed data that were available. The subcategories in the model are shown in Table 4-1. The information sources for the data used in the five modules are described below.

**Table 4-1 Subcategories in the Five Modules in the LEAP Model Input Data**

| Key Assumptions | Demand | Transformation | Resources | Non-Energy Sector Effects |
|---|---|---|---|---|
| Population<br>Household Size<br>Population growth rate | • Transportation (Seven classes of vehicles plus off road vehicles)<br>• Commercial<br>• Hotel<br>• Domestic<br>(Cooking, Lighting, Refrigeration, Television, Washing machine, All other)<br>• Industrial<br>• Street lighting | • Transmission & Distribution<br>• Loss reduction<br>• Electricity Generation<br>(Hydro, Thermal, Geothermal, Wind, Municipal solid waste, Photovoltaic (distributed)) | Primary<br>Wind<br>Geothermal<br>Solar<br>Municipal Waste<br>Biomass | Landfill emissions |

The final energy demand for all scenarios is shown in Figure 4-2. The Reference scenario has the highest demand – again because there are no mitigation measures – compared to the *S2* or *S3* scenarios.

**Figure 4- 1 Final Energy Demand for Dominica, All Scenarios**




## 4.4. IMPLEMENTATION OF MITIGATION MEASURES

The mitigation measures considered in this analysis address both the demand and supply of energy. The transportation (54%), domestic (18.5%) and industrial (13.6%) sectors which together account for 86% of the energy demand in 2008 will provide most of the opportunities for mitigation. Demand related mitigation measures include the introduction of LPG and hybrid vehicles and increasing the use of diesel fuelled vehicles and more efficient domestic electric appliances. In addition public education and other measures to increase awareness about energy conservation will reduce energy use in all sectors.

Mitigation measures in the energy supply are centred on the development and introduction of geothermal energy as well as other alternate and renewable energy supplies (wind, distributed photovoltaic, hydro and energy from municipal solid waste).

Successful implementation of the mitigation measures will *inter alia* depend on:

- Introduction of policies to encourage alternative fuelled (LPG) and/or hybrid vehicles.
- Development of policies and programmes designed to influence market behaviour towards adopting more efficient use in energy across all sectors
- The provision of tax and other incentives/disincentives for the development and use of innovative technologies that improve/worsen efficiency
- Development of a policy and institutions that will enable carbon emissions trading
- Strengthening the institutional capacities in the energy and environment sectors
- Promotion of strategic partnerships between the public and private sectors to finance and develop small and large scale renewable energy projects and implementation of more efficient energy end use technologies

## 4.5 RECOMMENDATIONS

The following recommendations are proposed to address information and policy gaps and build capacity in order to facilitate the implementation of mitigation measures.

- Complete the Sustainable Development Plan and National Energy Policy
- Revise the bases for tax/customs duties so that they are based on vehicle weight class and fuel type (not cc rating)
- Implement import and other policies to promote the introduction of alternate fuelled vehicles (LPG and/or hybrids)
- Develop and implement the regulatory framework to allow carbon trading to take place. This should include legislation establishing the DNR and associated entities and specification of the trading modalities for local and international entities (e.g., licensing, certification or regulation of such entities, owning certified emission reductions (CERs) and Verifiable Emissions Reductions (VERs) etc.)
- Build capacity to support carbon trading
- Enhance the import classifications of motor vehicles and electrical appliances and equipment to clearly distinguish between various categories of vehicles (based on fuel and vehicle weight) and appliances (based on technology and ranges of energy use). Examples are as follows:
    - Motor vehicles – to distinguish fuel used (i.e., diesel, gasoline, CNG, hybrid, electricity only etc.) and weight class
    - Refrigerators (range in SEER value, refrigerant (HC, HFC or HCFC)
    - TVs (based on technology and/or energy intensity)
    - Energy Star rated equipment/appliances
- Implement data collection and reporting systems to capture and report on gasoline, diesel and LPG fuel sales by sector
- Include more detailed information for the motor vehicle fleet and develop a suitable database and reporting system for the motor vehicle fleet

# 5. OTHER INFORMATION CONSIDERED RELEVANT TO THE ACHIEVEMENT OF THE OBJECTIVE OF THE CONVENTION

## 5.1 TRANSFER OF TECHNOLOGIES

Pursuant to decision 4/CP.7, its annex, and the implementation of Article 4, paragraph 5, of the Convention, non-Annex I Parties are encouraged, in the light of their social and economic conditions, to provide information on activities relating to the transfer of, and access to, environmentally sound technologies and know-how, the development and enhancement of endogenous capacities, technologies and know-how, and measures relating to enhancing the enabling environment for development and transfer of technologies.

### 5.1.1 Mitigation Technologies

Dominica's INC and GHG Inventory carried out for this 2nd National Communication points out that the country's forestry resources result in Dominica being a net sink of greenhouse gases. This means that Dominica is in fact already contributing towards measures for mitigation of the global climate. Government policy and national pride in the country's forests means that Dominica's forests can be projected to continue to make positive contributions to global greenhouse gas mitigation.

As a developing country, it is important that Dominica pursue mitigation strategies and/or activities that are consistent with its wider development goals and objectives. Mitigation measures associated with these policies in the Dominica context include sustainable forest utilization and management, utilization of renewable energy resources where technically and financially viable to do so and encouraging energy conservation in transport and electricity generation, distribution and end use

Mitigation technologies should focus on the Energy and Transportation sectors which combined are the major contributors to Dominica's GHG Emissions. Dominica is presently pursuing a number of initiatives aimed at Renewable energy development to reduce and replace fossil fuel use.

### 5.1.2 Adaptation Technologies

The INC Phase II Assessment was also conducted for the most important sectors vulnerable to the impacts of climate change. The assessment was based on the critical sectors identified in the INC, the Climate Change Issues Paper and other climate change related documents. Detailed adaptation technology needs were assessed for Coastal zones, Disaster management and Response, Water Resource management, Human Settlements, Agriculture and the Health sectors. Since the preparation of the INC a number of relevant adaptation technologies have been introduced.

## 5.2 RESEARCH AND SYSTEMATIC OBSERVATION (RSO)

Non-Annex I Parties are encouraged to provide information on climate change research and systematic observation, including their participation in and contribution to activities and programmes, as appropriate, of national, regional and global research networks and observing systems...

Following the methodological approach an assessment was conducted on the of the extent to which Dominica has operationalised systems necessary to generate the Essential Climate Variables (where relevant) and the capacity needs for addressing any deficiencies that were identified.

In the assessment, the following shortcomings were identified.

- The data being collected in Dominica is inadequate to support monitoring of climate change trends in Dominica.
- There is no data collection and monitoring of critical variables like sea levels and emissions of greenhouse gases, including carbon dioxide and methane.
- Most of the data collected relate to atmospheric surface variables and the collection is not comprehensive.
- Most of the data collection is limited to the airports, with precipitation being the only variable that is collected in other parts of the island.

- Distribution of the collection points have not been rationalized, with the result that even this data does not provide a comprehensive picture of precipitation in Dominica.

Dominica lacks a significant institutional capacity to carry out its responsibilities and obligations. At present, each of the stakeholders is “doing their own thing”. There is no central clearinghouse for the data and no central purchasing office for equipment. Several government departments are monitoring for rainfall-wind speed and direction in basically the same area, whilst a large section of Dominica has no records or history of rainfall data.

## 5.3 EDUCATION, TRAINING AND PUBLIC AWARENESS

Article 6 : Education, Training and Public Awareness of the Convention specifically outlines the responsibilities that signatory governments must realize in order to fulfill their commitment in regards to informing on and promoting knowledge of climate change. Implementation of a public awareness programme will facilitate greater participation in climate change reduction and will be in compliance with the Commonwealth of Dominica’s obligations as a signatory to the Convention.

An effective public awareness campaign on climate change in Dominica should have the following objectives:

- Inform and educate to increase knowledge on the anthropogenic causes of climate change
- Inform and educate to increase knowledge on the effects of climate change
- Inform and educate to increase knowledge on the individual and collective responsibilities required for mitigation of climate change through the reduction of the GHGs
- Inform and educate to increase knowledge on the individual and collective responsibilities required for adaptation to climate change

Chatterjee (2003) outlines six important tools for Civil Society, School Curriculum, Participatory process, Policy makers, organizing workshops and Seminars and for taking the help of Communication media, which are necessary in order to achieve an effective public awareness programme Due to its relevance to the Dominican context all of these tools, some of which are already being implemented, are applicable to Dominica and are recommended to be used in order to fully engage the Dominican population.

## 5.4 CAPACITY-BUILDING

Non-Annex I Parties are encouraged to provide, in accordance with decision 2/CP.7, information on how capacity-building activities, as contained in the framework annexed to that decision, are being implemented at national and, where appropriate, at sub regional and/or regional levels. This could include, inter alia, options and priorities for capacity-building, participation in and promotion of South-South cooperation, the involvement of stakeholders in capacity-building, coordination and sustainability of capacity-building activities, and the dissemination and sharing of information on capacity building activities.

Some of the more significant activities conducted and/or currently being implemented include the following:

- Climate Change Adaptation Policy
- Initial National Communication Phase II Enabling Activity Project
- National Capacity Self Assessment (NCSA)
- NCSA Strategy and Action Plan
- Dominica's Climate Change RAF Concepts Paper
- Sustainable Development Plan
- Sustainable Land Management Programme (SLM)
- Participation In Regional And International climate Change Related Programmes/Projects
- Participation in International Activities

# INTRODUCTION

The Commonwealth of Dominica ratified the UNFCCC in 1994, as recognition of the importance of climate change as a major environmental phenomenon with serious ramifications for all nations especially resource poor developing countries and SIDS of which Dominica is a member.

As one of the obligations under Article 12 of the UNFCC, Dominica committed to the production of regular National Communications to the COP. The first such report, the Initial National Communication was submitted in 2001. The INC 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

The INC process enhanced the general awareness and knowledge of climate change-related issues in Dominica and strengthened the dialogue, information exchange and cooperation among all relevant stakeholders including Government, non-government, academic and private sector agencies, and civil society.

The preparation of the INC was coordinated by the Environmental Coordinating Unit (ECU). It is a small unit established by a Cabinet Decision in 1999, to coordinate all environmental activities in Dominica. The overall function of the ECU, is to bring about more focused environmental management approaches to the solving of Dominica's environment problems, advise government of the development of more coherent environmental policies and enhance Dominica's compliance with international treaties and conventions to which it is signatory. It also serves as the focal point for Multilateral Environmental Agreements (MEA) to which Dominica is a party.

Following the publication of its Initial Communication, Dominica carried out a number of important climate change related activities:

- Initial National Communication Phase II Project - Building Capacity to Respond to Climate Change endorsed by Cabinet in May 2005 was a capacity building project intended to build upon the activities completed in the context of Dominica's INC. The overall goal was to allow Dominica to extend current knowledge to facilitate the emergence of national networks and promote the integration of climate change concerns in the developing national dialogue.

- Organization of several workshops for information sharing and awareness raising on climate Change;

- The Mainstreaming Adaptation to Climate Change in the Caribbean (MACC) Programme s which sought to reduce vulnerability (physical, social, economic and environmental) of Caribbean countries to the impacts of climate change. The climate vulnerability risk assessment for MACC were in the areas of Water Resources, Tourism, Agriculture and Coastal Zone. MACC also focused on *Public Education and Outreach* (PEO) strategies as a major component of the program in Dominica

- The National Capacity Self Assessment (NCSA) process commenced in Dominica in January 2004 and it focused on three thematic areas, Land Degradation, Biodiversity and Climate Change. The objective of the NCSA process is to allow for a thorough assessment of the capacity needs and constraints facing national efforts to improve environmental conservation and sustainable development programmes, and to meet global environmental management obligations. The NCSA process intended to analyze the institutional capacity framework that was initiated under the UNFCCC and the NBSAP, and facilitated the identification of management strategies relevant to sustainable environmental development.

- Accession to the Kyoto Protocol in January 2005

- In 2008, the Commonwealth of Dominica together with St. Lucia and St. Vincent and the Grenadines began implementation of the Special Programme for Adaptation in the Caribbean (SPACC) Piloting an Integrated Operational Approach to Climate Change Adaptation, Biodiversity and Desertification Planning and Management. The SPACC seeks to make adaptation to climate change an integral part of a broader agenda to address major MEA within national planning processes in the participating countries

- The National self-assessment exercise carried out in accordance with GEF Operational Procedures for the Expedited Financing of National Communications from Non-Annex I Parties (GEF/C.22/Inf.16). The main objective was to conduct highly consultative and participatory needs assessment of activities completed or under preparation that are relevant to the Second National Communication, while identifying priorities for implementation during the SNC process.

This Second National Communication is compliance with Dominica’s obligation to the UNFCCC. Chapter 1 sets the National Circumstances, and in particular the aspects of development policies related to the major components of Climate Change process. Although the baseline year for the report is 2000, Chapter 2 is devoted to Greenhouse Gases Inventories, carried out for the period 2000-2005, in accordance with the methodology recommended by the Convention Secretariat and the IPCC. This inventory is complemented by tables providing details on calculations carried out, data gaps, uncertainties, etc. Chapter 3 deals with Vulnerability to climate change and variability.. The Capacity for mitigating the effects of GHG emissions is presented in Chapter 4; this capacity is related to social and economic development policies of the country. It is followed by chapter 5 in which all other information related to achievement of the convention objectives is presented. It gives a detailed assessment of Dominica’s ongoing efforts and requirements to efficiently implement the Convention.

# 1 NATIONAL CIRCUMSTANCES

## 1.1 Country Profiles

The Commonwealth of Dominica occupies a central location along the archipelago of the Eastern Caribbean, lies between Guadeloupe to the north and Martinique to the south, at 15° 30’ North Latitude and 61° 25’ West Longitude Fig.1.1 Dominica is the most northerly and largest of the sub-regional Windward Islands grouping, with a total land area of 750.6 square kilometres (290 square miles). Dominica is very mountainous and of volcanic origin and measures 47 kilometers long and 22 kilometres wide, at its widest point.

The topography of the island is dominated by a central line of volcanic peaks that rise to 1,220 meters and from which radiate numerous ridges that extend to the coastline where they sometimes end abruptly as steep sea cliffs. The rich volcanic soils are porous but partly unstable with variable depths and degrees of drainage. The rich volcanic soils are usually well watered by numerous streams and rivers. The terrain is very rugged and steep. The high mountains and deep ravines are covered in rich tropical forests.

The central watershed areas are no more than 6.5 km from the sea in all directions and for conservation purposes has been demarcated as National Park Reserve in which no agricultural farming is permitted. A number of subsidiary peaks (about 610 meters) are found just outside this central line of ridges, dislocating to some extent the natural radial distribution of the main ridges. The relief is extraordinarily abrupt with highly dissected terrain, numerous steep or precipitous slopes and with relatively little flat land. Estimates of land slope classes as a percentage of the total area indicated that 85% of the land is very steep or mountainous, 13% is steeply undulating and 2% is flat or gently undulating. As a result only a relatively small proportion of the land area is considered available for agriculture.

Flat land is restricted to the coastal areas and certain areas in the centre of the island. Population centres are concentrated in these areas. Thus, farming is generally restricted to the many rugged slopes, which already is an indication of how vulnerable these farm lands are, and can become, if exposed to unsustainable land management regimes.

## 1.2 Biodiversity

Notwithstanding its small size, Dominica possesses an extensive range of terrestrial and marine biodiversity. In terms of terrestrial flora, some 155 families, 672 genera and 1226 species of vascular plants have been identified on the island. A number of plant species are considered endemic to the island. Seven (7) distinct vegetation communities are present ranging from montane rainforest to coastal swamp and dry scrub woodland. Fumarole vegetation associated with volcanic activity is also present. In terms of terrestrial fauna Dominica contains the most diverse stock of wildlife species in the eastern Caribbean. This includes some 175 species of birds, 18 species of wild mammal, 15 reptile species, amphibians, and various species of freshwater and estuarine fish and crustaceans.

Biodiversity is equally spectacular in the marine and coastal environment as the country's underwater topography and estuarine areas provide habitats for a large number of species. The sub-marine topography is similar to that of the land, rugged and mountainous with very deep valleys. There is a very narrow continental shelf around the island and as a result the water plummets to depths in excess of 60 meters very close to the shore. There is also a wide range of estuarine habitats at the mouths of the many rivers that drain to the sea that provide habitat for resident and migratory fauna (birds and fish species). Coral reefs are not as extensive in the coastal waters off Dominica as in the other Caribbean islands on account of the deep waters, however there are impressive formations along the south west coast that now attract growing interest by divers. Dominica is ranked in the top ten of the best dive sites in the world. The pelagic biodiversity sustain a vibrant fishing industry and also supports a growing whale watching industry.

Among the main threats to biodiversity in Dominica are deforestation, pollution, overexploitation of resources, unregulated development, natural disasters, and impacts from climate change.

## 1.3 Protected Areas

Twenty-five percent of Dominica's forest lands are legally protected either as forest reserves or National Parks. Dominica has two (2) declared Government Forest Reserves namely the Central Forest Reserve (410 hectares) established in 1951 and the Northern Forest Reserve (5,475 hectares) established in 1977. These two Forest Reserves in the north-central part of the island cover over 11% of Dominica's land area.

**Photo 1-1 Fresh Water Lake located in the Morne Trois Pitons National Park**

Three National Parks have been designated. The Morne Trois Pitons National Park (6,872 hectares) was established in 1975, the Cabrits National Park (5,388 hectares), which includes a marine component, was established in 1986, and the Morne Diablotin National Park (3,335 hectares) was established in 2000. The Morne Trois Pitons National Park was officially declared a UNESCO World Heritage Site in 1998. Management Plans have been developed for the three National Parks.

In 1998 an expanse of the marine waters of the south of the island was designated as Soufriere Scott head Marine Reserve (SSMR). That protection status granted to this marine areas and adjacent fringing coastline was among others an attempt to give protection, as well as zone areas of that marine space for designated sustainable marine related activities

## 1.4 Climate

The combination of its size and location results in the climate of Dominica being strongly influenced by features of the north tropical Atlantic. There is modulation by the annual migration of the north Atlantic subtropical high, the eastward spreading of the tropical Atlantic warm pool, the fairly steady easterly trades, and the passage of tropical waves, depressions, storms and hurricanes. The climate of Dominica is classified as “humid tropical marine”,

### 1.4.1. Rainfall

The country is among the wettest in the eastern Caribbean. Dominica receives, on average, between 250 and 380 cm of rain each year. The rainfall climatology depicted in Figure 1.1 shows a dry season from January through April and a primary wet season from September through November (Taylor et al 2010). The bulk of the rainfall occurs between June and November, which are the peak months for cyclonic activity.  The drier period extends from January to May.

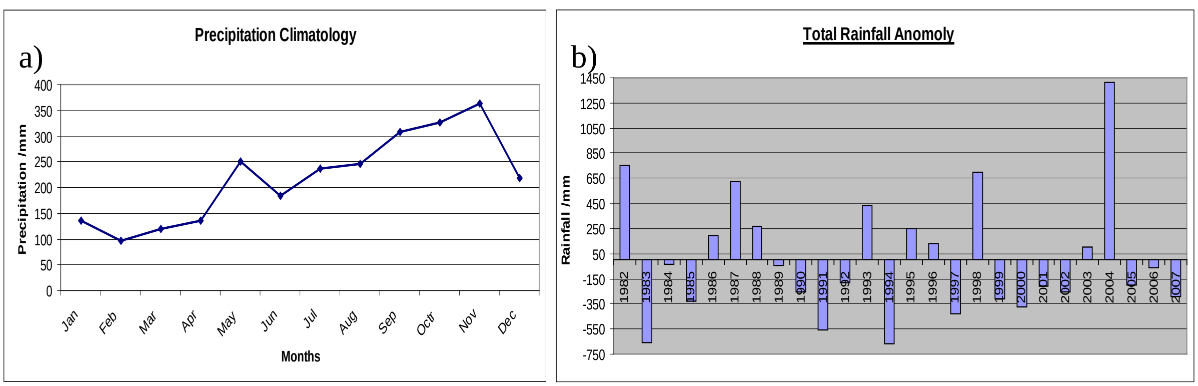



**Figure 1.1** (a) Mean annual monthly rainfall. Units are mm/month. (b) Rainfall anomaly with respect to full base period. Units are mm. Data for Melville Hall Airport 1982 -2007 (Taylor et al 2010)

Because of the island's elevated and rugged topography, micro-climatic variability can exist over very short distances and is influenced by the high moisture content of the air masses (the northeasterly trade winds) that enter from the Atlantic Ocean and the Caribbean Sea. Average annual rainfall over the island ranges from just above 2,000 mm (79 in) along the west coast to in excess of 7,620 mm (300 in) in the interior.  High rainfall makes the island susceptible to landslides particularly in mountainous areas. Dominica’s rugged topography results in considerable amount of orographic rainfall.

### 1.4.2. Temperature

The annual variation in maximum, minimum and mean temperatures is shown in Figure 1.2a. Dominica has an average temperature of 27$^{o}$C (80$^{o}$F).  The annual range is small for the mean temperature (~3 degrees), with peak temperature values occurring between July and

August. Maximum temperature values may reach as high as 31$^0$C and peak slightly later in the year, while minimum temperature values may drop to less than 22 $^O$C in the mean in January/February. Diurnal ranges are usually no greater than 3°C in most places.

The steep interior slopes of Dominica also alter temperatures. During the warmest period of the year a maximum of 33$^o$C may be observed along the coast compared to 27$^o$C in the mountains. In the nights, minimum temperatures of 18$^o$C and 13°C respectively are not uncommon.

a) b)

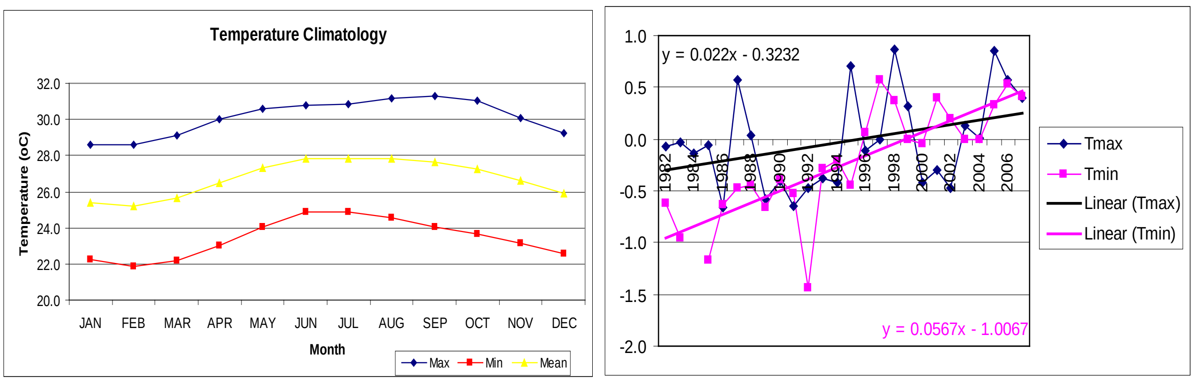



**Figure 1.2** (a) The climatology of minimum, maximum, and mean temperature for Dominica (Melville Hall Airport 1982 -2007). Units are $^O$C. (b) Annual maximum and minimum temperature anomalies for Dominica (Melville Hall Airport 1982 -2007). Anomalies are with respect to a full period. Trend lines added (Taylor et al 2010).

**Table 1.1 and Table 1.2** below provides rainfall and temperature data. The data provided by both Tables indicates the significant climatic differences that may exist within Dominica, despite the small size of the country.

**Table 1.1: Data Recorded at Melville Hall Airport Temperature, Rainfall and Humidity (1994-2007)**

| Year | Average Maximum Temperature (Celcius) | Min. Average Annual Temperature | Total Rainfall (Mm) | Average Relative Humidity (%) |
|---|---|---|---|---|
| 1994 | 30.5 | 21.0 | 1950.6 | 75 |
| 1995 | 31.6 | 20.8 | 2873.8 | 76 |
| 1996 | 30.8 | 21.3 | 2709.0 | 77 |
| 1997 | 30.9 | 21.8 | 2195.1 | 76 |
| 1998 | 30.1 | 24.0 | 3319.5 | 79 |
| 1999 | 29.7 | 23.4 | 2309.1 | 77 |
| 2000 | 29.4 | 23.7 | 2309.1 | 77 |
| 2001 | 29.7 | 23.8 | 2415.8 | 77 |
| 2002 | 29.4 | 24.0 | 2365.9 | 78 |
| 2003 | 29.9 | 23.6 | 2719.0 | 76 |
| 2004 | 29.8 | 23.3 | 3731.8 | 75 |
| 2005 | 31.8 | 21.5 | 2417.6 | 75 |
| 2006 | 31.5 | 21.7 | 2554.6 | 76 |
| 2007 | 30.2 | 23.7 | 2331.0 | 74 |

*Source: Commonwealth of Dominica Meteorological Office. 2008*.

**Table 1.2: Data recorded at Canefield Airport Temperature, Rainfall and Humidity (1994-2007)**

| Year | Max. Mean Annual Air Temperature | Min. Mean Annual Temperature | Total Rainfall (Mm) | Average Relative Humidity (%) |
|---|---|---|---|---|
| 1994 | 30.7 | 23.1 | 1547.2 | 69 |
| 1995 | 31.1 | 23.2 | 1706.2 | 72 |
| 1996 | 30.8 | 23.3 | 1986.3 | 72 |
| 1997 | 31.0 | 23.6 | 1800.3 | 69 |
| 1998 | 31.5 | 23.9 | 2204.2 | 72 |
| 1999 | 31.1 | 23.5 | 1660.8 | 70 |
| 2000 | 30.6 | 23.4 | 1266.1 | 68 |
| 2001 | 31.0 | 23.5 | 1573.2 | 67 |
| 2002 | 33.3 | 25.5 | 1476.8 | 68 |
| 2003 | 31.0 | 23.8 | 1644.0 | 68 |
| 2004 | 30.8 | 23.2 | 2057.3 | 70 |
| 2005 | 33.6 | 21.6 | 1803.1 | 68 |
| 2006 | 33.0 | 21.1 | 1737.8 | 64 |
| 2007 | 31.3 | 22.9 | 1678.0 | 62 |

Source: Commonwealth of Dominica Meteorological Office.2008

### 1.4.3 Other Climate Variables

Relative humidity across the country tends to be high (in excess of 75%) year round with little seasonal variation. Predictably the interior of the island sees highest humidity (> 85%). Winds are generally from the E or ESE, and wind speeds are fairly constant year round (3-5 metres per second). Though weakest mean winds occur in September-October, strong wind gusts are possible from June to November especially during the passage of tropical waves, depressions, storms or hurricanes (Taylor et al 2010)

### 1.4.4. Natural Hazards

The primary natural hazards affecting the island are tropical storms and hurricanes and their attendant impacts, which include erosion, landslides and floods. The Commonwealth Vulnerability Index rates Dominica as having the sixth (out of 111 countries evaluated) most vulnerable economy (to external shocks and natural hazards) in the world, and the most vulnerable in the Caribbean.

The island is located within the Atlantic hurricane belt. The island is impacted (brushed or hit) approximately once every four years. The severity of the impact on both the social and economic infrastructure is dependent on the approach, proximity and intensity of the system at the time of passing.. Hurricanes are characterized by strong winds and are generally accompanied by heavy rainfall and by storm surges in coastal areas. Impacts of these storms include loss of life, damage to property, and disruptions to the natural environment. Rainfall associated with the passage of tropical weather systems is an important source of freshwater.

Over the period 1987 to 1997, Dominica was affected by nine tropical cyclonic systems which ranged in intensity from localized wind blows to intense hurricanes.Tropical systems of note which have impacted Dominica include David (1979), Gert (1981), Gilbert (1988), Hugo (1989), Iris (1995), Marilyn (1995), Hortense (1996) and Lenny (1999) and Dean (2007). These tropical systems severely impact infrastructure, agriculture, transport and fisheries sectors. .

### 1.4.5 Seismic activity

Seismic activity in Dominica is frequent. It is estimated that over 90% of the population live within 5 kilometres of seismic activity zones. In November 2004 the country's vulnerability to seismic hazards was brought into sharp focus with the occurrence of torrential rains delivering over 530 mm over a 5-day period (recorded at the Melville Hall Airport between November 17th and 22nd) that coincided with a strong earthquake[3] on November 21st. The events triggered major landslides at the communities of Thibaud, Vielle Case and Penville situated in the north of the island. Massive flooding with observed heavy soil loss due to erosion contributed to significant silting of major rivers in the east such as the Rosalie River (Rosalie area), the Sari Sari and Thabari Rivers (La Plaine area), the Mahaut River (Morne Jaune area) along with sedimentation of the near-shore marine environments.

## 1.5 Demography

The island was originally populated by Amerindian peoples, known as Caribs and is the only island in the Caribbean still to possess distinct communities of these indigenous people of the Caribbean. The islands vibrant cultural traditions reflect its African, European, and Amerindian heritage.

Dominica is the least populated of the Windward Islands with an estimated population (July 2006) of 68,910 with an average density of 92 persons per sq. km. The largest community is Roseau (the capital city) and its environs with 14,847 persons representing almost 21% of the total population. Most of the population centres are along the coastal fringe.

[3] Source: http://earthquake.uszs.gov/recenteqsww/quakes/usrcaz.htp. The earthquake which had a measured magnitude of 6.3 on the Richter Scale occurred at 7:41:07 am (local time at epicenter at location 15.677° N, 61.650° W or 15 miles WNW (300°) from Portsmouth, Dominica, on November 21, 2004. While no fatalities were sustained, there was significant damage to buildings and other infrastructure (including hospitals, schools, churches and dwelling houses) in the north and north east of the island. The official estimate for necessary repairs, rehabilitation and reconstruction work to official buildings as a consequence of the recent earthquake and accompanying heavy rainfall is US$19.1 million. This estimate takes account of funds needed for restoring public works, i.e. roads, bridges, schools and health facilities. It does not include the cost of repairs to private homes and other facilities, nor does it represent a full economic, social and environmental impact of the damage.

Population estimates for 2001 indicate that Dominica had a population of approximately 71,000[4] persons. This reflects a decline from 74,750 in 1994. Topographic conditions have forced human settlements onto narrow coastal areas particularly in the south and west with approximately 44,000 persons (62%) living along the coast. **Table 1.3** below provides some basic demographic data for Dominica.

**Table 1.3 Dominica's Total Population Analyzed by Births, Deaths and Net Migration 1990 – 2006**

| *Year* | *Births* | *Deaths* | *Natural Increase* | *Net Migration* | *Total Increase* | *End of Year Population* | *Mean Population* |
|---|---|---|---|---|---|---|---|
| 1990 | 1604 | 612 | 1092 | -981 | 111 | 71568 | 71513 |
| 1991 | 1712 | 518 | 1194 | -895 | 299 | 71373 | 71471 |
| 1992 | 1836 | 566 | 1270 | -707 | 563 | 71936 | 71654 |
| 1993 | 1757 | 558 | 1199 | -802 | 397 | 72333 | 72134 |
| 1994 | 1605 | 530 | 1075 | -914 | 161 | 72494 | 72413 |
| 1995 | 1501 | 584 | 917 | -699 | 218 | 72712 | 72603 |
| 1996 | 1426 | 583 | 843 | -1288 | -445 | 72267 | 72490 |
| 1997 | 1340 | 513 | 827 | -995 | -168 | 72099 | 72183 |
| 1998 | 1236 | 595 | 641 | -756 | -115 | 71984 | 72042 |
| 1999 | 1293 | 618 | 675 | -1013 | -338 | 71646 | 71815 |
| 2000 | 1199 | 511 | 688 | -897 | -209 | 71443 | 71544 |
| 2001 | 1216 | 510 | 703 | -894 | -191 | 70401 | 70922 |
| 2002 | 1081 | 594 | 487 | -526 | -39 | 70362 | 70382 |
| 2003 | 1056 | 557 | 499 | -522 | -23 | 70340 | 70352 |
| 2004 | 1066 | 557 | 509 | -355 | 154 | 70494 | 70417 |
| 2005 | 1009 | 489 | 520 | -178 | 342 | 70836 | 70665 |
| 2006 | 1058 | 536 | 522 | -178 | 344 | 71180 | 71006 |

*Source: Ministry of Health, Immigration Department and Central Statistical Office*

## 1.6. Economy

Dominica's economy has traditionally been dominated by agricultural production and export. Dominica's agricultural sector is composed primarily of a large number of small farmers cultivating less than 10 hectares of land and with minimal technological and scientific inputs. By the 1970s, banana production and export, based on a preferential access regime for bananas in the UK, was the principal source of foreign exchange and employment. The collapse of protected markets for the fruit in the latter half of the 1990s has been catastrophic for the industry in Dominica as well as having major adverse impacts on other sectors of the national economy.

**Table 1.4** provides some select economic indicators for Dominica. The information in the Table demonstrates many of the economic difficulties facing Dominica. These are reflected in such indicators as the steadily growing gap between government revenues and

[4] *It is believed that recent economic difficulties have resulted in fairly extensive migration from Dominica as well as increased seasonal and other movement.*

expenditures, the dramatic decline in banana production, and the fluctuations in tourism arrivals.

The structural weaknesses in the economy and the worsening fiscal situation resulted in the Government of Dominica embarking on an economic stabilization programme with the International Monetary Fund (IMF) beginning in 2001. This programme is aimed, among other things, at maintaining fiscal stability and energizing economic growth. The programme emphasizes the role of government as a facilitator of economic activity with only a minimal role in direct provision of non-essential services, and is intended to reduce public sector expenditure to sustainable levels. To date this programme has been rated as essential but global issues such as the rising cost of petroleum products brings to bear more than desirable stress on the economy.

| | Unit | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Value of exports (FOB) | EC$m. | 135.71 | 142.41 | 145.16 | 170.34 | 150.45 | 144.07 | 118.04 | 115.19 | 108.00 | 111.75 | 111.86 | 111.89 |
| Value of imports (CIF) | EC$m. | 329.80 | 326.73 | 345.25 | 346.29 | 373.22 | 400.95 | 355.02 | 314.05 | 345.45 | 392.03 | 488.63 | 450.62 |
| Visible trade balance | EC$m. | (194.09) | (184.32) | (200.09) | (175.95) | (222.77) | (256.28) | (236.98) | (198.86) | (237.45) | 280.28 | 336.27 | 338.64 |
| Government Recurrent revenue | EC$m. | 155.03 | 173.83 | 188.61 | 205.00 | 200.75 | 213.73 | 202.32 | 192.90 | 204.30 | 234.60 | 257.28 | 266.86 |
| Government Recurrent Expenditure | EC$m. | 155.06 | 166.50 | 184.74 | 194.77 | 206.47 | 224.84 | 223.80 | 229.21 | 210.19 | 218.40 | 210.87 | 228.26 |
| Total stay over visitors | 000s | 60.47 | 63.26 | 65.45 | 65.50 | 73.51 | 69.60 | 66.39 | 69.19 | 73.19 | 80.09 | 79.26 | 84.04 |
| Cruise ship visitors | 000s | 134.92 | 193.48 | 230.58 | 244.60 | 202.00 | 239.80 | 207.63 | 136.86 | 177.04 | 383.61 | 301.51 | 379.64 |
| Electricity generated | 000kw h | 56,227 | 60,093 | 65,783 | 70,300 | 74..64 | 77.52 | 80.97 | 80.13 | 78.43 | 79.23 | 83.66 | 85.42 |
| Bananas exported | Tonnes | 33,070 | 43,012 | 37,366 | 28,602 | 29,51 | 28,788 | 19,061 | 18,379 | 11,956 | 14,484 | 11,953 | 12,852 |
| Total external debt | EC$m. | 278.19 | 276.64 | 240.29 | 245.42 | 359.86 | 407.84 | 490.09 | 564.92 | 620.89 | 626.46 | 702.56 | 680.36 |

**Table 1.4 Dominica Select Economic Indicators 1995-2006**

*Source: Central Statistical Office, Dominica*

Dominica possesses a relatively small but developing tourism sector based on the country's natural attractions - particularly its forests and marine resources. Government policy envisages nature-based tourism as constituting the principal platform for facilitating private sector led economic growth, alongside a diversified agricultural sector and service industries in such areas as offshore medical and financial services. A number of mid-sized hotels and a growing number of smaller eco-oriented inns and lodges presently characterize the hotel sector. Dominica's tourism attractions include its flora, fauna and other land based natural features, world-class scuba diving sites, whale watching and cultural festivals and activities.

A primary obstacle to the growth of Dominica's tourism industry has been the lack of adequate facilities for direct international air travel from the major tourism markets in Europe and North America. This is due to the extremely mountainous nature of the island that has served as a barrier to construction of an airstrip capable of accommodating large aircraft. Other problems confronting the sector include high operating costs, competition from other destinations, limited marketing, and the need for development of ancillary services.

**Table 1.4** indicates the increasing significance of the cruise ship sector. While resulting in increased numbers of tourists, the growth of mass based cruise tourism also presents challenges for Dominica in terms of issues such as carrying capacity and sustainable use of many of its main tourism attractions. However, the rising cost of petroleum is projected as threatening to, anticipated volume calls of cruise ships.

Dominica's manufacturing sector consists primarily of a number of light industries producing for the domestic and regional market. Manufactured goods include soaps and agro-processed items for regional and international markets as well as beverages, furniture and textiles for the local market. As with other Eastern Caribbean countries, Dominica's manufactured products are faced with high production costs, small markets, and competition from lower cost regional and international producers. Proposals for further liberalization of regional, hemispheric and international trade will present additional competitive challenges for these industries.

## 1.7 Energy Use

Electricity constitutes the primary source of commercial energy for industrial and other uses in Dominica. The country presently has an installed capacity of 21 megawatts consisting of 6MW (28.5%) of hydropower and 15MW of diesel powered units. During the 1960s, approximately 90% of electricity was derived from domestic hydro sources but this source is now believed to be close to its maximum exploitation in terms of economic feasibility and environmental protection concerns. The main end users of electricity are domestic, commercial and institutional customers and the pattern of consumption demonstrates the low energy use of industry and other non-domestic consumption at this time as illustrated in **Table 1.5.**

**Table 1.5 Electricity Operating Statistics Generation Sales and Consumers**

| DESCRIPTION | 2003 | 2002 | 2001 | 2000 | 1999 |
|---|---|---|---|---|---|
| **Peak Demand (Kw)** | 12,923 | 13,043 | 13,866 | 12,966 | 13,010 |
| *Growth (%)* | *(0.9)* | *(0.6)* | *6.9* | *(0.3)* | |
| **Generation (1000kWh)** | | | | | |
| Hydro | 28,523 | 35,929 | 27,036 | 31,590 | 32,410 |
| Diesel | 48,404 | 44,203 | 53,929 | 45,925 | 42,226 |
| Energy Purchased | 1,507 | | | | |
| *Total* | *78,434* | *80,132* | *80,965* | *77,515* | *74,636* |
| *Growth* | *(2.1)* | *(1.0)* | *4.4* | *3.8* | *6.2* |
| **Sales (kWh X 1000)** | | | | | |
| Domestic | 32,942 | 32,856 | 31,779 | 30,872 | 30,023 |
| Commercial | 21,669 | 22,758 | 17,021 | 16,052 | 15,503 |
| Hotel | 2,473 | 2,839 | 2,796 | 3,154 | 3,244 |
| Industrial | 4,354 | 4,607 | 4,009 | 4,420 | 4,553 |
| Lighting | 2 | 9 | 7,181 | 6,409 | 6,202 |
| Street Lighting | 1,295 | 1,125 | 1,128 | 1,098 | 1,069 |
| *Total* | *62,735* | *64,194* | *63,914* | *62,005* | *60,594* |
| **Consumers** | | | | | |
| Domestic | 24,333 | 23,210 | 23,069 | 22,802 | 22,196 |
| Commercial | 2,828 | 2,992 | 2,440 | 1,909 | 1,824 |
| Hotels | 60 | 18 | 21 | 23 | 23 |
| Industrial | 35 | 33 | 42 | 41 | 42 |
| Street lighting | 4 | 3 | 1,374 | 1,374 | 1,297 |
| General lighting | 253 | 239 | 234 | 234 | 223 |

*Source: Dominica Electricity Services Limited.*

**Table 1.5 Electricity Operating Statistics Generation Sales and Consumers**

| DESCRIPTION | 2008 | 2007 | 2006 | 2005 | 2004 |
|---|---|---|---|---|---|
| **Peak Demand (kW)** | | 14,501 | 14,467 | 14,368 | 13,190 |
| *Growth (%)* | | *0.2* | *0.7* | *8.9* | *2.1* |
| **Generation (kWh x 1000)** | | | | | |
| Hydro | | 21,885 | 27,797 | 27,876 | 33,736 |
| Diesel | | 64,497 | 57,619 | 55,779 | 45,493 |
| Energy Purchased | | 0 | 0 | 0 | 0 |
| *Total* | | *86,382* | *85,416* | *83,655* | *79,229* |
| *Growth (%)* | | *1.1* | *2.1* | *5.6* | *1.0* |
| **Sales (kWh x 1000)** | | | | | |
| Domestic | | 33,732 | 34,176 | 33,492 | 33,062 |
| Commercial | | 28,788 | 26,469 | 24,993 | 24,017 |
| Hotel | | 2,002 | 2,439 | 2,649 | 2,704 |
| Industrial | | 5,600 | 5,357 | 5,504 | 5,508 |
| Lighting | | 1 | 0 | 1 | 1 |
| Street Lighting | | 1,298 | 1,130 | 1,150 | 1,127 |
| *Total* | | *71,421* | *69,571* | *67,789* | *66,419* |
| **Consumers** | | | | | |
| Domestic | | 28,388 | 27,436 | 24,851 | 25,181 |
| Commercial | | 4,132 | 3,896 | 3,536 | 3,328 |
| Hotel | | 392 | 307 | 274 | 142 |
| Industrial | | 27 | 38 | 39 | 39 |
| Lighting | | 2 | 0 | 5 | 8 |
| Street Lighting | | 364 | 331 | 320 | 282 |

*Source: Dominica Electricity Services Limited.*

The other main source of energy use in Dominica is in the road transport sector. As in most other developing countries road transport consumes an increasing amount of petroleum. In the case of Dominica this has economic, environmental and health implications. **Table 1.6** contains the number of vehicles licensed between 1999 and 2006 and shows that there has been a 125% increase during the period. It is significant to note that less than 15% of newly registered vehicles are new. The remainder is purchased as re-conditioned/used vehicles from overseas.

**Table 1.6 Number of Motor Vehicles Licensed 1999-2006**

| Year | Private Cars | Taxis | Buses | Motor cycles | Trucks | Jeeps | Tractors | Total |
|---|---|---|---|---|---|---|---|---|
| **1999** | 5,846 | 158 | 1,184 | 324 | 1,749 | 1,331 | 47 | 10,638 |
| **2000** | 6,636 | 185 | 1,371 | 437 | 2,057 | 1,682 | 62 | 12,430 |
| **2001** | 7,283 | 208 | 1,494 | 527 | 2,199 | 1,971 | 68 | 13,750 |
| **2002** | 7,712 | 228 | 1,593 | 656 | 2,315 | 2,156 | 71 | 14,731 |
| **2003** | 8,110 | 243 | 1,693 | 775 | 2,414 | 2,330 | 77 | 15,642 |
| **2004** | 8,527 | 258 | 1,838 | 851 | 2,526 | 2,595 | 80 | 16,674 |
| **2005** | 9,379 | 316 | 2,145 | 933 | 2,748 | 5,667 | 84 | 21,272 |
| **2006** | 9,807 | 336 | 2,273 | 1,020 | 2,918 | 5,931 | 85 | 22,370 |

*Source: Inland Revenue Division.*

More recent years are reported to have seen a large increase in the number of vehicles on Dominica's roads, facilitated by the easy availability through the internet of comparatively cheap reconditioned vehicles from several sources globally. This will continue to be a source of concern as far as gas emissions in the atmosphere goes.

## 1.8. Renewable Energy thrust

The Government's objectives for the energy sector among other things highlights minimizing of the cost of energy, diversify energy sources, reduce the reliance on fossil fuels, and conserve energy, while at the same time, reducing emissions of Greenhouse gases. The short-term goal is to have at least 25% of all electricity generated in Dominica from renewable sources by the year 2010, while encouraging and promoting the need for energy efficiency and energy security.

# 2 GREENHOUSE GAS INVENTORY

## 2.1 OVERVIEW

This report presents the inventory of GHG emissions and sinks for the years 2000 to 2005 inclusive as a component of Dominica's Second National Communication (SNC). The SNC inventory includes that for the year 2000 in accordance with the convention requirements. Unfortunately, sufficiently detailed records of the information used to compile the 1994 GHG inventory for the INC were not available to allow a complete update of the 1994 inventory but the 1994 estimates were compared with those for the later years.

The Intergovernmental Panel on Climate Change (IPCC) Revised 1996 *Guidelines for National Greenhouse Gas Inventories: Volume 1 – Reporting Instructions, Volume 2 – Workbook and Volume 3 – Reference Manual* along with the accompanying software (Version 1.3.2) were used to carry out the necessary calculations and to compile the GHG emissions and removals. The *IPCC Good Practice Guidance* complementary to the *Revised 1996 IPCC Guidelines* was used to update emission factors or other default conversion factors where appropriate. All of the relevant completed worksheets and summary tables used in the software are included as appendices to this report.

The sectors considered in this inventory, according to the IPCC guidelines are the following: Energy, Industrial, Solvent and Other Product Use, Agriculture, Land Use & Forestry and Waste. In accordance with the Guidelines set out by the IPCC, $CO_2$ emissions from International Bunkers and burning of biomass are not included in the national totals, but are reported separately as Memo Items in the inventory.

The gases included in the current inventories are the direct GHGs namely carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), and partially fluorinated hydrocarbons (HFCs) and the indirect GHGs - non-methane volatile organic compounds (NMVOC), carbon monoxide (CO), sulphur dioxide ($SO_2$) and nitrogen oxides ($NO_x$).

### 2.1.1 Update Of and Comparisons With The 1994 Inventory

Estimates of the GHG inventories for 1994 and 2000 to 2005 are summarized in Table 2-1 (for all GHGs) and Table 2-2 (for $CO_2$ only). Detailed activity data for the 1994 inventory were limited to fuel import data and the areas occupied by four types of forests (Mixed Fast-Growing Hardwoods, Mixed Hardwoods, Other Forests – Dry, Other Forest Seasonal, Other Forests Moist and Mangroves) and the number of non-forest trees. No other activity or emission factor data were available for verification although it was stated that default IPCC emission factors were used. The INC report indicated that all relevant IPCC worksheets, summary report sheets and uncertainty tables used in the 1994 inventory were provided as appendices but they were not available in the hardcopy or electronic formats. The 1994 inventory did not include estimates for HFCs, NOx, CO or $SO_2$ but except for HFCs, estimates of the 1994 emissions for these gases were recalculated in this report.

**Table 2-1 Comparisons of GHG Emissions (Gg) for 1994, 2000 to 2005**

| Year | $CO_2$ | $CO_2$ | $CH_4$ | $N_2O$ | NOx | CO | NMVOC | $SO_2$ | HFCs |
|---|---|---|---|---|---|---|---|---|---|
| | Emissions | Removals | | | | | | | |
| 1994# | 72.8 | 170 | 0.968 | 0.0946 | 0.432 | 4.45 | 2.43 | 0.105 | NA |
| 2000 | 106 | -138 | 1.57 | 0.118 | 0.595 | 6.32 | 1.64 | 0.177 | 0.0046 |
| 2001 | 118 | -137 | 1.57 | 0.108 | 0.676 | 6.86 | 3.85 | 0.213 | 0.0050 |
| 2002 | 113 | -133 | 1.56 | 0.101 | 0.673 | 7.06 | 2.77 | 0.190 | 0.0017 |
| 2003 | 111 | -131 | 1.55 | 0.107 | 0.614 | 6.13 | 2.30 | 0.202 | 0.0019 |
| 2004 | 111 | -130 | 1.56 | 0.076 | 0.577 | 5.75 | 3.22 | 0.186 | 0.0027 |
| 2005 | 119 | -128 | 1.56 | 0.097 | 0.630 | 6.06 | 2.30 | 0.218 | 0.0030 |

# Estimates for 1994 were updated in this report.

**Table 2-2 Comparisons of $CO_2$ Emissions (Gg) for 1994, 2000 to 2005**

| | 1994 # | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|
| **1 Energy** | 72.8 | 106 | 118 | 113 | 111 | 111 | 119 |
| A Fuel Combustion (Sectoral Approach) | 0.0 | 106 | 118 | 113 | 111 | 111 | 119 |
| 1 Energy Industries | 20.2 | 34.9 | 40.3 | 33.1 | 36.1 | 34.1 | 41.8 |
| 2 Manufacturing Industries & construction | 4.10 | 9.10 | 10.1 | 10.5 | 13.2 | 11.6 | 11.0 |
| 3 Transport | 37.7 | 47.1 | 53.7 | 55.4 | 46.8 | 42.9 | 46.8 |
| 4 Other Sectors | 10.8 | 14.7 | 13.8 | 14.3 | 15.0 | 22.3 | 19.5 |
| a Commercial/Institutional | 7.33 | 10.0 | 9.43 | 9.91 | 10.7 | 18.4 | 15.4 |
| b Residential | 3.41 | 4.07 | 3.67 | 3.59 | 3.42 | 3.08 | 3.29 |
| c Agriculture/Forestry/Fishing | 0.100 | 0.631 | 0.721 | 0.766 | 0.856 | 0.811 | 0.766 |
| **5 Land-Use Change & Forestry (2)** | | | | | | | |
| A Changes in Forest & Other Woody Biomass Stocks (Removals) | -355 | -198 | -198 | -193 | -192 | -190 | -188 |
| B Forest and Grassland Conversion | 26.5 | 60.4 | 60.4 | 60.4 | 60.4 | 60.4 | 60.4 |
| C Abandonment of Managed Lands## | -43.7 | 0 | 0 | 0 | 0 | 0 | 0 |
| D $CO_2$ Emissions & Removals from soil## | 0.37 | 0 | 0 | 0 | 0 | 0 | 0 |

# Updated estimates from this study. ## No data available for 2000 to 2005 but assumed data for 1995 presented in the INC

### 2.1.2 $CO_2$ Emissions

#### 2.1.2.1 Energy Sector

The INC included fuel import data (for Reference Approach calculations), end use emissions by fuel and estimates of $CO_2$ emissions for the energy sector. Detailed information on the fuel consumption for the energy subsectors was not available. The INC $CO_2$ emissions included estimates for naphtha and lubricants. It was assumed that a) the "naphtha" was Spraytex that was used for banana leaf spot disease control which is not burned but is volatile and b) 50% of the lubricants are oxidised. Adjustments reversing the combustion of naphtha and lubricants reduce the energy sector $CO_2$ emissions. NMVOC emissions from Spraytex are reported in the Solvent and Other Product Use sector.
Emissions for the Energy Sector show the expected increase in the later years relative to 1994 and this is consistent with increases in electricity generating capacity, electricity consumption and the motor vehicle fleet.

#### 2.1.2.2 Land Use Change and Forestry

The main differences between the 1994 and inventories for the later years are in the land use change and forestry sector. The 1994 inventory assumed that only 14.9 kha of forested areas were anthropogenically impacted and that there was uptake due to abandoned lands. According to FAO country report (2005) 21.6 kha of the country's total forest of 48 kha is anthropogenically affected. Charles (2000) reported that some commercial harvesting of forests took place up to the mid-1990s and it is possible that such harvesting took place in 1994 but the 1994 inventory did not include data for commercial harvesting. No current data were available to make estimates of abandoned lands and in any event it is believed that the amount of abandoned lands is negligible. The regrowth from harvesting and abandonment of managed lands account for the large sinks reported in the 1994 inventory.

### 2.1.3 Methane

The original estimates for methane emissions (2.97 Gg) were higher in 1994 due to the high value for waste disposal on land (2.73 Gg in 1994 compared to 0.679 Gg in 2000) even though there were no estimates for methane emissions from wastewater handling in 1994. The methane emissions from enteric fermentation and manure management are lower in 1994 but no animal population data were available. The total methane emissions for 1994 are recalculated as 0.944 Gg with 0.013 Gg from the Energy sector, 0.253 Gg from Agriculture using data reported in the 1995 Agricultural census and 0.679 Gg from the Waste sector.

### 2.1.4 Nitrous Oxide

Nitrous oxide emissions in 1994 were reported as 0.042 Gg with 0.032 Gg from agriculture and 0.01 Gg from waste. Animal population data (from the 1995 Agricultural Census), fertilizer imports (from UN Trade Statistics) and population data together with Population and Housing Census data reported in the INC were used to recalculate $N_2O$ emissions at 0.079 Gg from the Agricultural Sector and 0.015 Gg from the waste sector.

## 2.2 ENERGY SECTOR

### 2.2.1 Methodology

Two methods are used to calculate the $CO_2$ emissions for the energy sector. These are the Reference Approach and the Sector Approach, the latter being an end use or bottom-up approach and the former, a top-down approach based on aggregate fuel supply.

Dominica does not produce any primary or secondary fossil fuels. Secondary liquid fuels - gasoline, jet and cooking kerosene, gas oil/diesel, residual (heavy) fuel oil (Bunker C) and liquefied petroleum gas (LPG) and small quantities of ethane, naphtha and shale oil are imported for local consumption. Lubricants and bitumen are also imported.

Activity data (fuel imports and fuel end use data) for the energy sector were obtained from several sources.

- The Central Statistical Office (CSO), Dominica, provided fuel import data for 2000 to 2005.
- Imports and sales of jet A1 fuel, gasoline and diesel for 2003/2004, 2004/2005 and 2005/2006 were provided by National Petroleum Dominica.
- The Caribbean Energy Information System (CEIS) also provided energy demand/consumption data broken down by fuel (Table 2.3) and by sector (Table 2.4) for 2000 to 2005. The bunker data however were incomplete for some years especially for 2005. The breakdown by sector gave the total volumes of fuels (unfortunately by summing the volumes different types of fuel for the various end uses instead of barrel of oil equivalents (boe) or other energy unit) consumed for selected end use categories). The CEIS sectors did not always match the IPCC energy subcategories. However, it was feasible to reallocate the CEIS sector data into the IPCC subcategories since some categories had only one type of fuel and by making other assumptions.
- Annual fuel consumption data for electricity generation for 2000 to 2005 were obtained from Dominica Electricity Limited (DOMLEC).
- Dominica Brewery provided their diesel fuel consumption data.

IPCC default emission factors were used in making the emissions estimates.

### 2.2.2 $CO_2$ Emissions

#### 2.2.2.1 Comparison of the Reference and Sectoral Approaches

The total national $CO_2$ emissions estimated by the reference and sectoral approaches are summarized in Table 2.5. Data for the Reference approach were based on import data except when there were gaps in which case CEIS data were substituted. The agreement between the two approaches is varied and relative to the sectoral approach, ranges from -4% to 5% in four of the years to 11 to 20% in two years. For the sectoral approach locally available (verifiable) data were not always available and gaps were filled using the CEIS data.

**Table 2.3 Energy Demand and Consumption, Dominica, 2000-2005 ('000 bbl)**

| Product/Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| AVIATION GASOLINE | 0.2 | 0.4 | 0.4 | 0.0 | 0.0 | 0.0 |
| TURBO FUEL | 4.7 | 4.6 | 5.9 | 4.6 | 1.5 | 0.0 |
| UNLEADED GASOLINE | 119.9 | 132.1 | 137.4 | 115.4 | 106.4 | 113.2 |
| FUEL OIL *(Bunkers)* | 13.8 | 10.5 | 10.9 | 12.2 | 12.4 | 0.0 |
| KEROSENE | 2.0 | 1.2 | 0.0 | 0.2 | N/A | 2.7 |
| DIESEL/ GAS OIL | 115.6 | 128.9 | 134.1 | 157.8 | 147.5 | 152.7 |
| LPG | 27.6 | 24.5 | 25.5 | 25.6 | 23.1 | 27.4 |
| OTHER | N/A | N/A | N/A | N/A | N/A | 2.3 |
| TOTALS | 283.8 | 302.1 | 314.2 | 315.8 | 290.9 | 298.4 |

Source: Caribbean Energy Information Services (CEIS), 2009

**Table 2.4 Energy Demand and Consumption, Dominica, 2000-2005 ('000 bbl)**

| Sector/Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| AGRICULTURE | 1.4 | 1.6 | 1.7 | 1.9 | 1.8 | 1.7 |
| COMMERCIAL | 2.5 | 2.3 | 2.4 | 2.8 | 2.6 | 2.4 |
| TRANSPORTATION | 147.2 | 161.6 | 168.0 | 144.0 | 130.4 | 127.1 |
| GOVERNMENT | 10.6 | 11.8 | 12.3 | 14.5 | 13.4 | 12.4 |
| RESIDENTIAL | 15.2 | 13.6 | 14.1 | 13.3 | 12.1 | 11.2 |
| ELECTRIC UTILITY | 73.2 | 76.7 | 79.8 | 91.5 | 74.9 | 91.7 |
| TOURISM | 13.5 | 12.0 | 12.5 | 12.3 | 11.3 | 10.4 |
| OTHER MFG | 11.6 | 12.9 | 13.4 | 17.8 | 14.9 | 13.7 |
| CONSTR. | 8.5 | 9.5 | 9.9 | 11.6 | 10.9 | 10.6 |
| OTHER | 0.1 | 0.1 | 0.1 | 6.1 | 18.7 | 17.3 |
| TOTALS | 283.8 | 302.1 | 314.2 | 315.8 | 291.0 | 298.4 |

Source: Caribbean Energy Information System, 2009

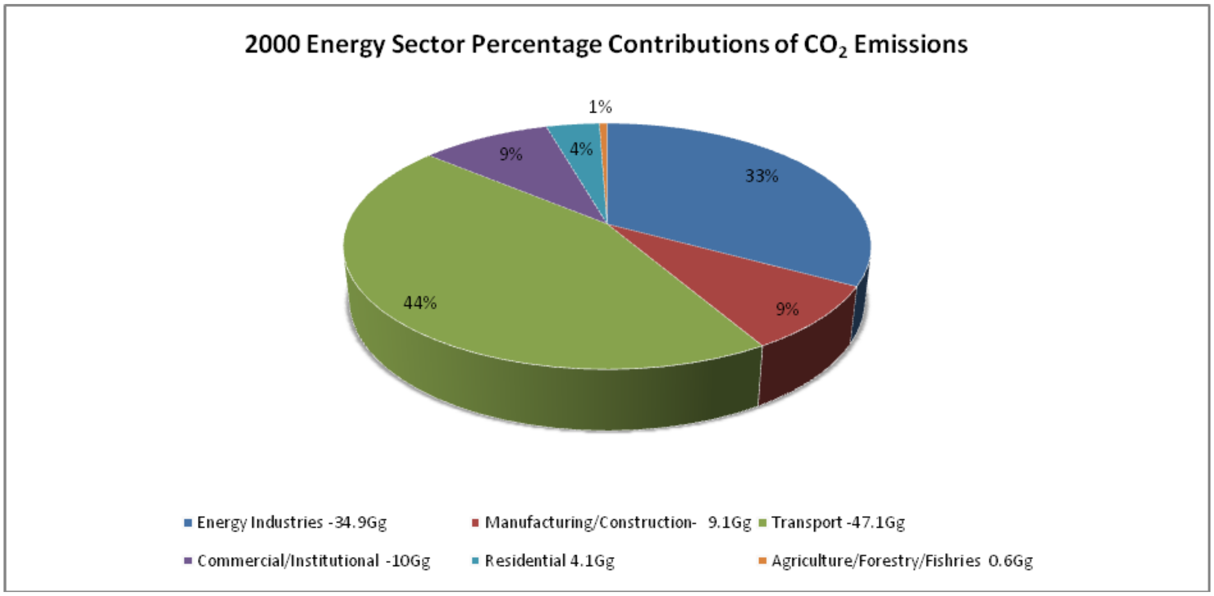
**Table 2.5 Comparison of $CO_2$ Emissions (Gg) for the Reference and Sectoral Approaches**

| **$CO_2$ Trends Energy** | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| Reference Approach | 107 | 104 | 90 | 116 | 107 | 114 |
| Sectoral Approach | 106 | 118 | 113 | 111 | 111 | 119 |

### 2.2.2.2Energy Sector Carbon Dioxide ($CO_2$) Emissions

The percentage contributions of $CO_2$ emissions by subsectors within the energy sector for the base year 2000 utilizing the Sectoral Approach is presented in Figure 2-1. The Energy Industries (33%) and Transportation (44%) subsectors are the main contributors accounting for 77% of total emissions from the sector. The contributions are similar in the other years assessed and account for between 70% and 80% of the $CO_2$ emissions while the Manufacturing Industries & Construction and Other (residential, commercial and forestry and fishing subsectors) respectively account for the remainder (see Table 2-6 and Figure 2-2). There is no consistent trend in the total emissions or in the subsector emissions over the period 2000 to 2005. The transport sector has the largest $CO_2$ emissions (43 to 54 Gg) and accounts for 39 to 49% of the emissions between 2000 and 2005.

**Figure 2.1 2000 Energy Sector Percentage Contributions of $CO_2$ Emissions**




Apart from the activity data for electricity generation (Energy industries) there was no other locally available and verifiable end use data. There is a need to compile fuel (i.e., gasoline, diesel and LPG etc.) sales data to various end users (service stations, manufacturing, commercial/institutional and agriculture/forestry/fishing) in order to improve the emissions estimates.

### 2.2.2.3 Memo Items

The 1996 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.

Carbon dioxide ($CO_2$) emissions from International Bunkers arise from jet kerosene sold to international aircraft and bunker C fuel to marine vessels. There are two airports (Melville Hall and Canefield Airports) on Dominica and international flights occur from both airports. The Canefield airport can only accommodate smaller aircrafts. Although total annual landing and take-off (LTO) data were available for both airports, it was not feasible to estimate the fuel used for domestic flights since the numbers of domestic and international LTOs were not available. Although there are some intra-island flights their number is small relative to the international flights and hence it was assumed that all aircraft fuel consumption was for international bunkers.

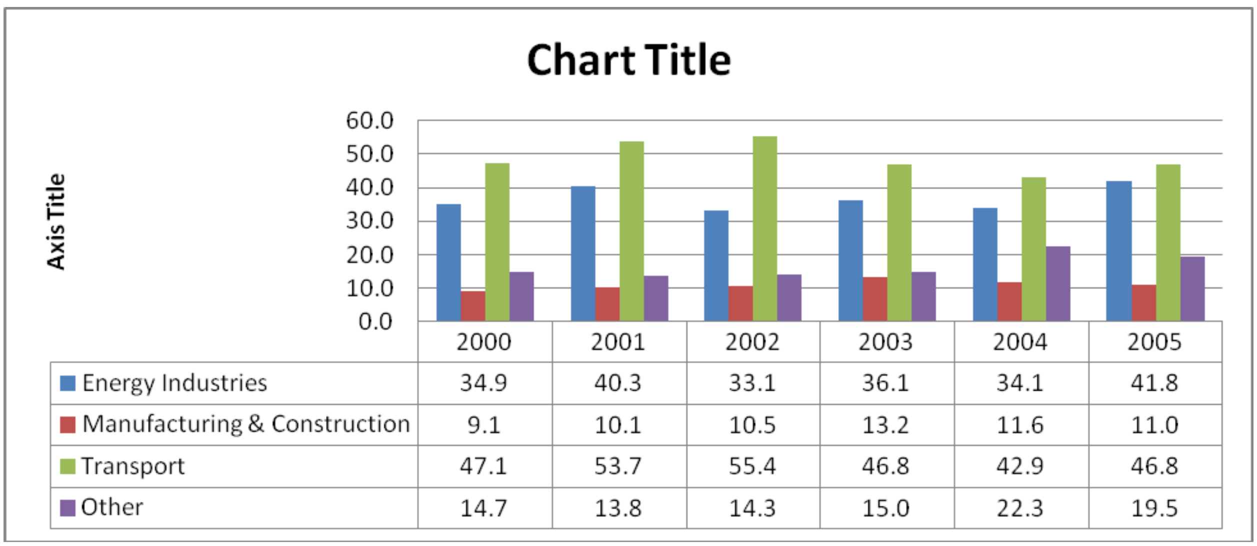
The years 2004 and 2005 were marked by sharp increase in international marine bunker emissions as a result of the availability of increased berthing facilities.

There are no reported data for the amounts of charcoal used or produced but census data reported in the Country Poverty Assessment (2003) and a survey of living conditions (Betti et al 2006) for 2001 indicate that 5% of households use charcoal and 13% use wood for cooking. Estimates of wood and charcoal used in the residential sector were made based on the assumptions that the typical amount of fuel used for cooking in developing countries (6000 kcal/person/day) (FAO 1983). Also considered in the estimates was Dominica's census population data, the heat content data for wood and charcoal and the typical conversion ratio for wood to charcoal (23%) (Amous 1999).

**Table 2.6 Summary of Energy Sector $CO_2$ Emissions (Gg)**

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| **1 Energy** | 106 | 118 | 113 | 111 | 111 | 119 |
| A Fuel Combustion (Sectoral Approach) | 106 | 118 | 113 | 111 | 111 | 119 |
| 1 Energy Industries | 34.9 | 40.3 | 33.1 | 36.1 | 34.1 | 41.8 |
| 2 Manufacturing Industries & Construction | 9.1 | 10.1 | 10.5 | 13.2 | 11.6 | 11.0 |
| 3 Transport | 47.1 | 53.7 | 55.4 | 46.8 | 42.9 | 46.8 |
| 4 Other Sectors | 14.7 | 13.8 | 14.3 | 15.0 | 22.3 | 19.5 |
| a Commercial/Institutional | 10.0 | 9.4 | 9.9 | 10.7 | 18.4 | 15.4 |
| b Residential | 4.1 | 3.7 | 3.6 | 3.4 | 3.1 | 3.3 |
| c Agriculture/Forestry/Fishing | 0.6 | 0.7 | 0.8 | 0.9 | 0.8 | 0.8 |
| 5 International Bunkers | 8.33 | 7.67 | 7.53 | 7.48 | 43.05 | 238.97 |

**Figure 2-2 Energy Sector $CO_2$ Emissions in 2000 - 2005**




### 2.2.3 Energy Sector Non $CO_2$ Emissions

Non-$CO_2$ emissions include emissions of methane ($CH_4$), nitrous oxide ($N_2O$), nitrogen oxides (NOx), non-methane volatile organic compounds (NMVOC), carbon monoxide (CO) and sulphur dioxide ($SO_2$). The $N_2O$, $SO_2$ and HFC emissions (see Table 2.7) are relatively small (less than 0.2 Gg) while the average annual $CH_4$, NOx, CO and NMVOC emissions were respectively 1.56 Gg, 0.63 Gg, 6.37 Gg and 2.68 Gg.

**Table 2.7 Non-$CO_2$ Energy Sector Emissions (Gg) for Dominica: 2000 - 2005**

| Year | $CH_4$ | $N_2O$ | NOx | CO | NMVOC | $SO_2$ | HFCs |
|---|---|---|---|---|---|---|---|
| **2000** | 1.57 | 0.118 | 0.595 | 6.32 | 1.015 | 0.177 | 0.0046 |
| **2001** | 1.57 | 0.108 | 0.676 | 6.86 | 3.85 | 0.213 | 0.0050 |
| **2002** | 1.56 | 0.101 | 0.673 | 7.06 | 2.77 | 0.190 | 0.0017 |
| **2003** | 1.55 | 0.107 | 0.614 | 6.13 | 2.30 | 0.202 | 0.0019 |
| **2004** | 1.56 | 0.076 | 0.577 | 5.75 | 3.22 | 0.186 | 0.0027 |
| **2005** | 1.56 | 0.097 | 0.630 | 6.06 | 2.30 | 0.218 | 0.0030 |

## 2.3 INDUSTRIAL SECTOR EMISSIONS

The industrial sector in Dominica is limited. The facilities that are GHG sources are a brewery, bakeries and asphalt paving which give rise to NMVOC emissions. HFCs are released from refrigeration and air conditioning use.

### 2.3.1 Methodology

Import data for bitumen, solvents and refrigeration and air conditioning products were obtained from the CSO, Government of the Commonwealth of Dominica. Default IPCC emission factors based on production levels or on import data were then used to estimate NMVOC emissions following the *Revised 1996 IPCC guidelines*.

The *Revised 1996 IPCC guideline* Tier 1 methodology was used to estimate the potential HFC emissions. The estimate was based on the number of different types of refrigeration and air conditioning products and equipment (e.g., household or larger (commercial) refrigerators, window and larger air conditioning units and motor vehicles (all of which were assumed to have air conditioners). IPCC defaults were used to estimate the quantity of HFC material in each product and potential losses.

Data for the amount of road surface area paved or the amount of asphalt actually produced were not available so it was assumed that all of the bitumen imported was used for road paving and that paving material contained 10% bitumen (Photo 2.1). The default emission factor for NMVOC emission for road paving was used. Production data for brewed products and alcoholic beverages were obtained from the brewery. Default emission factors offered under the IPCC workbooks were used in calculating the GHG emissions. Production data for bread and similar products were not available so no emissions from bread making were estimated. The potential release of HFCs was based on customs import data for products that contain HFCs (refrigerators, air conditioning equipment and motor vehicles). Import data were obtained from the CSO.

### 2.3.2 Emissions from Industrial Processes

There are no emissions of $CO_2$ from industrial processes in Dominica. The non-$CO_2$ emissions are NMVOCs from road paving (Photo 2.1) and HFCs from the use of equipment that contains HFCs. Table 2.8 shows the emissions from the Industrial sector for 2000 to 2005. No production data for bread and other food products (whose preparation results in NMVOC emissions) were available.

**Table 2.8 Emissions from Industrial Processes**

| | Annual Emissions (Gg) | | | | | |
|---|---|---|---|---|---|---|
| | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** |
| NMVOCs | 0.342 | 2.473 | 1.340 | 1.039 | 2.033 | 1.061 |
| HFCs | 0.00461 | 0.00502 | 0.00170 | 0.00187 | 0.00275 | 0.00295 |

**Photo 2.1 Bath Road to Goodwill link road**

## 2.4 SOLVENT AND OTHER PRODUCT USE

The use of solvents and certain products can result in emissions of NMVOCs. Nitrous oxide is released in certain medical applications (anaesthetics). These source categories are included in the Revised IPCC Guidelines although there is no specific guidance in the IPCC manuals on how to estimate the emissions from these sources.

Emissions from solvent and product use were not calculated in the INC 1994 inventory because specific IPCC methodologies had not been provided in the guidance documents and the UNFCCC software did not have a module to handle these emissions. For this inventory, estimations of NMVOC emissions were estimated for products such as paints, varnishes, thinners, enamels and household product use.

### 2.4.1 Methodology

Estimates of the emissions from solvent and other product use are based the amounts of products used and the percentage of NMVOC or $N_2O$ that evaporates during use. Import data for paint products were obtained from the CSO and it was assumed that all imports were used in the same year. It was also assumed that the imported paints had the same solvent content limits as the US Federal EPA solvent content limits.

The emission factors represent the use of household products in the US and no data on the use of these products in Dominica (i.e., country-specific emission factors) were available. The emission factor was multiplied by the population in each year to give the NMVOC emissions from household product use in each year. Emissions of $N_2O$ were not estimated since no import data were available.

### 2.4.2 Activity and Emission Factor Data

Import data for paints categorized based on typical solvent content and the corresponding emission factors are summarized in Table 2.9.

**Table 2.9 Emission Factor and Import Data for Paints**

| | Emission factor (g/Litre) | Imports (kg) (CSO) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
| Polyester | 250 | 108,905 | 71,994 | 28,919 | 104,413 | 135,108 | 96,471 |
| Varnish | 450 | 14,529 | 3,279 | 3,625 | 1,515 | 1,362 | 2,527 |
| Enamels | 450 | 16,891 | 6,831 | 427 | 9,723 | 1,719 | 2,908 |
| Water based | 250 | 28,329 | 31,437 | 20,911 | 18,034 | 5,101 | 24,809 |
| Emissions (Gg) | | 0.0299 | 0.0185 | 0.0278 | 0.0250 | 0.0233 | 0.0226 |

**Source: CSO**

### 2.4.3 NMVOC Emissions

Estimates of the total NMVOC emissions from Solvent and Other Product Use are shown in Table 2.10.

**Table 2.10 NMVOC Emissions from Solvent and Other Product Use**

| | NMVOC Emissions (Gg) | | | | | |
|---|---|---|---|---|---|---|
| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
| Paints | 0.0299 | 0.0185 | 0.0278 | 0.0250 | 0.0233 | 0.0226 |
| Personal Care products | 0.254 | 0.244 | 0.250 | 0.250 | 0.251 | 0.252 |
| Total | 0.284 | 0.263 | 0.278 | 0.275 | 0.274 | 0.275 |

## 2.5 AGRICULTURE

Dominica's agricultural sector is based on the cultivation of bananas and citrus mainly for export and root crops, vegetables and fruit mainly for local consumption. Cultivation of bananas has declined dramatically over the past ten years largely due to change in export marketing arrangements. There is limited export of some root crops and citrus. Livestock (cattle, goats, sheep, pigs and poultry) are reared for local consumption.

Agricultural activities lead to emissions of $CH_4$ from enteric fermentation and $CH_4$ and $N_2O$ emissions from fertilizer application to cultivated soils, excretion from grazing animals, atmospheric deposition of $NH_3$ and NOx, and from leaching of agricultural soils.

### 2.5.1 Methodology

The IPCC Tier 1 approach was used to calculate methane emissions from enteric fermentation and manure management emissions using regional default IPCC emission factors and the country-specific populations for each category of livestock.

$N_2O$ emissions from soils, animal production and from the application of fertilizers are estimated based on the amounts of nitrogen input from synthetic fertilizers, animal waste, nitrogen fixing crops and crop residues. Direct and indirect $N_2O$ releases to the atmosphere are then estimated from these inputs using default IPCC emission factors.

Animal population data were obtained from estimates made by FAO[ii] although the estimate for cattle appears high. The most recent agricultural census for Dominica was in 1995 and these data are also included in Table 2.11.

Crop production data were obtained from International Monetary Fund (IMF) (2005, 2007 reports (2005, 2007) which included data provided by CSO. Annual import data obtained from CSO for synthetic fertilizer was used as a surrogate for fertilizer use.

**Table 2.11 Animal Population in Dominica**

| Animal Category | 1995 Agricultural Census | 2000 to 2005 FAOSTAT |
|---|---|---|
| Cattle | 3,305 | 13,400 |
| Pigs | 3,858 | 5,000 |
| Sheep | 3,323 | 7,600 |
| Goats | 10,918 | 9,700 |
| Rabbits | 2,308 | |
| Poultry | 66,522 | 190,000 |

### 2.5.2 $CO_2$ Emissions

No $CO_2$ emissions were released from the agriculture sector.

### 2.5.3 Non-$CO_2$ Emissions

#### 2.5.3.1 Methane

Total annual $CH_4$ emissions for the period 2000-2005 (0.748 Gg) showed an increase over the year 1994 (0.226Gg). This is primarily a result of a larger number of cattle and an accompanied increase in enteric emissions which accounted for over 90% of total $CH_4$ emissions from the agricultural sector. Table 2.12 shows the agriculture sector $CH_4$ emissions for 2000 to 2005.

**Table 2.12 Methane ($CH_4$) Emissions for the Agriculture Sector, Dominica, 2000-2005**

| Agriculture and Land Use $CH_4$ Emissions (Gg) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1994 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
| Enteric fermentation | 0.226 | 0.748 | 0.748 | 0.748 | 0.748 | 0.748 | 0.748 |
| Manure management | 0.014 | 0.0315 | 0.0315 | 0.0315 | 0.0315 | 0.0315 | 0.0315 |

An average of 0.75 Gg of methane was emitted due to enteric fermentation while 0.03 Gg emitted as a result of animal manure management. There were no trends between 2000 and 2005 since the animal population remained fairly constant.

#### 2.5.3.2 Nitrous Oxide

Nitrous oxide emissions from manure management and agricultural soils are shown in Table 2.13 for the period under review the nitrous oxide emissions ranged from 0.06 to 0.10 Gg annually.

**Table 2.13 Nitrous Oxide Emissions from the Agriculture Sector, Dominica, 2000 - 2005**

| | $N_2O$ Emissions (Gg) | | | | | |
|---|---|---|---|---|---|---|
| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
| Agriculture | 0.101 | 0.091 | 0.085 | 0.091 | 0.060 | 0.081 |
| A Enteric Fermentation | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| B Manure Management | 0.00627 | 0.00063 | 0.00063 | 0.00063 | 0.00063 | 0.00063 |
| C Rice Cultivation | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| D Agricultural Soils | 0.0950 | 0.0906 | 0.0840 | 0.0900 | 0.0593 | 0.0801 |

## 2.6 LAND USE CHANGE AND FORESTRY

Human activity that changes the way in which land is used or which affects the amount of biomass in existing biomass stocks give rise to emissions of $CO_2$ as well as $CH_4$ and $N_2O$. Other GHGs such as nitrogen oxides, CO and NMVOCs are also emitted especially when land is burned. In contrast, primary forests which are devoid of human activities are considered to be in equilibrium with respect to changes in $CO_2$.

Land-uses that impact biomass stocks are accounted for by estimating the net change in biomass over a 10 year time frame. In Dominica, changes that impact biomass stocks are mainly due to harvesting of wood for construction and fuel, removal of forest cover for road construction, and converting forested areas to other use such as agriculture or residential development. In addition to forest and land-use changes, the change in the carbon content of soils are considered based on changes in cultivation and soil management practices.

Land use in Dominica (Table 2.14) derived from the satellite (LandSat) based land cover and vegetation maps show that ~48 kha or ~63% of the total area (750 km$^2$) is forested. The FAO classification indicates that the four Montane forest classes are primary forests while the other classes which were 19.76 kha in 2000 are anthropogenically impacted.

**Table 2.14 Land Use in Dominica**

| National Classes 2000 | FAOSTAT 2000 (1000 ha) |
|---|---|
| Montane Cloud Forest | 0.25 |
| Evergreen Montane Shrubland | 1.06 |
| Montane Rain Forest | 3.02 |
| Submontane Rain Forest | 23.49 |
| Disturbed Submontane Rain Forest | 8.35 |
| Lowland/Submontane Seasonal Evergreen Forest | 5.65 |
| Lowland Drought Deciduous Shrub/Semi- | 5.51 |
| Seasonally Flooded | 0.25 |
| **Total forest** | **47.58** |
| Fallow/Cleared Land | 2.68 |
| Active Agriculture | 21.76 |
| Urban/Residential/Bare Soil/Rock | 1.29 |
| Short/Medium/Tall Grassland | 1.67 |
| Fumerole | 0.02 |
| Fumerole Sulphurous | 0.00 |
| **Total other land** | **27.42** |
| **Total land area** | **75.00** |

Source (FAO, 2005). Global Forest Resources Assessment: Country Reports Dominica, Forestry Department, Food and Agriculture Organization of the United Nations. FRA2005/082, Rome,

### 2.6.1 Methodology

There are not sufficiently detailed forestry data to allow use of the most recent IPCC Good Practice Guidance methodology (2003) hence the methodology in the Revised 1996 Guidance documents was used but incorporates information in the Good Practice Guidance where data exist. The estimates were based primarily on an analysis of land-use changes provided in the FAO (2005) report.

The changes in forest cover biomass for the anthropogenically impacted forest types forest were estimated using the data in Table 2.15derived from the FAO 2005 report. Application of lime to soils is not a practice in Dominica. No data were available for amounts of abandoned lands or for changes in land use that would affect soil carbon. Regional IPCC default emission factors were used to estimate the growth rate of biomass for different forests. Conversion factors relating to Carbon Fraction, Biomass Conversion/Expansion, and Fraction of Biomass Oxidized were taken as default values from the IPCC Workbooks.

The FAO report included the areas covered by the various classes for 2000 and 2005 based on extrapolation of data for 1984 and 2000 (see Table 2.15. The areas for the intervening years (2001 to 2004) were estimated by interpolation of the 2000 (47.58 Kha) and 2005 (46.27 Kha) data. Based on the data the total annual decline was calculated at 0.26 kha/y. No data were available to make estimates for the amount of this decline that was attributed to forest that was burned. In the absence of reliable data it was assumed that similar fractions (25%) were burned on-site and off-site and the remainder (50%) left to decay.

The amount of plantation forests in Dominica is negligible (< 40 ha) and those plantations were established nearly 40 years ago (FAO 2005).

**Table 2.15 Forest Cover in Dominica, 1984 to 2005**

| | Area (1000 ha)# | | | |
|---|---|---|---|---|
| **National Classes 2000** | **1984** | **1990** | **2000** | **2005** |
| Montane Cloud Forest | 0.17 | 0.20 | 0.25 | 0.28 |
| Evergreen Montane Shrubland | 0.80 | 0.90 | 1.06 | 1.14 |
| Montane Rain Forest | 3.64 | 3.41 | 3.02 | 2.83 |
| Submontane Rain Forest | 24.49 | 24.11 | 23.48 | 23.17 |
| Disturbed Submontane Rain Forest | 9.09 | 8.81 | 8.35 | 8.12 |
| Lowland/Submontane Seasonal Evergreen Forest | 7.17 | 6.60 | 5.65 | 5.17 |
| Lowland Drought Deciduous Shrub/Semi- | 6.24 | 5.97 | 5.51 | 5.28 |
| Seasonally Flooded R.F./W.L./G.L | 0.17 | 0.20 | 0.25 | 0.28 |
| **Total forest and other wooded land** | **51.77** | **50.20** | **47.58** | **46.27** |
| **Total other land** | **23.23** | **24.80** | **27.42** | **28.73** |
| **Total land area** | **75.00** | **75.00** | **75.00** | **75.00** |

# Data for the years 1990 and 2005 were forecast using linear interpolation and extrapolation of the data from 1984 and 2000 (total annual forest loss of 260 ha/yr).

Although there have been sporadic commercial harvesting of forests in Dominica in the last century the latest commercial venture folded in the mid-1990s (Charles 2000). FAO report harvesting of 47,200 $m^3$ sawn wood forest products in 2003 and 65,500 $m^3$ in later years (2004 to 2007) but none between 2000 and 2002. These data could not be substantiated and were not used in the inventory.

Charcoal is used for cooking but there are no available estimates for the amount of charcoal produced or of wood used to make charcoal. The percentages of households that use wood or charcoal as the main fuel for cooking were estimated respectively at 13% and 5% in 2003 (CPA 2003). It is also believed that charcoal and wood is used for other purposes (incidental domestic use and bay oil distillation). No data are available for the amount of charcoal or wood used in the bay oil industry.

Estimates for the typical energy use for cooking using wood or charcoal vary widely from country to country and within countries but most estimates were in the range 1 to 1.5 kg/person/day (Alexander and Fairbridge 1999). The equivalent amount of wood used in Dominica households for wood and charcoal cooking was estimated to be in the range 10 to 11 ktonne/year and this was assigned to other wood use in estimating changes in biomass stocks.

No data were available on changes in forestry or agricultural land management practices in order to estimate emissions of $CO_2$ due to changes in land management practices (abandonment of managed lands) or soil carbon content. In any event most of the agricultural land management changes were assumed to be for crop rotation and/or changes in crops.

### 2.6.2 $CO_2$ Emissions from Land Use Change and Forestry

Despite the progressive decline in $CO_2$ removals during the period 2000-2005, Dominica's land use change and forest sector represents a net sink of $CO_2$ (see Table 2.16). The releases (emissions) due to conversion from forested areas to settlements remained constant over the period, but this is far outweighed by the sink changes due to woody biomass stocks (removals).

**Table 2.16 Carbon Dioxide ($CO_2$) Emissions and Removals From Land Use Change and Forestry, Dominica, 2000 - 2005**

| **Category** | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| **5 Land-Use Change & Forestry** | -138 | -137 | -133 | -131 | -130 | -128 |
| A Changes in Forest and Other Woody Biomass Stocks (Removals) | -198 | -198 | -193 | -192 | -190 | -188 |
| B Forest and Grassland Conversion | 60.4 | 60.4 | 60.4 | 60.4 | 60.4 | 60.4 |
| C Abandonment of Managed Lands | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| D $CO_2$ Emissions and Removals from Soil | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| E Other (please specify) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

## 2.7 WASTE SECTOR

Emissions from the waste sector arise from the treatment and disposal of municipal or industrial solid waste and from the treatment and disposal wastewater from domestic and industrial sources. Solid waste treatment methods include disposal in landfills or burning waste in incinerators or in waste to energy plants. The main pollutants released during these processes are $CH_4$ and $CO_2$ from landfill sites and $CO_2$ and other pollutants from incineration. Wastewater treatment can release $CH_4$ in anaerobic systems and $CO_2$ in aerobic systems.
Dominica has two solid waste disposal sites one of which was closed in 2005. There is a sewage system in Roseau which is used to convey sewage from residencies and businesses in Roseau and surrounding communities to a primary treatment facility and then to a submarine outfall. Domestic sewage in rural areas is treated in individual septic pits or latrines. There are no municipal or industrial wastewater treatment facilities.

### 2.7.1 Methodology

The default IPCC methodology which uses a mass balance approach was used to estimate $CH_4$ emissions from solid waste disposal sites. The mass balance approach involves estimating the degradable organic carbon (DOC) content of the solid waste (i.e., the organic carbon that is accessible to biochemical decomposition), and using this estimate to calculate the amount of $CH_4$ that can be generated based on the total volume of waste deposited in the disposal site. IPCC default emission factors were used for the fraction of DOC that degrades and the fraction of carbon released as methane.

Indirect $N_2O$ emissions from human sludge were estimated from the nitrogen content of human sludge which was based on the per capita protein consumption of an average person in Dominica and then by applying a default IPCC emission factor (kg $N_2O$/kg human Sludge N). A waste characterization study (DSWMC, 2006) conducted in 2002 provided country-specific estimates of the degradable organic carbon in waste. Data for the amount of waste received at the sanitary landfill during the first nine months of 2007 were used to estimate the per capita waste generated. It was assumed that the per capita waste generation in 2007 was the same as in 2000 to 2005. Population data obtained from the CSO and per capita solid waste disposal noted above were used to calculate total solid waste per year.

### 2.7.2 $CH_4$ Emissions from Solid Waste Disposal Sites

Emissions of $CH_4$ and $N_2O$ are shown in Tables 2.17 and 2.18 respectively. In 1994 there were a lot more solid waste disposal sites located all over the island as compared to the period 2000-2005. This explains the drop in $CH_4$ emissions from the year 1994.

**Table 2.17 $CH_4$ Emissions from Waste, Dominica, 2000 - 2005**

| | $CH_4$ Emissions (Gg) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **1994** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** |
| **Waste Total** | 2.73 | 0.679 | 0.674 | 0.668 | 0.665 | 0.668 | 0.673 |
| Solid Waste Disposal on Land | 2.73 | 0.470 | 0.466 | 0.463 | 0.459 | 0.463 | 0.466 |
| Wastewater Handling | | 0.209 | 0.208 | 0.205 | 0.205 | 0.205 | 0.207 |

**Table 2.18 $N_2O$ Emissions from Waste, Dominica, 2000 - 2005**

| | $N_2O$ Emissions (Gg) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **1994** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** |
| **Waste Total** | 0.01 | 0.015 | 0.015 | 0.015 | 0.015 | 0.014 | 0.015 |
| Solid Waste Disposal on Land | 0.00 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Wastewater Handling | 0.01 | 0.015 | 0.015 | 0.015 | 0.015 | 0.014 | 0.015 |

## 2.8 SUMMARY

Emissions of the direct greenhouse gases can be expressed as an equivalent amount of carbon dioxide ($CO_2$e) that would have the same global warming potential (GWP) when measured over a specified timescale (generally, 100 years). $CO_2e$ reflects the time-integrated radioactive forcing of a quantity of emissions or rate of greenhouse gas emission.

In order to convert the various greenhouse gases to CO2e they are multiplied by their global warming potential (GWP). The GWP approved for use by the IPCC for conducting national inventories for $CO_2$, $CH_4$, $N_2O$ and HFC134a are respectively 1, 21, 310 and 1300. Note that HFCs are assumed to be all HFC134a. The $CO_2e$ emissions for 2000 to 2005 are summarised in Table 2.19. The data show that $CO_2$ emissions from mobile combustion sources (i.e., on road transportation) followed by energy industries (electricity generation) in the energy sector are the two largest overall contributors to $CO_2e$ emissions. The next largest source is direct and indirect $N_2O$ emissions in the agricultural sector.

**Table 2.19 $CO_2e$ Emissions for Dominica, 2000 to 2005**

| | | | $CO_2e$ (Gg) | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sector | Source Categories | GHG | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
| Energy | Fuel combustion | $CH_4$ | 1.02 | 1.05 | 1.05 | 1.00 | 1.01 | 1.02 |
| Energy | Mobile Combustion: Road Vehicles | $CO_2$ | 47.1 | 53.7 | 55.4 | 46.8 | 42.9 | 46.8 |
| Energy | Energy Industries | $CO_2$ | 34.9 | 40.3 | 33.1 | 36.1 | 34.1 | 41.8 |
| Energy | Other Sectors: Residential CO2 | $CO_2$ | 4.07 | 3.67 | 3.59 | 3.42 | 3.08 | 3.29 |
| Energy | Manufacturing Industries and Construction | $CO_2$ | 9.10 | 10.14 | 10.55 | 13.25 | 11.63 | 10.95 |
| Energy | Commercial institutional | $CO_2$ | 9.97 | 9.43 | 9.91 | 10.70 | 18.40 | 15.43 |
| Energy | Agriculture/Forestry/ Fishing | $CO_2$ | 0.631 | 0.721 | 0.766 | 0.856 | 0.811 | 0.766 |
| Energy | Fuel combustion | $N_2O$ | 0.393 | 0.424 | 0.411 | 0.404 | 0.403 | 0.397 |
| Industrial Processes | Consumption of Halocarbons | HFC | 0.00461 | 0.00502 | 0.00170 | 0.00187 | 0.00275 | 0.00295 |
| Agriculture | Enteric Fermentation | $CH_4$ | 15.7 | 15.7 | 15.7 | 15.7 | 15.7 | 15.7 |
| Agriculture | Manure management | $CH_4$ | 0.662 | 0.662 | 0.662 | 0.662 | 0.662 | 0.662 |
| Agriculture | (Direct and Indirect)Agricultural Soils | $N_2O$ | 29.4 | 28.1 | 26.0 | 27.9 | 18.4 | 24.8 |
| Agriculture | Manure management | $N_2O$ | 1.94 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 |
| LULUCF | Forest and Grassland Conversion | $CH_4$ | 1.32 | 1.32 | 1.32 | 1.38 | 1.32 | 1.32 |
| LULUCF | Forest and Grassland Conversion | $CO_2$ | -138 | -137 | -133 | -133 | -130 | -128 |
| LULUCF | Forest and Grassland Conversion | $N_2O$ | 0.134 | 0.134 | 0.134 | 0.140 | 0.134 | 0.134 |
| Waste | Solid Waste Disposal on Land | $CH_4$ | 9.88 | 9.78 | 9.72 | 9.64 | 9.72 | 9.78 |
| Waste | Wastewater Handling | $CH_4$ | 4.39 | 4.37 | 4.31 | 4.31 | 4.31 | 4.35 |
| Waste | Wastewater Handling | $N_2O$ | 4.52 | 4.50 | 4.58 | 4.58 | 4.45 | 4.58 |
| | | | | | | | | |
| All | All | $CO_2$ | -31.7 | -19.1 | -19.7 | -21.5 | -18.6 | -8.77 |
| All | All | $CH_4$ | 33.0 | 32.9 | 32.8 | 32.7 | 32.7 | 32.9 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| All | All | $N_2O$ | 36.4 | 33.4 | 31.3 | 33.2 | 23.6 | 30.1 |
| All | All | HFCs | 0.00461 | 0.00502 | 0.00170 | 0.00187 | 0.00275 | 0.00295 |
| National Total | All | All | 37.7 | 47.1 | 44.4 | 44.4 | 37.7 | 54.2 |

Table 2.20 provides a national summary of the Greenhouse Gas Inventory for the baseline year 2000, with data disaggregated on a sectoral basis. The data shows that Dominica is a net sink for $CO_2$ amounting to a net removals of 31.60 Gg of $CO_2$. Similar results are obtained for the years 2001-2005.

**Table 2.20 National Summary of the Greenhouse Gas Inventory of anthropogenic emissions by sources and removals by sink of GHG not controlled by the Montreal Protocol and GHG precursors for the Baseline Year 2000**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$ (Gg) | $CH_4$ (Gg) | $N_2O$ (Gg) | CO (Gg) | $NO_X$ (Gg) | NMVOC (Gg) | $SO_2$ (Gg) | HFCs (Gg) |
|---|---|---|---|---|---|---|---|---|
| **Total (Net) National Emissions and removals** | **-31.6** | **1.57** | **0.117** | | **0.595** | **1.64** | **0.177** | **0.00461** |
| **1 All Energy** | **106** | **0.049** | **0.00127** | | **0.579** | **1.015** | **0.177** | |
| ***Fuel Combustion* (Sectoral Approach)** | **106** | **0.0487** | **0.0013** | **5.76** | **0.579** | **1.01** | **0.177** | |
| Energy and transformation industries | 34.9 | 0.0014 | 0.0003 | 0.0071 | 0.0943 | 0.0024 | 0.124 | |
| Manufacture Industry and Construction | 9.1 | | | | | | | |
| Transport | 47.1 | 0.0002 | 0.0001 | 0.0012 | 0.0248 | 0.0006 | 0.0301 | |
| Commercial- Institutional | 10 | 0.0128 | 0.0004 | 5.09 | 0.417 | 0.954 | 0.0171 | |
| Residential | 4.1 | 0.0342 | 0.0005 | 0.668 | 0.0428 | 0.0572 | 0.0035 | |
| Agriculture, Forestry, Fishing | 0.6 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0017 | |
| Fugitive Emissions | NO | NO | | NO | NO | NO | NO | |
| **2 Industrial Processes** | | | | | | **0.342** | | **0.00461** |
| Road paving asphalt | NO | NO | NE | NE | NE | 0.342 | NE | NO |
| Alcoholic beverages | NO | NO | NE | NE | NE | NE | NE | NE |
| Refrigeration and Air Conditioning Use | NO | NO | NE | NE | NE | NE | NE | 0.00461 |
| **3 Solvent and Other Product use** | | | **NE** | | | **0.284** | | |
| Paints | | | NE | | | 0.0299 | | |
| Personal Care products | | | NE | | | 0.254 | | |
| **4 Agriculture** | | **0.779** | **0.101** | | | | | |
| Enteric Fermentation | | 0.748 | | | | | | |
| Leaching of agricultural soils | | | 0.095 | | | NE | | |
| Cultivation of histosols | | | | | | NE | | |
| Manure management | | 0.0315 | 0.00627 | | | NE | | |
| Grazing animals | | NE | NE | NE | NE | NE | | |
| **5 Land Use Change and Forestry** | **-138** | **0.0630** | | | **0.0157** | | | |
| Changes in Forestry and other woody biomass stock | -198 | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Forest and grassland conversion | 60.4 | 0.0630 | NE | NE | 0.0157 | | | |
| Abandonment of Managed lands | | | | | | | | |
| **6 Solid Waste** | | **0.679** | **0.015** | | | | | |
| Solid Waste disposal on land | | 0.47 | | NE | | NE | | |
| Sewage | | 0.209 | 0.015 | NE | NE | NE | | |
| **Memo Items** | | | | | | | | |
| **International Bunkers** | 8.33 | NA | NA | NA | NA | NA | NA | |
| Aviation | | NA | NA | NA | NA | NA | NA | |
| Marine | | NA | NA | NA | NA | NA | NA | |
| **$CO_2$ emissions from Biomass** | NE | | | | | | | |

**NE (not estimated), NA (not applicable), NO (not occurring)**

## 2.9 DATA GAPS

The Initial National Communication Phase II Report completed in 2005 identified several areas for which emission factors or relevant data for computing GHG emissions were either unavailable or incomplete. The report also identified a number of uncertainties with respect to GHG emissions in Dominica. In light of these data issues and the uncertainties identified, default values of emission factors proposed by the IPCC were used to compute GHG emissions. These did not capture the local realities, were not country specific and should be treated as estimates and approximations.

### 2.9.1 Data gaps by sectors

The key data gaps by key areas for which additional information will be required as identified in the INC Phase II Report are reported as follows. Even though the INC Phase II Report was completed in 2005, many of the identified data gaps and uncertainties are still relevant today and therefore most of the information provided in this section is reproduced from the report. This is in addition to the current data gaps and uncertainties identified and reported in the present 2010 GHG inventory.

#### 2.9.1.1 Transport

Information on the following is required to compute emission factors since those used were proxies:

- Class of vehicle and type of pollution control equipment fitted;
- Type of fuel consumed and average rate of consumption;
- Condition of the vehicles which is influenced by the age and level of maintenance; and
- Operating factors such as driver behavior, weather conditions, road type and traffic type.

In addition, given the expansion in transportation that has taken place in Dominica since 1994, current *levels of emissions have to be higher* even with the indefinite moratorium on leaded gasoline. Moreover, *the use of diesel engines on most mass transit buses* may be a big contributor to GHG emission specifically $CO_2$

#### 2.9.1.2 Energy Industries

The contribution from the Energy Industries comes from power plants using gas/diesel oil mainly for the production of thermal electricity.  Bitumen is also imported but using mainly in road pavement. This bitumen is partially combusted as a preparation for use in road pavement and that should contribute to $CO_2$ emission. Data on tonnage of imported bitumen, or area of paved roads, are required to give a more accurate estimate of emissions of $CO_2$ and NMVOC.

The INC report does not cover the emission of nitrous oxides from substances used in dry cleaning. Several such businesses have emerged recently and data from these sources should be collected and emissions calculated.

#### 2.9.1.3 Agriculture

Current livestock data by population and type is required to give a more accurate calculation of both enteric fermentation and manure management. The most recent data available is from the 1995 Dominica Agricultural Census.

#### 2.9.1.4 Waste Sector

Emission factors for solid waste have to be developed and accurate volume of waste must be determined. Wastes are not separated before being emptied into the landfill. Different waste kinds will have differing levels and rates of Methane ($CH_4$) emission.

#### 2.9.1.5 Land Use Change and Forestry Sector (LULUCF)

Dominica, according to the National Inventory on Greenhouse Gases, is a net remover of GHGs. However, the data used to determine the level of removals were estimates, as data on non-forest trees were based on expert opinion. Accurate data on non-forest trees are required. While Dominica has no savannas, bush fires are a common practice every year during the dry season. Large acreages are burnt. It is important to calculate the emissions from that since the persistent burning has turned the large patches of forest into permanent grassland.

### 2.9.2 Recommendations for improving data by sectors

Recommendations for improving the data by sectors are taken from the current GHG Inventory report of 2009**.**

#### 2.9.2.1 Energy

It is recommended that statistics for fuel consumption (end use) for road transportation, marinas, manufacturing, commercial, residential and agriculture/forestry/fishing be compiled (in addition to those being compiled for international bunkers and electricity generation).

#### 2.9.2.2 Industrial Processes

Although there are import data for devices that contain HFCs (motor vehicle, refrigerators, and air conditioning systems) there do not appear to be data for bulk imports of HFCs.  Such data should be compiled to improve the accuracy of HFC emissions. This would require compound-specific imports of HFCs to be recorded using appropriate HS Codes.

#### 2.9.2.3 Agriculture

It is recommended that annual estimates of the animal populations be made for the years between agricultural censuses.

#### 2.9.2.4 Land Use and Forestry

Changes in land use data especially for lands changing from forest should be recorded. There is uncertainty in the amount of wood removed for various purposes (charcoal making, domestic or commercial fuel) and whether or not there are abandoned lands. Optimal and cost effective means to obtain these data need to be developed.

#### 2.9.2.5 Waste Sector

There are reliable data on the amounts of waste deposited in the waste management sites and it is recommended that such data collection continue and with periodic surveys of waste composition.

## 2.10. UNCERTAINTIES

Uncertainties in the inventory arise from both emission factors and the activity data. Since default emission factors were used their uncertainties are those recommended in Table A1-1 of the IPCC Reference Manual Volume 1.

Uncertainties in the activity data were due mainly to the unavailability of some data either because records were not maintained or not compiled at all. In such cases best estimates were made or estimates were based on surrogate data. The factors that lead to uncertainties in the activity data used in the Dominica inventory are discussed in the following sections.

### 2.10.1 Energy

Although fuel import data were available they were incomplete and data from importers or secondary data from the Caribbean Energy Information System (CEIS) were used in some cases.

End use consumption data for diesel and to lesser extent gasoline used in transportation were not compiled hence allocation of fuel used for road transport and at marinas could not be reliably estimated. In the case of diesel fuel accurate data for the amount used in electricity production are available and accounted for about 27% of the total consumption. The remainder was allocated to road transportation since the amounts used at marinas and for other purposes (e.g., boilers or standby diesel generators) were unknown but were assumed to be small.

Data for fuel use in the domestic aviation (between the two airports in Dominica) were not available.

### 2.10.2 Industrial Processes– Non-CO2 Emissions

The factors below contribute to the uncertainties in estimating the NMVOC and HFC emissions:

- Since production data were not available from local bakeries no estimates were made
- Compound-specific import data for bulk hydro fluorocarbons were not available so estimates were based on a Tier 1 approach

### 2.10.3 Agriculture

The factors below contribute to uncertainties in the estimates of methane emissions from the Agriculture sector.

- It was assumed that the nitrogenous based fertilizer imports in each year were the same as consumption for that year
- There were no local recent census data for cattle, sheep, goats and poultry so FAO data were used.
- It was assumed that 100% of poultry and swine are raised in pens and that 100% of ruminants (cattle, sheep, and goats) and equine (horses, mules/asses) are reared in pastures. The uncertainties in these assumptions are considered low.

### 2.10.4Land Use Change and Forestry

The Forestry Division lost many of its experts who had gathered extensive forestry data over the years and information on where historical data could be located was not available.

There are no longer any lands that are considered plantations and data with regards to abandonment of managed lands were not available. The change in forest cover between 2000 and 2005 was assumed to be to settlements.

There is considerable uncertainty (estimated at +/-50%) in the available data for the amount of charcoal produced and the amount of wood used by wood-oven bakeries.

### 2.10.5 Waste Sector

Reliable municipal solid waste (MSW) data have been available only since 2005 hence the MSW disposed in 2000 was estimated by scaling the 2005 data by the ratio of the population in 2000. The annual amounts of MSW should be available in the future.

### 2.10.6 Overall Uncertainties

The uncertainties in the emission inventory for 2000 are summarised in Table 2.21. The total uncertainty in the $CO_2$ equivalent emissions in 2000 was 82%. Similar uncertainties were assumed to apply for the other years.

**Table 2.21 Uncertainties in the Emissions Inventories for Dominica**

| Sector | IPCC Source Category | Gas | $CO_2$ eq | $U_E$ | $U_A$ | $U_T$ |
|---|---|---|---|---|---|---|
| | | | Gg | % | % | % |
| Energy | $CO_2$ Emissions from Stationary Combustion | $CO_2$ | 34.9 | 7 | 10 | 12 |
| Energy | $CO_2$ Emissions from Manufacturing Industries and Construction | $CO_2$ | 9.10 | 7 | 20 | 21 |
| Energy | $CO_2$ Mobile Combustion: Road Vehicles | $CO_2$ | 47.1 | 7 | 20 | 21 |
| Energy | Other Sectors: Residential CO2 | $CO_2$ | 4.07 | 7 | 15 | 17 |
| Energy | Other Sectors: Commercial CO2 | $CO_2$ | 9.97 | 7 | 20 | 21 |
| Energy | Other Sectors: Agriculture/Forestry/Fishing CO2 | $CO_2$ | 0.631 | 7 | 20 | 21 |
| LULUCF | Forest and Grassland Conversion | $CO_2$ | 0.0 | 50 | 25 | 56 |
| LULUCF | Changes in Forest and Other Woody biomass stocks | $CO_2$ | 0.0 | 50 | 15 | 52 |
| Energy | $CH_4$ (Non-CO2) Emissions from Stationary Combustion | $CH_4$ | 0.030 | 50 | 20 | 54 |
| Energy | $CH_4$ Emissions from Manufacturing Industries and Construction | $CH_4$ | 0.005 | 50 | 20 | 54 |
| Energy | $CH_4$ Mobile Combustion: Road Vehicles | $CH_4$ | 0.270 | 50 | 20 | 54 |
| Energy | Other Sectors: Residential CH4 | $CH_4$ | 0.688 | 50 | 20 | 54 |
| Energy | Other Sectors: Commercial CH4 | $CH_4$ | 0.030 | 50 | 20 | 54 |
| Energy | Other Sectors: Agriculture/Forestry/Fishing CH4 | $CH_4$ | 0.001 | 50 | 20 | 54 |
| Energy | $CH_4$ Fugitive Emissions from Oil and gas Operations | $CH_4$ | 0.0 | 50 | 25 | 56 |
| Agriculture | $CH_4$ Emissions from Enteric Fermentation in Domestic Livestock | $CH_4$ | 15.7 | 20 | 20 | 28 |
| Agriculture | $CH_4$ Emissions from Manure Management | $CH_4$ | 0.662 | 30 | 20 | 36 |
| Waste | $CH_4$ Emissions from Solid Waste Disposal Sites | $CH_4$ | 9.88 | 45 | 15 | 47 |
| Waste | $CH_4$ Emissions from Wastewater Handling | $CH_4$ | 4.39 | 45 | 15 | 47 |
| Energy | $N_2O$ (Non-$CO_2$) Emissions from Stationary Combustion | $N_2O$ | 0.088 | 170 | 20 | 171 |
| Energy | $N_2O$ Emissions from Manufacturing Industries and Construction | $N_2O$ | 0.023 | 170 | 20 | 171 |
| Energy | $N_2O$ Mobile Combustion: Road Vehicles | $N_2O$ | 0.126 | 170 | 20 | 171 |
| Energy | Other Sectors: Residential $N_2O$ | $N_2O$ | 0.128 | 200 | 20 | 201 |
| Energy | Other Sectors: Commercial $N_2O$ | $N_2O$ | 0.026 | 200 | 20 | 201 |
| Energy | Other Sectors: Agriculture/Forestry/Fishing N2O | $N_2O$ | 0.0016 | 200 | 20 | 201 |
| Agriculture | $N_2O$ Emissions from Manure Management | $N_2O$ | 1.94 | 200 | 20 | 201 |
| Agriculture | $N_2O$ (Direct and Indirect) Emissions from Agricultural Soils | $N_2O$ | 29.4 | 500 | 10 | 500 |
| Waste | $N_2O$ Emissions from Wastewater Handling | $N_2O$ | 4.52 | 5 | 20 | 21 |
| Industrial Processes | HFC Emissions from Substitutes for Ozone Depleting Substances (ODS Substitutes) | HFCs | 6.00 | 25 | 25 | 35 |
| **ALL** | **Total** | | **180** | | | **82** |

## 2.11 INSTITUTIONAL ARRANGEMENTS

In order to sustain the process of data collection and management a description of the institutional arrangements required to make the inventory preparation a continuous process is presented. The information which is reproduced entirely from the INC Phase II Report is still very relevant today.

### 2.11.1 Forestry

The Forestry, Wildlife and Parks Division is responsible for the management of all forest on state lands. The Division has divided Dominica into four (4) ranges or management areas. Each area is manned by forest rangers. Additional appointed staff below the level of Assistant Forest Officer include ten (10) Forester IIs (Forest Guards) and one (1) Forester I (Forest Ranger).

These Officers submit reports on a regular basis and the reports are collated by an officer using a generic spreadsheet. The data collected include:

- Selective logging
- Deforestation
- Squatting (which involves forest removal)
- Biomass burning
- Plant characteristics

The information is categorized by programme areas and is received on a small computer network located in the offices of the Division.

There are several key issues of concern:

- Verification of the data
- Reliability.

*Data Gaps*

- The Division does not collect data on non-forest trees given the costliness of the undertaking.
- It does not collect data on forest on private lands except in the Laoma region of the Carib Territory as part of its research and reforestation programme.

*Action Required*

- One of the officers in each of the ranges should be given responsibility to verify information to ensure reliability. Accurate data on forestry is critical since Dominica is a net sink country and could derive benefits from retaining that status.
- The existing computer network must be expanded to include the clerical staff that can assist in data input and management. The current officer can then be free to focus on data analysis.
- The data storage should move from a spreadsheet to a database. This is to facilitate the ease with which queries can be made and reports prepared.
- The forest rangers need to be trained in data collection, verification and management.
- All officers need to be trained in data analysis, report writing and information sharing for decision-making. The Statistical Division can be approached for assistance.
- Modalities have to be developed for collecting data related to the forests on private lands to ensure comprehensive national coverage.

### 2.11.2 Agriculture

The Division of Agriculture is responsible for agricultural development and planning in Dominica, including animal husbandry and plant cultivation. There is a special department responsible for livestock. This Division has been hardest hit with respect to the current austerity measures being undertaken by the government. It is expected that most of the workers in the propagation unit will be released at the end of the 2004 financial year.

Several attempts have been made to develop information system within the Ministry of Agriculture. DAISY and AIMS have been two such systems. An Agricultural Information Unit was established but has been heavily understaffed. While STABEX funding has been available to develop the system not much has been done.

There have been changes in the organizational arrangement as a result of the worker redundancy. There were five agricultural districts and district officers were responsible for data collection and information gathering. The current team approach has seriously affected the progress made.

The Division is responsible for data on the following

- Burning of agricultural waste.
- Livestock manure.
- Head count of livestock.

*Data Gaps*

- Data is disorganized.
- The absence of a systematic collection system as a result of organizational changes.

*Action Required*

- Establish a platform for information management.
- Develop a network for information sharing.
- Need to establish a central location for data collation and management.
- Existing data has to be organized.
- Develop/select database software to input data.
- Clerks should be fitted with computers and trained in data management.
- Use extension and other field officers in collection of data on agricultural waste.
- Train two officers in data collection and analysis.

### 2.11.3 Transport

There has been a huge influx of vehicles in Dominica since 1995. Many of these vehicles are reconditioned or used vehicles and while an environmental levy has been imposed proportionate to the age of the vehicle, this has not abated the flow into Dominica. In addition, the sale of leaded fuel has been discontinued but diesel is still being sold. Buses and dump trucks are mostly diesel engines. There is therefore an increased demand for fuel in Dominica and the possible increase in emissions from this source over the past ten (10) years.

Several institutions are responsible for transport data that impact on GHG emissions. These are

- Filling stations for fuel imports and sales.
- Auto dealers and mechanics for information of age of vehicles, fuel efficiency devices installed.
- Ministry of Communication and Works and Finance for policy formulation regarding the transport sector and GHG emissions.

*Data Gaps*
- Absence of data on chemical content of fuel.
- Absence of data on fuel efficiency devices.
- Absence of a systematic data collection on the age of vehicles.

*Action Required*
- Bulk or Filing stations need to establish databases for information on analysis of information.
- Bulk or Filing station need to store data on chemical content of fuel imported into Dominica.
- Auto dealers and mechanics should collect data on age of vehicle, engine particulars, fuel efficiency devices mounted if any.
- Auto dealers and mechanics should develop platforms for data management and analysis.
- Attendants, dealers and mechanics should be trained in data collection and management.
- Ministry of Communication and Works, Agriculture and the Environment, Finance and Planning, need to establish policy for the proper collection, management and reporting of data on GHG Emission.

### 2.11.4 Energy (Electricity Generation)

DOMLEC is the lone electricity company in Dominica. The company operates three fuel-generated power stations. These are responsible for the generation of 21 mw of electricity. Diesel is the fuel used in this generation. DOMLEC needs to monitor its fuel use to determine the contribution of this sub-sector to GHG emissions.

*Action Required*
- An alphanumeric database is required for queries and reports.
- Develop separate databases for each generation station.
- Train plant attendant in electricity generation and GHG emissions.
- Install fuel efficiency devices or maintain fuel efficiency practices in the generation of electricity.
- Maintain record on efficiency practices.

### 2.11.5 Bitumen

In 2005, the Public Works Garage was solely responsible for the import and use of the Bitumen used in the construction of roads. A technician was responsible for the plant and oversaw the preparation of the product. This plant is at a nearby but remote location from the main garage offices. Data on bitumen is collected at the site manually and transferred to the main office of the garage where they are kept in manual files. While it may be easy to retrieve that information on demand, no officer is responsible for data management with respect to bitumen. One officer with two portfolios has to take on this additional work. There are no electronic platforms for the bitumen section.

The garage uses ACCPAC, which is accounting software and the current computer system at the main office is networked. .

*Data Gaps*

- Some of the equipment is obsolete.
- Data on imports and production of bitumen are kept but that on chemical content are not kept.

*Action Required*

- The plant should be included as part of the larger garage electronic network system/develop a separate platform with appropriate software.
- An appropriate electronic database should be developed for the management of data in respect of bitumen.
- Train the technicians in the basic use of computers and data management.
- Mount an awareness programme for employees in the bitumen plant in GHG emissions and Bitumen.
- Establish protocol(s) for information sharing within and between the garage and ECU.
- Develop and maintain a website of the garage with bitumen information posted.

### 2.11.6 Solid Waste

The Solid Waste Management Corporation is responsible for the management of solid waste in the Commonwealth of Dominica. It is a quasi-government corporation established in an attempt to privatize waste management in Dominica. The Corporation depends on government for most of its revenue. The current fiscal difficulties experienced by the government have affected the operations of the Corporation. Recently a garbage levy was imposed on selected areas of Roseau.

*Gaps*

- The need for developing and maintaining appropriate database system
- Appropriate training in data collection, and analysis
- Methane production experiments to be conducted on sample projects
- Existence of a website or portal for posting information
- Absence of a clear public education programme designed to reduce waste

*Action Required*

- Train officers in data management and analysis
- Conduct workshop for officers in solid waste and GHG emissions
- Review and expand database for effective management of solid waste
- Develop website for disseminating data and information

- Develop and implement a public awareness programme designed to reduce waste
- Design policies and guidelines for the separation of waste
- Design and conduct test and studies in methane production in solid waste
- Monitor the production of methane on site and devise ways to use as small scale alternative energy

### 2.11.7 Overall Activity Management and Coordination

The ECU is responsible for coordination of the environmental programme and activities in Dominica. Set up under the Ministry of Agriculture and the Environment, it is staffed with a Head and three (3) support staff.

While the unit has been mandated with the task of monitoring *inter alia* GHG emissions in Dominica, it too does not have the capacity to meet its own mandates. The inadequate staffing, expertise and equipment are among the key factors responsible. However data already exist in several sources as identified and including the Bureau of Standards which can assist in quality assurance/standards for household and other goods – stoves, refrigerators, computers and the like.

*Strengths*

- The very existence of a coordinating unit creates a platform for the monitoring of GHG emissions.
- There are three officers within the unit including an administrative assistant who can assist in the monitoring process.
- There is a strong awareness and commitment to environmental conservation.

*Data Gaps*

- The unit has neither platforms nor databases for the monitoring of GHG emissions.
- There are no clear policies and procedures for reporting data or collecting information on GHG.
- There is no expertise within the unit in monitoring GHG emission or calculation of emission factors.
- Absence of a legislative mandate for GHG monitoring and other environmental issues

*Action Required*

- Increase staffing capacity for monitoring GHG emissions.
- Train staff in graduate level data management and reporting.
- Develop and maintain a data management system.
- Train one or two officers at the graduate level in calculation of emission factors.
- Formulate /sponsor policies, standards and procedures for GHG emission data collection, management, analysis and reporting in collaboration with Bureau of Standards.
- Prepare pamphlets and flyers.
- Conduct radio programmes as part of a public awareness campaign on GHG emissions.
- Manage the national database for GHG emissions and monitor these emissions.
- Prepare an annual report on GHG emissions in Dominica.

- Disseminate information to stakeholders, flag critical sectors.
- Develop a platform (website) for easy posting and dissemination of information.
- Transmit Environmental levy to the ECU as a measure of sustainability once donor funding has been depleted
- Provide legislative mandate/framework for ECU to formalise its operations and its ability to access donor funding

## 2.12 CONCLUSIONS

Two methods are used to calculate the $CO_2$ emissions for the energy sector. These are the Reference Approach and the Sector Approach. The percentage contributions of $CO_2$ emissions by subsectors within the energy sector for the base year 2000 utilizing the Sectoral Approach shows that the Energy Industries (33%) and Transportation (44%) subsectors are the main contributors accounting for 77% of total emissions from the sector. The contributions are similar in the other years assessed and account for between 70% and 80% of the $CO_2$ emissions while the Manufacturing Industries & Construction and Other (residential, commercial and forestry and fishing subsectors) respectively account for the remainder . The transport sector has the largest $CO_2$ emissions (43 to 54 Gg) and accounts for 39 to 49% of the emissions between 2000 and 2005.

Non- $CO_2$ ( $N_2O$, $SO_2$ and HFC) emissions for the period are relatively small (less than 0.2 Gg) while the average annual $CH_4$, NOx, CO and NMVOC emissions were respectively 1.56 Gg, 0.63 Gg, 6.37 Gg and 2.68 Gg.

The use of Solvents and Other Products use can result in emissions of NMVOCs. Estimates of the emissions are based the amounts of products used and the percentage of NMVOC or $N_2O$ that evaporates during use. During the period 2000-2005 NMVOC emissions ranged between 0.284 – 0-275 Gg. This was mainly attributed to emissions from personal care products.

As per the Agricultural Sector, there were no $CO_2$ emissions. Total annual $CH_4$ emissions for the period 2000-2005 (0.748 Gg) showed an increase over the year 1994 (0.226Gg). This is primarily a result of a larger number of cattle and an accompanied increase in enteric emissions which accounted for over 90% of total $CH_4$ emissions from the agricultural sector.
An average of 0.75 Gg of methane was emitted due to enteric fermentation while 0.03 Gg emitted as a result of animal manure management. Nitrous oxide emissions from manure management and agricultural soils ranged from 0.06 to 0.10 Gg annually.

Despite the progressive decline in $CO_2$ removals during the period 2000-2005 (-138 to -128), Dominica's Land Use Change and Forest Sector represents a net sink of $CO_2$. The releases (emissions) due to conversion from forested areas to settlements remained constant over the period, but this is far outweighed by the sink changes due to woody biomass stocks (removals).

Emissions from the Waste Sector arise from the treatment and disposal of municipal or industrial solid waste and from the treatment and disposal wastewater from domestic and industrial sources. $CH_4$ emissions from the sector for the period 2000-2005 ranged from 0.679 to 0.673 Gg. Total $NO_2$ emissions for the same period remained constant at 0.015 Gg and was only due to waste handling

The data show that $CO_2$ emissions from mobile combustion sources (i.e., on road transportation) followed by energy industries (electricity generation) in the energy sector are the two largest overall contributors to $CO_2$e emissions. The next largest source is direct and indirect $N_2O$ emissions in the agricultural sector. Dominica is a net sink for CO2 amounting to a net removals of 31.60 Gg of CO2. Similar results are obtained for the years 2001-2005.

The GHG inventory data for the years 2000 to 2005 have large uncertainties. Uncertainties in the activity data were due mainly to the unavailability of some data either because records were not maintained or not compiled at all. In such cases best estimates were made or estimates were based on surrogate data. The total uncertainty in the $CO_2$ equivalent emissions in 2000 was 82%. Similar uncertainties were assumed to apply for the other years.

An assessment carried out for the preparation of the INC Phase II Report indicated a number of shortcomings with the various Ministries/ Institutions responsible for collecting/processing specific sectoral data required for calculating GHG Inventories. There is a need for developing the capacity of these Ministries/Institutions to adequately carry out their function and to make the preparation of the GHG Inventory a continuous process. While the various Ministries/institutions should be responsible for the collection and processing of specific sectoral data, the ECU should be responsible for the coordination of annual GHG Inventory. In this regard there is an urgent need for developing the capacity of the staff at the ECU to coordinate this process.

# 3 VULNERABILITY TO CLIMATE CHANGE

Vulnerability is defined by the IPCC as the combination of sensitivity to climatic variations, the probability of adverse climate change, and adaptive capacity. Generally it refers to a system'ssusceptibility to the adverse effects of climate change. How vulnerable the system is, is influenced by a number of factors which are to be considered in the assessment of its vulnerability.

The IPCC defines adaptation to climate change as "adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities". Closely aligned to this is the concept of adaptive capacity, which the IPCC refers to as "the ability of a system (ecological and/or socio-economic systems) to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences".

Like the Initial National Communication, 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 further updated available information.

Dominica displays a complex mixture of vulnerabilities stemming primarily from its geographical characteristics. To a large extent these vulnerabilities reflect its position as a small island country and involve various environmental and socio- economic vulnerabilities. The country's adaptive capacity for climate change is also conditioned by its physical and socio-economic context.

Nurse (2003) identifies a number of principal indicators of environmental vulnerability affecting small islands, all of which are of relevance to Dominica. These include:

1. The extent of risk associated with natural hazards, such as earthquakes, hurricanes, droughts and floods;
2. The extent of internal, low intensity extensive anthropogenic hazards (e.g. deforestation) which over time reduce resilience;
3. Exposure to externally driven, high intensity anthropogenic impacts e.g. transport of toxic wastes; and
4. Risks from global climate change.

Nurse notes that environmental vulnerability relates to the risks of damage to a country's natural capital and by extension threatens the likelihood that it can achieve sustainable development. This is particularly important for States like Dominica which are directly dependent on natural resources for their principal economic activities. In the case of Dominica, the country's relatively pristine natural environment also provides important cultural and quality of life attributes (e.g. fresh-water, clean air, and biological diversity). Any intensification of these environmental vulnerabilities is therefore likely to have significant adverse social and economic consequences.

In a 2001 report on the impact of natural disasters on economic development in Dominica, the World Bank notes that between 1978 and 2001 a number of events – Hurricanes David and Frederick in 1979, Allen in 1980, Hugo in 1989, the three tropical storms of 1995, Hurricane Lenny in 1999, the Layou River landslide of 1997, and a volcano alert in 1998 – highlight the inherent vulnerability of Dominica to a range of natural disasters.

The World Bank report indicates that available historical data for Dominica points to a correlation between periods of cumulative hurricane events coinciding with periods of economic decline. The report notes that there was a bunching of severe hurricanes events during three periods – from mid 1760s to 1780 (6 years out of 16), from 1813 to 1834 (8 years out of 21), and from 1876 to 1893 (5 years out of 17). These periods were officially recorded as periods of economic difficulty, depressed agriculture and trade. Looking at the more recent experiences the Banks report points out that "each of the three major storm events tested was found to have a statistically significant negative impact on both total and agricultural GDP". The study notes that Hurricane David (the most catastrophic in modern times) resulted in migration of an estimated 25% of the population, to the extent where 20 years later the population had still not recovered to its 1978 levels. The report indicates that such recurring events (most notably the multiple events of 1979/1980) also serve to intensify budgetary pressure by increasing recurrent expenditure on relief and on the capital costs of reconstruction, effectively diverting resources away from productive investments and from regular recurrent investments in health, education and other social services.

Following these natural disaster events, decision makers in Dominica in public and private sectors have been forced to decide between rapid reconstruction and longer term vulnerability reduction. By default, emphasis has been on quick recovery given socio-economic and political realities and the financial costs associated with long term disaster mitigation measures in Dominica where topography makes for high per capita infrastructure needs. The World Bank's report notes that with the exception of financial services Dominica's economy remains highly vulnerable to tropical storms and hurricanes.

## 3.1 Methodology

Various methodological approaches exist for assessing climate change impacts and adaptation requirements and range from highly sophisticated climatological modeling to information based on local expert opinion[5]. Most of the approaches are generally based on variants of the IPCC (1994) Basic Methodology which utilizes a seven step approach. The methodological approach adopted should be based on the type of outputs that are required as well as other factors such as availability of data.

For this report the assessment will utilize a modified version of the Adaptation Policy Framework (APF), developed by the United Nations Development Programme (UNDP) as a tool for climate change impact and adaptation assessment. The APF emphasizes five major principles:

1. Adaptation policies and measures are to be assessed in a developmental context (i.e. they should be complementary to and/or consistent with wider sustainable development efforts such as poverty reduction, environmental protection, economic growth);

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[5] The UNFCCC Compendium on Methods and Tools to evaluate impacts of , vulnerability and adaptation to, climate change". The Compendium provides an in-depth listing of available tools for climate change vulnerability and adaptation assessment. See http://unfccc.int/adaptation/methodologies_for/vulnerability_and_adaptation/items/2674.php

2. Adaptation to short term climate variability and extreme events are explicitly included as a step towards reducing vulnerability to long term climate change;
3. The Adaptation strategy and the process by which it is achieved are equally important;
4. Adaptation occurs at various levels within the society including at the local level;
5. An essential element of response to future climate change is building of capacity to deal with current climate.

The APF is a flexible tool in which the following steps are used in different combinations depending on the amount of information available and the point of entry to the project:

- Defining the scope and design of the assessment – this will establish the scope and focus of the study, identify project objectives and outcomes, and identify approaches and methods.
- Assessing vulnerability under current climate – intended to understand the characteristics of existing climate related risks and the scope of ongoing climate adaptation policies and measures.
- Characterizing future climate related risks – this utilizes data from international climate models to identify what Dominica's future climate is likely to be. This includes rainfall and temperature projections as well as information on sea-level rise.
- Developing an Adaptation strategy – based on projected impacts utilize stakeholder consultations and documented proposals, identify and evaluate prospective measures for reducing vulnerability to existing and projected climate risks.
- Continuing the adaptation process – this involves devising vulnerability reduction/adaptation policies and measures that are sustainable.

While initial efforts to conduct climate change assessments focused primarily on impact assessment, the APF is intended to increase attention on identification and implementation of adaptation options. This is likely to be relevant to Dominica where existing climate extremes (particularly hurricanes, floods, and droughts) already constitute barriers to sustainable development. Central to the APF is recognition of the advantages of taking early adaptation action on climate change[6].

The APF approach recognizes the importance of understanding and responding to current climate vulnerability as the most immediate adaptation task. This requires that the assessment process be linked with the concerns and perspectives of stakeholders at sectoral, community, and national levels. Consequently, stakeholder consultations constitute an important element of the APF process.

[6] The economic significance of early adaptation (and mitigation) is highlighted in the 2006 Stern Review of the Economics of Climate Change. See http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm

## 3.2 Climate scenarios trends and projections

Global Circulation Models (GCMs) are useful tools for providing future climate information. GCMs are mathematical representations of the physical and dynamical processes in the atmosphere, ocean, cryosphere and land surfaces. Their physical consistency and skill at representing current and past climates make them useful for simulating future climates under differing scenarios of increasing greenhouse gas concentrations

Projections of rainfall and temperature characteristics for Dominica through the end of the century are extracted from two GCM projects. In each case data from multiple GCMs were analyzed (9 in one instance and 3 in the other) and it is the consensus results which are presented. Details of both projects are provided in the Appendix at the end of the chapter.

An inherent drawback of the GCMs, however, is their coarse resolution relative to the scale of required information. The size of Dominica precludes it being physically represented in the GCMs, and so there is a need for *downscaling* techniques to provide more detailed information on a country or station level. The additional information which the downscaling techniques provide do not however devalue the information provided by the GCMs especially since (1) Dominica's climate is largely driven by large-scale phenomenon (2) the downscaling techniques themselves are driven by the GCM outputs, and (3) at present the GCMs are the best source of future information on some phenomena e.g. hurricanes.

Data from two downscaling methods are applied. *Dynamical* downscaling employs a regional climate model (RCM) driven at its boundaries by the outputs of the GCMs. Like GCMs, the RCMs rely on mathematical representations of the physical processes, but are restricted to a much smaller geographical domain (the Caribbean in this case). The restriction enables the production of data of much higher resolution (typically < 100 km).

Available RCM data for Dominica are from the PRECIS (Providing Regional Climates for Impact Studies) model (Taylor et al. 2007). . The PRECIS model resolution is 50 km.

*Statistical* downscaling enables the projection of a local variable using statistical relationships developed between that variable and the large scale climate. The relationships are premised on historical data and are assumed to hold true for the future. Statistical downscaling is especially useful for generating projections at a location, once sufficient historical daily data are available.

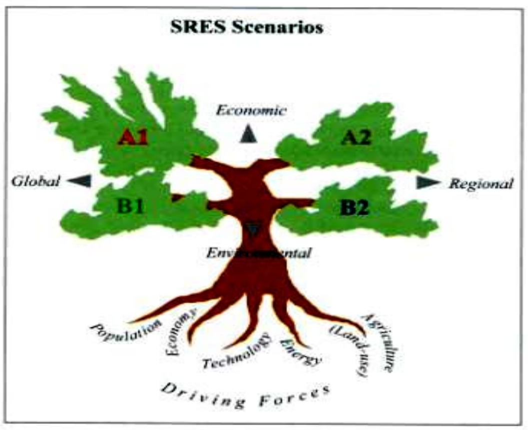
Statistical downscaling was undertaken for rainfall and temperature data for Melville Hall Airport station. The process was facilitated using the Statistical Downscaling Model (SDSM) (Wilby et al. 2002)..

### 3.2.1 Scenarios

The GCMs, RCM, and statistical downscaling model are run using the Special Report Emission Scenarios (SRES) (Nakicenovic et al., 2000). Each SRES scenario is a plausible storyline of how a future world will look like. That is, the scenarios explore pathways of future greenhouse gas emissions, derived from self-consistent sets of assumptions about energy use, population growth, economic development, and other factors. They however explicitly exclude any global policy to reduce emissions to avoid climate change. Scenarios are grouped into families according to the similarities in their storylines as shown in Figure 3.1.

Since there is an equal probability of each storyline becoming the future, the results presented in the following section cover a range of scenarios, namely the A2, B1, B2 and A1B (see again Figure 3.1). A2 and B2 are representative of medium-high and medium-low emissions scenarios respectively (see Figure 3.2), while A1B can be seen as a compromise between the two. The A1B scenario is characterized by an increase in carbon dioxide emissions through mid century followed by a decrease.

The future climate is presented as absolute or percentage deviations from the present day climate which is in turn represented by averaging over 30 year periods, usually 1961-1990 or 1971-2000. The results are presented for 10 year bands centered on 2015, 2030, 2050 and for the end of the century (2070-2100).




- A1 storyline and scenario family: a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and rapid introduction of new and more efficient technologies.
- A2 storyline and scenario family: a very heterogeneous world with continuously increasing global population and regionally oriented economic growth that is more fragmented and slower than in other storylines.
- B1 storyline and scenario family: a convergent world with the same global population as in the A1 storyline but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies.
- B2 storyline and scenario family: a world in which the emphasis is on local solutions to economic, social, and environmental sustainability, with continuously increasing population (lower than A2) and intermediate economic development.

**Figure 3.1: Special Report on Emission Scenarios (SRES) schematic and storyline summary (Nakicenovic et al., 2000).**

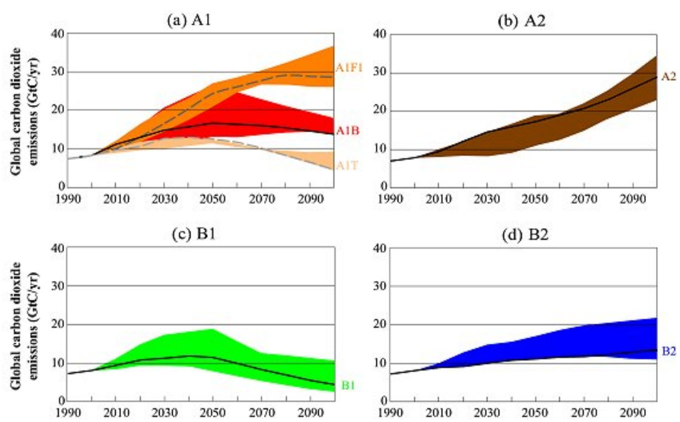



**Figure 3.2**: Total global annual $CO_2$ emissions from all sources (energy, industry, and land-use change) from 1990 to 2100 (in gigatonnes of carbon (GtC/yr) for the families and six SRES scenario groups (**Nakicenovic et al., 2000).**

### 3.2.2. Temperature

Irrespective of scenario, model or methodology used, there is a projected annual mean temperature increase for Dominica. Figure 3.3 gives the range of increase projected for each time slice above as gleaned from the GCMs and RCM.

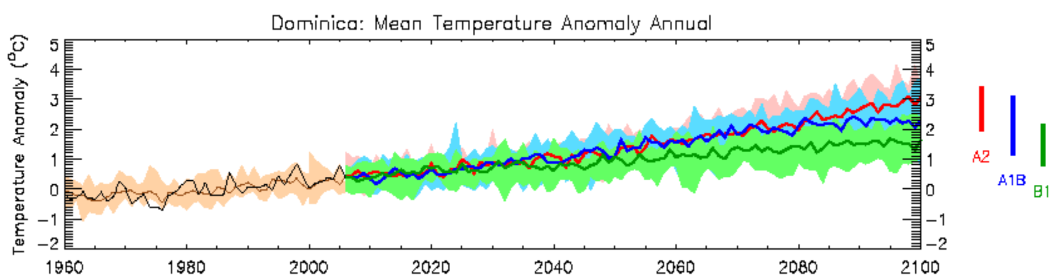
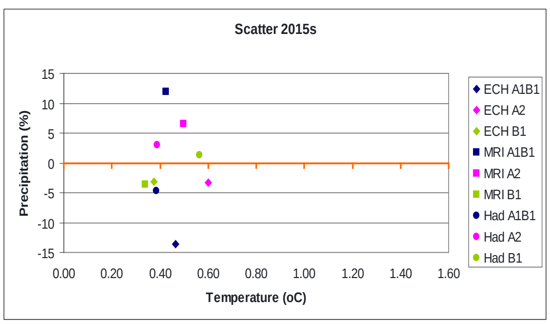


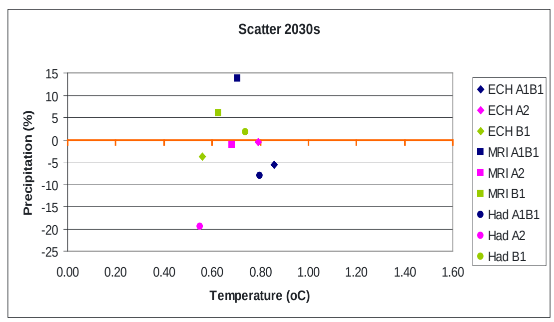

**Figure 3-3** Annual mean temperature anomaly 1960-1990. Units are °C. Black line: Average of observational datasets for current climate. Brown line and brown shading: Ensemble median and range for model projections of recent climate. Coloured lines and shading: Ensemble median and range of projections under 3 emissions scenarios. Bars at the far right demonstrate the change by 2080-2100 under each emissions scenario. All values are given as an anomaly from 1971-2000 mean climate (Taylor 2009).

The GCMs suggest that the mean annual increase in temperature will be between 0.4°C and 0.5°C by the 2015s, 0.6°C - 0.8°C by the 2030s, 0.9°C - 1.3°C by the 2050's and between 1.5°C (B1 scenario) and 3°C (A2 scenario) by the end of the century (2100) . The RCM shows a similar rate of increase with an annual temperature change of 1.8–2.3°C by the 2090s. These projections are consistent with IPCC projections for the Caribbean which show annual mean temperatures increasing by 1.4°C to 3.2°C, with a median increase of 2.0°C by 2100. The increases are however slightly less than the anticipated global average warming (Taylor et al 2009)

### 3.2.3 Rainfall

According to Taylor et al (2009), there are fewer consensuses in the projected rainfall for Dominica than for temperature. Figure 3.4 shows the annual percentage change for three GCMs running a variety of scenarios. There is a clear tendency toward drier in the annual mean, with greater consensus toward the end of the century. For the 2015s, the models project changes ranging from -15% to +13% (dependent on scenario and model), with 5 of 9 model runs indicating a decrease in the annual mean rainfall For the 2030's the range is from -20% to +15% and 6 of 9 runs indicate a drier Dominica. By the 2050's the range is -21% to +10% and 7 of 9 runs indicate drier conditions than the present. The RCM captures the same drying trend but is more drastic. It projects the annual rainfall to be 30%-50% less than present day amounts by the end of the century. This is consistent with the IPCC projections of a drier Caribbean by the century's end.



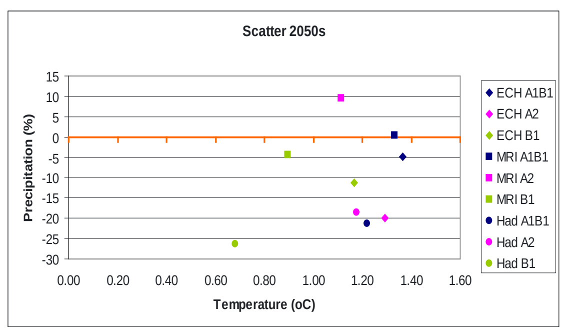




**Figure 3.4** Scatter plot of projected change in mean annual rainfall and temperature for 3 GCMs (Had, MRI and ECH) run under A2, B1 and A1B SRES scenarios. Each marker indicates the change produced for a model run under a different scenario. Diagrams are for the 2015s, 2030s and the 2050s. Markers below the orange line indicate a projection of drier conditions. (Taylor 2009)

### 3.2.4 Seasonality

In general the seasonality of Dominica (Fig.3-5) remains the same in the future i.e. the pattern of cooler dry winter-hot wet late summers will still prevail, though monthly temperatures will be on average 2 degrees higher by the 2050's (as indicated by the rightward shift of the polygons). Other discernible changes in the polygon shape are accounted for by the aforementioned drying tendency as the century progresses, which is captured by the polygon progressively becoming shorter (Taylor et al 2009).

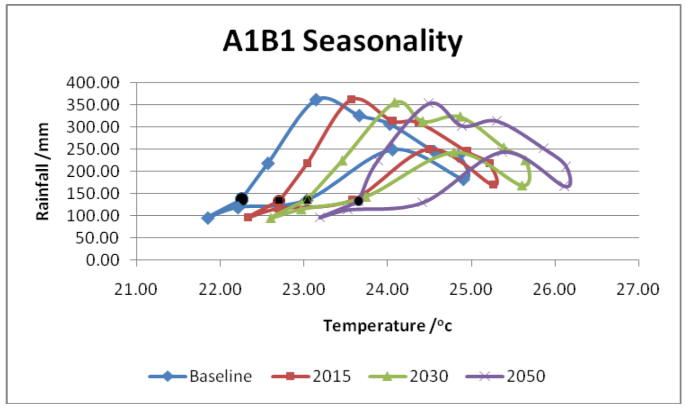



**Figure 3.5** Seasonality diagrams for Dominica. Polygons show the variation in mean rainfall and temperature for a given year. Plots are for current climate (baseline), and the 2015's, 2030's and 2050's, under the A1B1 scenario. The black dot indicates January. Each year follows counter clockwise. (Taylor 2009)

### 3.2.5 Hurricanes

Since the models examined do not explicitly model hurricanes, it is the IPCC's projections which are relied on. Based on a range of models, the IPCC suggests that future hurricanes of the north tropical Atlantic will *likely*[7] become more intense, with larger peak wind speeds and heavier near storm precipitation.

There is however less confidence in model projections of (i) a *decrease* in the *number* of relatively *weak* tropical cyclones, (ii) *increased numbers* of *intense* tropical cyclones, and (iii) a global *decrease* in the *numbers* of tropical cyclones. Some modelling studies attribute any possible global decrease in the number of cyclones to increased stability of the tropical troposphere (due to differential warming in the vertical in a warmer climate) which compensates for the impact of the warmer ocean temperatures.

### 3.2.6 Sea Level Rise

Ocean expansion (due to warming) and the inflow of water from melting land ice have raised the global sea level over the last decade. Large deviations among the limited set of models addressing the issue, however, make future estimates of sea level change uncertain, including for the Caribbean.

[7] In the IPCC Summary for Policymakers, the following terms have been used to indicate the assessed likelihood, using expert judgement, of an outcome or a result: *Virtually certain* > 99% probability of occurrence, *Extremely likely* > 95%, *Very likely* > 90%, *Likely* > 66%, *More likely than not* > 50%, *Unlikely* < 33%, *Very unlikely* < 10%, *Extremely unlikely* < 5%.

As with hurricanes, it is the IPCC's projections which are relied on. Whereas it is not presently possible to project sea level rise for Dominica, changes in the Caribbean are projected to be near the global mean. Under the A1B scenario, sea level rise within the Caribbean is projected to be between 0.17 m and 0.24 m by 2050 (IPCC 2007). For comparison, global sea level rise is projected to average 0.35 m (0.21 to 0.48 m) under the same scenario by the end of the century (relative to the period 1980-1999). It is important to note, however, that changes in ocean density and circulation will ensure that the distribution of sea level rise will not be uniform across the region.

Taylor et al (2009) summarizes Dominica's climate as follows:

- There is evidence to suggest that the climate of Dominica is changing. Both maximum and minimum temperatures have increased in the recent past.
- The warming trend is expected to continue. The country is projected to be warmer by up to 1.3$^{o}$C by the 2050s, and between 2 and 3 degrees by the end of the century.
- Winter months will see marginally larger increases in temperature than summer months.
- The frequency of very hot days and nights will increase, while the number of very cool days and nights will decrease.
- The country is likely to be drier in the mean. Projections are for up to 20% drier by mid century when models show more consensus about the trend, and up to 50% drier by 2100.
- July-August will likely be drier.
- The seasonality of Dominica will be largely unchanged. The cooler (with respect to late season temperatures) dry early months and wet hotter late months will still prevail.
- Hurricane intensity is likely to increase (as indicated by stronger peak winds and more rainfall) but not necessarily hurricane frequency.
- Caribbean sea levels are projected to rise by up to 0.24 m by mid century.
- Sea surface temperatures in the Caribbean are projected to warm, up to approximately 2$^{o}$C by the end of the century.
- ENSO's impact on Dominican rainfall (early and late season) will likely continue, given projections of the phenomenon's continued occurrence in the future.

## 3.3 ASSESMENT OF SECTORAL IMPACTS OF CLIMATE CHANGE IN DOMINICA

This section covers the assessments of impacts of climate change on various sectors in Dominica as well as identifying adaptation options.. These sectors include Forest, Fresh Water Resources, Agriculture, Human Settlements, Coastal Zones and Fisheries. The sectoral chapters utilize the same basic structure consisting of:

- An overview of the sector – including climatic conditions, geography, historical development, major issues facing the sector at present.
- Current stresses and trends. Identification of local factors affecting vulnerability to existing climate.
- Current adaptive capacity and strategies
- Socio-economic scenarios.
- Future scenarios of climate change. Potential/likely impacts on the sector.
- An identification of Adaptation strategies and measures.

### 3.3.1 FOREST VULNERABILITY AND ADAPTATION TO CLIMATE CHANGE

#### 3.3.1.1 Dominica's Forest Resources

Dominica's topographical diversity has produced a rich array of flora and fauna with extensive rainforests, a multitude of rivers and stream and cascading waterfalls all of which contribute to Dominica's reputation as "The Nature Island of the Caribbean". Forests dominate the island's landscape and they have been a key geographic determinant in shaping the island's history and development. Sixty six percent (66%) of the land area (51,752 ha) was estimated to be covered by vegetative cover of various types (Initial National Communication, 2001).

**Photo 3.1 A slice of Dominica's forests"**

Generally, two types of vegetative zoning characterize the island and are determined by its current climate. Firstly, a wetter eastern coast due to prevailing north east trade winds which leads to more lush vegetative communities, 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, and sensitive in changes to, climatic parameters of precipitation, temperature and wind levels.

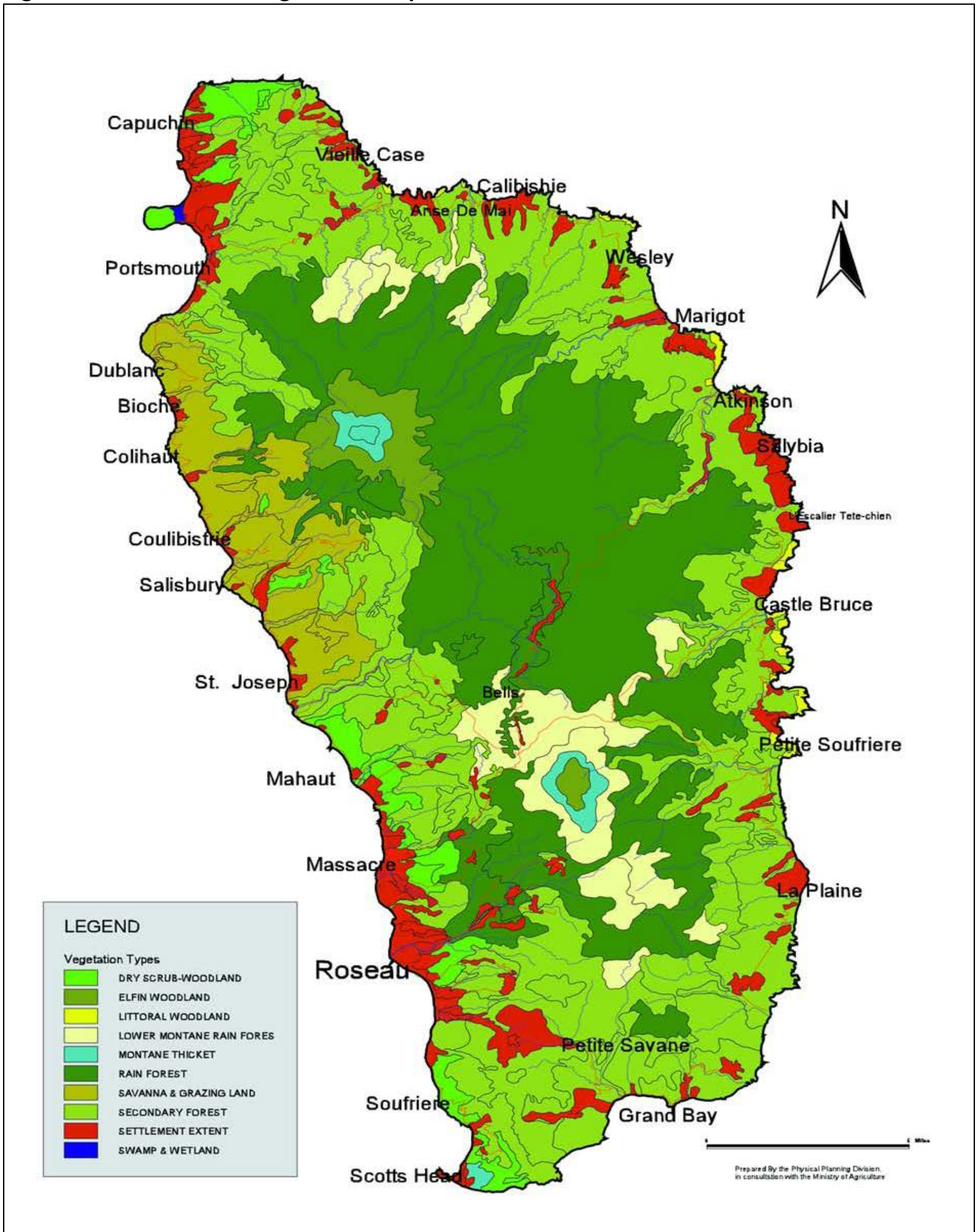
Categorically, seven (7) distinct vegetation communities are present ranging from montane rainforest to coastal swamp and dry scrub woodland (Prins 1987) as outlined in Table 3.1. Figure 3.6 presents a generalized vegetation map of Dominica which provides a more comprehensive representation of the vegetation types. Fumarole vegetation associated with volcanic activity is also present. Together these communities support a plethora of terrestrial biodiversity consisting of some 155 families, 672 genera and 1226 species of vascular plants (Nicolson 1991). There are 60 woody plant species on average per hectare.

Dominica's steep slopes, once denuded of their cover by clearing and exposed to the erosive force of rain, are particularly vulnerable to accelerated erosion and recurrent landslides.

**Table 3.1 Major Vegetation types found On Dominica**

| **Vegetation Type** | **Area (ha)** | **% Landmass** | **Location/ remark** |
|---|---|---|---|
| **Coastal Swamp Forest** | 30 | 0.1 | Cabrits, along Indian River and beaches of North East. Dominant species is *Pterocarpus offici nales* |
| **Littoral Woodland** | 140 | 0.2 | Narrow strip along windward coast. Major species: *Thespesia populnea, Erithalis fruiticosa* |
| **Dry Scrub Woodland** | 6,240 | 7.9 | Leeward coast, well developed at Cabrits and drier areas of the island: e.g. *Sabinea carinales, Bursera simaruba* |
| **Deciduous/Semi-Evergreen Forest** | 7,170 | 9.1 | Transitional between dry scrub woodland and rainforest. Best developed on leeward side. Index species include: *Rhyticoccus amara and Coccoloba venosa* |
| **Rain Forest** | 33,562 | 42.5 | Dominant in interior. Main species: ferns, Dacryodes excelsa, Talauma, Ormosia, Pouteria |
| **Montane Rain Forest** | 4,440 | 5.6 | Transitional b/w rainforest and Elfin woodland. Best developed in southern parts of island in Morne Trios Piton National Park. Index species; *Podocarpus coroaceus* |
| **Elfin Woodland** | 170 | 0.3 | Found in highest elevation in Diablotin and Trois Piton zones. Dominant species: Clusia, mangle, palms |
| **Total** | **51,752** | **65.7** | |

**Figure 2-6 Generalized Vegetation Map of Dominica**




Source : NBSAP 2001-2005

#### 3.3.1.2 Economic importance of Forest Resources

Dominica's forest resources provide incalculable economic value to the country. This includes an array of wood and non wood forest products**.** Dominica's forest provides fertility for the top soil through the constant decaying process of the leaves of the trees referred to as compost production. Soil erosion and land slips are also reduced and averted by forests, especially when established on steep slopes, as is commonly the case in Dominica. Dominica's forest also provides an important carbon sink potential resulting in Dominica being a net sink GHG emitter.

One of the most significant functions of the forest, and for which an economic valuation is difficult, is its function as a source for providing fresh water (through watersheds and water catchments). The local water authority (DOWASCO), and the local electricity company (DOMLEC) both make direct use of Dominica's water resource. The forest provides a supply of fresh water for use by DOWASCO and DOMLEC to provide water and electricity. Dominica's extensive water resources allow the country to be an exporter of water. This includes the sale of bulk water to cruise ships, occasional bulk sales to other Caribbean islands, and bottled water sales regionally and internationally. Dominica's water resources also form the basis for the islands important agricultural sector..

Dominica's tourism industry is based largely on its position as an eco-tourism destination, with its verdant forests and related features being the country's principal income earners especially in relation to the cruise ship sub-sector. Popular sites such as Trafalgar Falls and Indian River are all related to forestry biodiversity, and the islands representation as the "nature island of the Caribbean" is based largely on a scenario of lush forests and accompanying eco-tourism oriented attractions.

#### 3.3.1.3 Stresses

There are concerns from forestry stakeholders that some developments have resulted in fragmentation of a number of important ecosystems. Quarries were also viewed as having negative impacts on forested areas. Additionally, deforestation and poor watershed management relating to agriculture, the introduction of the invasive lemon grass species and its subsequent spread along many areas on the west coast, and improper garbage disposal have also adversely impacted on forested ecosystems. The brush fire season in Dominica usually coincides with the "dry" season, with the greatest amount of activity occurring in the months of March through May particularly on the drier west coast.

Unseasonal hunting (the closed season which is also the reproductive period) and unsustainable river fishing activities pose major threats to the wildlife on the island. Legislation is inadequate and fines and fees are low. Resource conservation efforts are constrained by financial and technical limitations with only limited available knowledge of sustainable exploitation levels.

The practice of shifting cultivation is not considered a major environmental stress but it is considered a growing problem by the Forestry Division. There have been isolated reports of trespassing and deforestation in Forest Reserves, National Parks and on unallocated State lands. Illegal tree cutting and charcoal production is however a growing problem. Many natural hazards periodically affect or threaten Dominica; among them are hurricanes, earthquakes, volcanic eruptions, storm surges, and landslides. The devastating impact of these natural disasters, particularly hurricanes, can be attributed as one of the root causes of biodiversity loss in Dominica.

#### 3.3.1.4 Overview of Adaptation Efforts

The Forestry Division and other forest stakeholder partners are involved in various efforts at enhancing the sustainable development of Dominica's forestry resources. While there is increasing recognition of climate change considerations on forestry at policy levels, at this stage measures for adaptation to climate change are generally contained within wider programmes for sustainable development rather than being directly climate change oriented. This reflects a pragmatic approach to sustainable development as well as reflecting the limited availability of resources for measures to respond to some of the emerging areas of concern. At the same time, important initiatives for enabling forestry adaptation to climate change are planned through the Special Project for Adaptation to Climate Change (SPACC) project.

Strengthening of legislation and regulations governing forest management on government and private property remains a priority for the Forestry Division. The Physical Planning Act of 2002 helps to regulate developmental activities by mandating the use of environmental impact studies for large scale developments but has only limited application in the absence of a national development plan with legal status.

The Silvicultural Unit of the Division propagates selected species for reforestation programmes particularly in critical watersheds areas. Reforestation helps in restoring the resilience of degraded forest ecosystems The Forestry Division priorities within the 2007/2008 Corporate Plan include the sustainable utilization of the islands' forest, wildlife and national park resources, revenue generation, public awareness and education. Key result areas and objectives in the short term are summarized in the table below. Many of the projects to be undertaken will enhance the Division's capacity to respond to climate change in the short term.

##### 3.3.1.4.1 Special Project for Adaptation to Climate Change

The Special Project for Adaptation to Climate Change (SPACC) is an initiative of the Environmental Co-coordinating Unit conceptualized to address resources use conflicts in the Morne Trois Piton National Park (MTPNP) area and to build responsiveness to climate change. The project is envisaged as a part of sub-regional project also including sites in Saint Lucia and St Vincent and The Grenadines.

The project aims at implementation of adaptation measures in the MTPNP and neighbouring communities of Colihaut, Dublanc, and Bioche. Activities will be aimed at maintaining ecosystem integrity and preventing biodiversity loss in face of changes in climate. Efforts will also seek to reduce fragmentation and maintain ecosystem integrity. Under this project a buffer zone will be demarcated and established in the base of the MTPNP to restrict developmental encroachment on the parks resources. Additionally the Morne Diablotin National Park and its basal communities will benefit in terms of parrot conservation and bird watching as well as maintenance and improvements to the water catchment areas. Financing for the project is being sourced through the Global Environment Facility (GEF).

#### 3.3.1.4.2 Mountain Chicken Captive Breeding and Research Facility

In view of the crisis facing Dominica's endemic frog species, the projects' priority is to assess the remaining population size and distribution of Dominica's amphibians and the extent of chytrid spread across the island. Construction of a molecular diagnostics laboratory, training in amphibian survey, disease screening and molecular diagnostic techniques, will all serve to develop capacity within the Forestry Division. Public educational campaigns will target both the local people and the many tourists who visit the island in order to curtail the spread of the disease. There are immediate plans to put in place a surveillance network which will involve the general public and Dominican Hunters Association to report any ill or dead crapaud (Forestry Division Corporate Plan 2007/2008).

Ex-situ breeding of the Dominican mountain chicken is currently being researched. In 2007 a joint initiative between the Zoological Society of London and the Forestry and Wildlife Division resulted in seven mountain chickens transported from Dominica to be bred in the UK. Simultaneously, the construction of an in-country captive breeding facility has commenced at the Botanical Gardens. The long term goals of the project will involve the development of a management plan to address the threat of chytridiomycosis to amphibians across the Caribbean region, the hosting of International Training Workshops, and the creation of an international captive breeding programme for the Dominican crapaud, including a breeding centre on the island.

#### 3.3.1.4.3 GEF Funded Projects

A number of other completed, ongoing and proposed projects are aimed at community capacity building, biodiversity conservation and strengthening community involvement in the management of biological resources particularly those administered by the GEF local office on the island. The collective impact of these projects will no doubt enhance awareness and lay the foundation for future adaptation measures to climate change.

### 3.3.1.5 Climate Change Impacts and Risks

As Dominica's Initial National Communications to the UNFCCC points out, it is difficult to assess how changing climatic conditions will affect Dominica's landscape given its topographical variability especially for the mountainous tropical interior. Additionally, research in climate change impacts on these terrestrial ecosystems, as well as on the wildlife is still very much in its infancy in Dominica and the smaller States of the Caribbean. In many instances, the data sets and technical expertise required to conduct the detailed analyses are not available in Dominica.

Based on expert opinion, the key issues regarding the impact of climate change on forest ecosystems are:

- Generally the faster the rate of climatic change and the greater the degree of variability, the higher the probability of substantial disruption of Dominica's forest ecosystems structures and functions.

- Forested ecosystems may not react uniformly in response to climate change. Rather, each species may respond differently. Existing species associations may be altered and new communities of plants and animals will take their place. Noticeably on the west coast of the island the rapid successional rates of the *Cymbopogan citratus* commonly called the lemon grass is associated with higher temperatures and dryness (Interview with Acting Chief Fire Officer). This invasive species not only changes ecosystem structure but predisposes the area to bush fires and other hazards.

- Those ecosystems that are 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. For Dominica and other small island States, insularity means that such options may not be available.

- Increasingly ecosystem resilience and genetic variability within populations are being reduced through habitat fragmentation. They will be further pressured by climate change. In some cases opportunistic species may invade new ecosystems.

- For many forested ecosystems, increases in the frequency and severity of extreme weather events such as drought, storms, and floods will cause some of the most serious impacts. Shifts in seasonal precipitation patterns and weather variability will become critical. For example, rainfall patterns influences the endangered Sisserou parrots. Unseasonal torrential rainfall during the dry season can cause deflowering of fruit bearing species and subsequent food shortages. It can also cause flooding of nests and drowning of young chicks and hence cause high mortality rates. Both the Jaco and Sisserou occupy elevations within 900 to 2400 ft areas with marked seasonal conditions. Climatic shifts may significantly alter these altitudinal zonations which in turn may impact on breeding, habitat selection and food availability.

#### 3.3.1.5.1 Increased Temperatures

Projected increases in temperature will take place against a background of overall drying trends. Some of the possible impacts of temperature change on Dominica's forests and terrestrial ecosystems are likely to be:

- Alterations in the species diversity of many forested ecosystems.. Examples of this already exist with the gradual shift into higher elevations of invasive drought tolerant lemon grass species.

- Reduction in flow volumes of streams and river due to longer drier period. This is already a seasonal phenomenon in Dominica in the dry season and will likely be exacerbated by higher seasonal temperatures and increasing drought conditions. Reduced stream /river volumes will negatively affect plant growth, reduce forest cover and consequently will impact forests

- Increase in the incidence of higher pests and diseases occurrences associated with changing temperate and rainfall patterns could affect many wild species.

- Higher pest related problems, droughts, variable rainfall as well as more frequent hurricanes and storms, could lower recovery periods of disturbed ecosystems and food availability for wildlife which in turn could induce intense competitive interaction between and within species.

The range of natural life zones occurring in Dominica displays a heterogeneity and rich diversity that is unique within the eastern Caribbean. Under the climate change projections particularly for rainfall and increased temperature, such diversity is likely to be lost with increasing homogeneity in habitats. This can be expected as current areas of microclimate are lost. Given the projections of reduced rainfall and increasing temperature, drought could become a more persistent feature of future climate, and resulting in the dry forest to very dry forest zones expanding.

Dominica's vegetation types, especially in its mountainous interior exhibits a pronounced altitudinal zonation due principally to climatic effects. Climatic shifts are likely to affect vegetational zonation. For example, assuming a lapse rate of 1 $^oC$ per 500 ft, the low scenario(B1) of 1.7 $^oC$ would elevate vegetative zones by 850 ft and the high scenario (3.5 $^oC$) by 1750 ft by 2100. Under the high temperature scenarios elfin woodlands could disappear completely, and some species unique to Dominica could be lost (Parry, 2001).

Considerable gaps remain in the understanding of the impacts of drought and heat stress on Dominica's forest resources. The impacts of drought, accompanied by warmer temperatures, are likely to be particularly important in affecting species diversity and therefore the overall functioning of the forest ecosystem. Research work aimed at analyzing species response to drought will be an important information tool for managing the forest.

#### 3.3.1.5.2 Hurricanes and Tropical Storms

Climate change impacts from projected changes in storm intensity, and possibly frequency, are likely to have very significant implications for Dominica's forests. Hurricanes and tropical storms adversely impact forests through wind and water damage. Damage may include defoliation, breaking of stems, breaking of branches and crowns, and uprooting and toppling of trees. In the longer term as trees recover, changes occur in species dominance and composition

Hurricane David the following year set back regrowth by defoliation of the new less resistant regrowth. While no other hurricanes have had the same effects the frequency of peripheral and other passing storms has meant that forests have continued to be negatively affected.

Experts are of the view that forest gaps and adjoining forests suffer greater hurricane impact than undisturbed forests. Estimates of recovery times for Dominica's forests vary. The World Bank in a report on the impacts of natural disasters on Dominica indicates that some experts have viewed Dominica's forests as "resilient" and have suggested a thirty year recovery period. This is likely to be an optimistic scenario for Dominica given its existing three year time horizons for storm/hurricane return period and the projections for even more intense activity. A 2007 UN Food and Agriculture Organization (FAO) assessment of Dominica's forests has pointed out that as a result of hurricane/storm activity, the forest trees "have become more destabilized and fragile (vulnerable) over the years so that hurricanes of say 60 – 80 miles per hour will topple many trees. Additionally, the lands especially steep slopes, have also become more unstable. Therefore, continuous rainfall, or strong rains will cause tremendous havoc through landslides, land slips and flooding. (FAO 2007)"

The experience of Hurricane David in 1979 and Dean in 2007 provides an indication of many of the adverse impacts on Dominica's associated with hurricane and tropical storm activity. Hurricane David in 1979 resulted in widespread devastation to forested areas. Hurricane Dean which was accompanied by intense rainfall resulted in extensive defoliation with fallen or uprooted trees occurring throughout the forest all over the island, but in a very scattered way. Landslides and landslips occurred on many slopes. Rivers caused great havoc along adjacent lands, in many instances tearing away at the properties of private owners. One impact of Dean was to destabilize a number of trees along nature trails used in the tourism industry, and presenting the risk of damage to visitors and guides.

The FAO report indicates an increase in crop depredation (i.e. the destruction of agricultural crops e.g. fruits, flowers, vegetables, vines etc by wildlife animals) and indicates that "in Dominica this has become out of control. Indeed, since the passage of Hurricane Dean, not only is the crop depredation by birds expected, but a marked increase has already been observed. This is because a high percentage of fruits and seeds normally eaten by birds, especially the Island's two endemic birds (i.e. the red necked and sisserou parrots), had been blown down by the winds of Dean". Such instances of crop depredation are likely to increase where hurrricane damage occurs to wildlife forest habitats.

### 3.3.1.6 Enabling risk reduction and adaptation to climate change

#### 3.3.1.6.1 Introduction

Adaptation refers to the ability of an entity to respond to changes in its climate in a manner that will enable its sustainability. Adaptation may be either autonomous or planned. The significance of Dominica's forestry resources to its ecological integrity and socio-economic circumstances make the goal of minimizing adverse impacts on these resources an important element of any strategy to adapt to climate change.

Projected increases in temperature and changes in rainfall patterns and other climatic parameters can be expected to have significant impacts on forest systems in Dominica and elsewhere. It is likely that in many instances opportunities for these natural systems to adapt to changes in climate will not exist as the sheer magnitude of some of the changes overwhelms the possibility for natural adaptations. In such a context efforts should be directed towards reducing the extent of current risks that enhance vulnerability.

High species diversity per unit area in tropical moist forests such as those in Dominica, create narrow ecological niches that make adaptation difficult raising the risks of species loss. Management and planning efforts for a natural system such as Dominica's forests should be directed at maximizing the opportunities for retaining system health and integrity through natural processes as well as through management monitoring and interventions. This will require wide stakeholder support and understanding and a resolute commitment to long term protection of forest habitats.

Given the extent of the uncertainties concerning specific impacts of climate change, climate change adaptation policies and measures should be directed towards addressing existing stresses and risks that can be expected to weaken ecosystem resilience.

#### 3.3.1.6.2 Recommendations for Adaptation

The significance of Dominica's forest resources has resulted in the identification of a wide range of recommendations for strengthening management of these resources. These recommendations have been most comprehensively brought together in the Policy on Planning for Adaptation to Climate Change prepared by the Government of Dominica under the regional Caribbean Planning for Adaptation to Climate Change (CPACC) project. The Policy provides a detailed set of recommendations, identifies lead agencies for implementation, and indicates the level of priority for the activity. The forestry related components of the Policy are provided in Table 3.2 below.

**Table 3.2 Adaptation Framework for Forestry**

| Strategy and Actions | Rationale | Priority | Time frame | Resource Needs | Remarks | Institutions |
|---|---|---|---|---|---|---|
| Development and enforcement of land use policy | To ensure the sustainable use of the available land resources | Very High | Short-term | Financial<br><br>Human | Available locally trained personnel and literature utilized to facilitate the process | Division of Agriculture, Land & Surveys<br><br>Forestry Div., Physical Plan-ning Div., ECU, ESPWA |
| Review, strengthen, and enforce legislation and regulations governing forest management | To maintain integrity of terrestrial and forestry resources | Very High | Short-term | Consultants Financial Human | Presently, enforcement of existing laws remains a major challenge.<br><br>Will greatly assist in manage-ment of recreational use of the forest (eco-tourism) | Division of Forestry, Ministry of Legal Affairs, Min. of Tourism<br><br>NGOs, NDC, ECU |
| The implementation and promotion of agro forestry systems | To prevent land degradation while providing land for agricultural production | Very High | Short to medium-term | | These will be researched and analysed | Division of Agriculture, Div. of Forestry, ECU |
| Develop formal mechanism of collaboration with private land owners situated in and adjoining watersheds | To protect and ensure the quality of the national water supply | Very High | Short-term | Financial | In areas of high risks of soil erosion and chemical pollution from land-based sources | DOWASCO, Min. of Legal Affairs, Div. of Agri., Farmers' Organizations<br><br>Lands & Surveys Div., Div. of Forestry, Physical Plan-ning Unit, PCB, ECU, Min. of Community Development |

| Strategy and Actions | Rationale | Priority | Time frame | Resource Needs | Remarks | Institutions |
|---|---|---|---|---|---|---|
| Reforestation of critical watersheds, deforested, and severely degraded lands | To enhance the integrity and resilience of watersheds, deforested, and severely degraded lands | Very High | Short-term | Financial Human | Enhancement of Dominica's carbon sink potential | Division of Forestry, Min. of Education, Community Development, COMPACT, ECU |
| Encouragement of urban forestry | To help alleviate urban environmental stresses, particularly heat stress | High | Short-term | Human Financial | To encourage new develop-ments do to take green areas into consideration. | DAPE, DSA, Div. of Forestry, Min. of Comm-unity Develop., NGOs, Physical Planning Unit, Media, ECU |
| Implementation of a coordinated public education and awareness campaign on forestry and other terrestrial resources | To sensitize society at all levels on the impacts of climate change on Forestry, and its impacts on sinks | Very High | Short-term | Financial Human Equipment | Opportunities exist locally for mass dissemina-tion of public awareness material. Deficiency in production of relevant material for broadcasting | Media houses, GIS, ECU, Fisheries Div., Forestry Div. |
| Implement Biodiversity Strategy and Action Plan and initiate the development of a regional approach to critical habitat management | To develop an understanding of tropical ecosystem responses to climate change | High | Long-term | Financial Human | Biodiversity action plan presently being reviewed by Cabinet for endorsement | MACC, CARICOM, CEHI, ECU |
| Build institutional capacity for climate change responses | To strengthen linkages between climate early warning systems and | Very High | Medium to Long-term | Financial Human | Need to coordinate and integrate efforts of the different public and private sector institutions | ECU, Min. of Agriculture & The Environ-ment, Min. of Health, Physical Planning Unit, Disaster Man-agement |

| Strategy and Actions | Rationale | Priority | Time frame | Resource Needs | Remarks | Institutions |
|---|---|---|---|---|---|---|
| | forestry & terrestrial management systems | | | | involved | Office Forestry Div. |

Source: Policy on Planning for Adaptation to Climate Change. ECU. 2002t

The extent of the recommendations underlines the complexity of the tasks involved. Important however is to recognize that climate change should not be viewed as an additional subject from ongoing programmes, but rather that climate change considerations should be integrated into ongoing and planned programmes and activities.

Notwithstanding the importance of all of these elements, the focus here will be on three inter-related elements of the forest risk reduction and adaptation framework – awareness and understanding, regulation, and forest management practices.

### 3.3.1.6.3 Awareness and Understanding

Underlying any aspect of natural resource management are requirements for public understanding and support and the existence of a functioning regulatory framework. Enhancing public awareness of the mechanisms and structures for risk reduction and adaptation to climate change is an essential first step in addressing the issues of vulnerability to climate change. Environmental awareness, and specifically awareness of the importance of the forest, is well established in Dominica. Understanding of the significance of climate change and particularly of the dynamics of the interactions between climate and forest ecosystems however remains minimal at this stage.

Important efforts at promoting understanding of climate change are already underway by the ECU and other agencies. These should be built on and efforts should now be made to further incorporate concerns for climate change into forest education and awareness. This requires that technical staff within the forestry department are sensitized to climate change concerns and are provided with the capacity for promoting understanding of climate change and its linkages with Dominica's forests.

A first line of response for reducing vulnerability of forest ecosystems must be to enhance understanding at community and national levels of the role of forests in protection against climate variability and change and of methods for risk reduction in forest use. This is necessary so as to build up constituencies of support for actions that will be required for improving management of the forests. In many instances it is quite likely that measures required will conflict with established practices such as pesticide use or methods of residential construction in and around forested areas. In such instances public support, based on an understanding of the need to protect forest resources, is important in providing an enabling environment of public opinion for such forest management measures.

The adaptation framework at Table 3.2 above adequately identifies the main parameters of the public awareness programmes needed.

#### 3.3.1.6.4 Strengthening Legal and Regulatory Mechanisms

There is no national land use policy or plan, which means that the use of private land is largely unregulated. Approval from the Division of Physical Planning is required for building. While the recently enacted Physical Planning Act also stipulates that planning approval is required for all development, the law has not yet been fully implemented.

No entity is responsible in general for management of watershed areas as many of these are located outside of the protected areas managed by Forestry.

The CPACC/Government of Dominica’s adaptation framework highlights development and enforcement of a land use policy as the first element of the framework. This is hardly surprising given the centrality of the policy to forest management. The importance of the national land use policy cannot be over-emphasized as this will form the basis for land use decision making. Of central importance in the context of forestry management is that there should be the incorporation of forestry concerns including those pertaining to climate change into the national land use policy. The present situation where there is *de facto* almost no control of conversion of privately and publicly owned forested lands into alternative uses, clearly presents threats to forest ecosystem integrity and has already led to problems of pollution, land slippage, deforestation, and introduction of alien invasive species into sensitive forest areas.

While awareness of the ecological and socio-economic importance of the forest is fairly high, the legal and regulatory framework required for effective management and control of forests, particularly on private lands remains weak or non-existent. This frustrates any efforts that might be made to control inappropriate development in forested areas. More immediately in terms of implications for climate change is that continuation of bad forest management practices heightens risks associated with climate change such as land-slides, soil loss, and other forms of land degradation.

A particularly urgent requirement is for the preparation and approval as a regulatory tool of a national physical development or land use plan. At present no comprehensive vision for land use exists in Dominica. The opportunity is also now presented for integrating concerns for climate change into the planning and approval process in a manner that would not have been possible before.

The extent of the risks posed by climate change, and their multi-sectoral impacts, means that forest managers must increasingly work with physical planners to proactively manage the nation’s important forest resources. A strengthened and updated regulatory framework will be an essential element of this.

#### 3.3.1.6.5 Promoting Resilience of Forest Systems

The ultimate goal of enhancing awareness and strengthening legal frameworks is the protection and management of the forests in the context of unprecedented changes in weather and climatic conditions. These challenges will themselves require more vigorous and robust approaches to forest management.

The World Wildlife Fund (WWF) has identified the following likely impacts of climate change on forest species:

- Disturbance – climate change will increase the level of disturbance or variability of rainfall and temperature. This will have important, yet unknown, effects on forests.
- Simplification – climate change is likely to result in a reduction of species diversity as those species better able to adapt to changing conditions. This will favor fast growing short-lived weed and invasive species.
- Movement – geographically and altitudinally as climatic conditions shift. The extent to which trees will be able to migrate to keep pace with climate is uncertain. This is of particular interest/concern for Dominica. geographic migration presents very limited options for small island ecosystems.
- Age reduction – disturbance, increased forest fires, pests and other stresses will encourage an existing trend towards replacement of older growth forests with younger stands.
- Extinction or extirpation – vulnerable forest habitats at the edge of their ecological niche and some threatened species could disappear altogether. This is particularly significant for Dominica with its high level of endemics and small micro-climatic biodiversity life zones.

No single forest management approach is likely to be able to cope with such a wide range of impacts, coming in addition to existing pressures and stresses on forest lands and resources. There will clearly be need for strengthening the technological and technical capability of stakeholders involved in forest management to devise responses for management of these impacts. Experiences form other countries such as Martinique/Guadeloupe, Cuba, and the US can be vital in providing guidance for best practices.

As the WWF points out however, many of the basic principles of sound forest management will be required. This will involve

- Reducing present threats – a healthy ecosystem will constitute the best and most sustainable response to changing climate conditions. This will require the strengthening of public, private and NGO agencies involved in utilizing and managing the country’s forests.
- Avoid fragmentation and provide connectivity – “edge effects” weaken the micro-climate and contributes to a loss of biodiversity, further weakening resilience to climate change.
- Maximize the size of the management unit – in the case of Dominica this again points to the need for integrated national planning based on an agreed land use planning framework.
- Provide buffer zones and flexibility of land uses – ecosystem management cannot be restricted to a specific boundary. Buffer zones can allow for managed resource use in adjacent areas, contributing to sustainable livelihoods while enabling greater protection of critical habitats.

Only limited experience in management of buffer zones in small island forest ecosytems like Dominica exists. The proposed SPACC project is aimed at developing practical experience in such integrated sustainable use in the context of climate change. It is envisaged that similar type initiatives will be required as climate change impacts affect traditional resource uses and increases pressure on forest resources.

What is clear is that projections for changes in climate and their likely impact on Dominica's forest resources will require a more vigorous and resolute approach to various aspects of forestry management including adoption of more aggressive responses to resource use conflicts if Dominica's important forest resources are to be effectively managed. New areas of forest management such as *in situ* and *ex situ* conservation may also need to be further explored to ensure species survival and development.

#### 3.3.1.7 Conclusion

Within the Caribbean Dominica's forests occupy a unique position in terms of their diversity and the extensive nature of these resources. The islands forests constitute an essential element of the country's vital agricultural and tourism industries as well as providing other social and economic benefits. While tremendously rich in diversity and in potential for sustainable development, Dominica's forests are subject to a host of anthropogenic threats including deforestation, pollution, over-exploitation of commercially valuable species, and fragmentation.

Global climate change is expected to result in a number of adverse impacts for forestry globally and more particularly in Dominica. Increases in temperature, changes in rainfall distribution and intensity, and intensification of hurricane and tropical storm activity can be expected to have severe consequences for the islands forest resources and will come on top of other stresses already being experienced.

The importance of the forests to sustainable development in Dominica justifies actions being taken that will protect the forests while allowing for managed use. The uncertainty surrounding the timing and full extent of global climate change means that actions pursued should be consistent with wider goals for forest management and integrated into development planning. Among the priority actions required are a set of interrelated requirements for enhancing awareness of climate – forest linkages, development and implementation of a national land use policy, and active management to promote forest resilience as a primary tool for risk reduction to a changing climate.

### 3.3.2 FRESH WATER RESOURCE VULNERABILITY AND ADAPTATION TO CLIMATE CHANGE

Water nourishes and sustains all living things. At the same time water is probably the Earths most climate sensitive resource as well as being extremely vulnerable to adverse impacts from human activity. Such recognition is understandable based on the direct relationship that exists between water availability and quality of life. The availability of adequate supplies of clean water is a requirement for sustainable development, and the absence of necessary water supplies serves as an obstacle to social and economic development. . The two major issues of concern to water managers and indeed to all living organisms, are water availability and water quality. Availability of clean water is required for a healthy population as well as being an essential element for agriculture and food production, industry, and service sectors particularly tourism.

Many non climatic factors influence water quality and availability. Water resources are critically influenced by human activity including agriculture, changes in land use, and solid and liquid waste management practices.

#### 3.3.2.1 Observed Changes in the Hydrological Cycle

Climate, freshwater, and biophysical and socio-economic systems are interrelated in complex ways so that changes in one of these will induce changes in another. The Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change (IPCC) points out that while scenarios for future water availability vary according to the scientific models used and also vary for differing parts of the world, most estimates for mid-latitude areas (such as the Caribbean) point to an overall decrease in freshwater availability resulting from changing rainfall patterns and from enhanced evaporation.

The IPCC TAR notes that projected changes in global climate are likely to result in degraded water quality through higher water temperatures and increased pollutant load from runoff and overflow of waste facilities. Quality is likely to be degraded where flows decrease. Alternatively increases in precipitation could provide local increases in water quality by increasing dilution. The IPCC TAR points out that the “greatest vulnerabilities are likely to be in unmanaged water systems and systems that are currently stressed or poorly or unsustainably managed”. The IPCC reports that droughts have become more common especially in the tropics and subtropics since the 1970s

#### 3.3.2.2 Methodological Approach

The purpose of this assessment is to examine the issues relating to the vulnerability of Dominica’s water supply to global climate change, and to identify critical interventions that may be adopted to reduce risk and where possible enable adaptation to a changing climate. This assessment deals only with freshwater. Sea-level rise is dealt with only insofar as it impacts freshwater resources.

The assessment provides an overview of freshwater resources in Dominica and looks at the current climate and other stresses presently facing water resources. Utilizing the findings of the PRECIS model runs for Dominica an assessment is done of the possible impacts of some of the principal parameters of climate change (increased temperatures, greater rainfall variability and a trend towards drier conditions, and intensified hurricane activity) on Dominica's freshwater resources. Following this, policies and measures for promoting risk reduction and for adaptation to climate change are identified

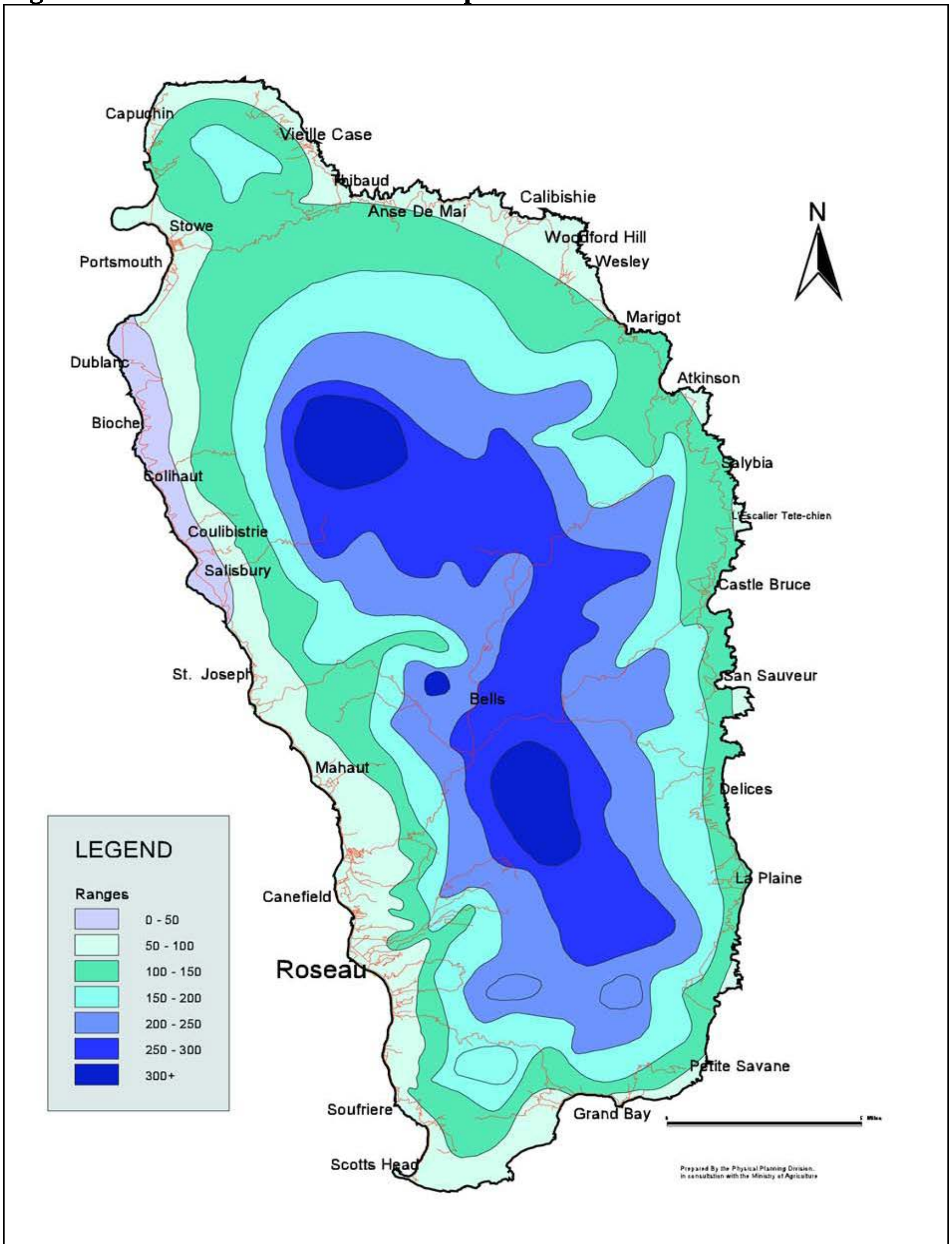
### 3.3.2.3 Freshwater Resources

#### 3.3.2.3.1 Hydrographic Features

Dominica is one of the wettest islands of the Eastern Caribbean due to high rainfall in the interior (up to 7600mm) arising from the influence of its topographical nature and the North East Trade Winds. The eastern Atlantic coast receives an annual average rainfall averaging 4445mm. 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 1250mm (Canefield Meteological Office, 2007) Figure 6.1 below shows patterns of rainfall distribution around the island.

This unequal distribution of precipitation influencing fresh water availability on the island is likely to become more acute as a result of climate change impacts and with the current and proposed developments on the western side of the island. It has been observed that during the peak dry season on the island that there is a greater reduction in flow volumes of river on the west coast as compared to the eastern Atlantic coast.

**Figure 3.7 Rainfall Distribution Map of Dominica**




Source: National Biodiversity Action Plan, 2001 (rainfall recorded in mm)

This rainfall regime is generally sufficient to sustain a steady flow in a number of rivers throughout the island although in the peak dry season volume reductions occur and other kinds of human influences have also negatively impacted on water sheds, surface flow characteristics and water quality.

### 3.3.2.3.2Water Resource Use in Dominica

Rivers are the main source of potable water in Dominica. The main uses of water in Dominica are domestic supply, hydropower, and export. The abundance of surface water has minimized the need to explore for groundwater and hydrological studies have indicated only limited aquifers with low yields. Generally available water resources are adequate to supply domestic requirements except during extended drought periods. Dominica Water and Sewage Authority (DOWASCO) provides services to an estimated 90% of the population with 16,000 connected customers in 2003.

The majority of Dominica's agriculture is rain-fed. Increasingly the demand for fresh water for irrigation and greenhouse farming is growing as the island seeks to become self-sufficient in food production.

**Photo 3.2 Layou River on the West Coast of Dominica**

Freshwater is bottled by two manufacturing plants for domestic and regional consumption. In addition, a number of small industries utilize freshwater as part of their manufacturing process whilst DOMLEC, the island sole electricity provider depends on surface hydrology for the generation of electricity.

Dominica's abundant water resources provide many opportunities for recreational and touristic uses. The islands numerous waterfalls, rivers, lakes and hot springs constitute some of the island's principal tourism sites and attractions. Dominica's freshwater resources are also an integral element of the islands cultural heritage and folklore. River sites are important for various domestic washing and bathing purposes, and are popular destinations for various types of social occasions.

The present supply systems are generally adequate to satisfy national demands, although intermittent shortages are experienced in some of the systems during the dry season. During these dry spells, water consumption increases and 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 (Martin, 1999).

#### 3.3.2.3.3 Institutional Arrangements for Freshwater Resource Management.

In 1989 government established DOWASCO with the responsibility for water and sewerage services throughout the island. DOWASCO currently operates 44 water systems serving 90% of the islands' population. Estimated current water production capacity is 10 million imperial gallons per day, from 44 different sources[8]. The largest single source, serving the urban area of Roseau and a number of nearby communities, has a capacity of 1 million gallons per day. The other 43 systems serve rural communities. Water is delivered through 13,869 domestic connections, of which 5669 (41%) are metered. There are 599 public standpipes throughout the island that allows for public access. A number of small communities are served by systems built by NGO's.

All the existing water systems are dependent on above ground sources typically at an elevation which will permit gravitational flow. Consequently water distribution on the island is mostly gravitational. The Water and Sewage Act of 1989 declares that all existing catchments (gathering grounds) should either be retained as forest reserves, protected forests or be declared controlled areas to ensure reliability of water supply. Given that a majority of the catchment sites are located on privately owned lands, implementation is weak although there is collaboration with private land owners in an effort to restrict activities on these lands. DOWASCO also works in collaboration with various government ministries particularly the Forestry Division to protect catchments sites from deforestation or other forms of human disturbances and from animals' intrusion into water source areas. The Ministry of Health is responsible for the monitoring and enforcement of water quality standards. That Ministry also monitors septic tanks, pit latrines, and public sewerage services.

The top pollutants reported by DOWASCO are sediments, bacteria and nutrient runoffs. Sediments are the major cause of riverine pollution and are often the result of denuded slopes from agricultural and developmental activities especially during period of intense rainfall. Dirt increases water turbidity in most systems and make the water aesthetically unacceptable with the increased potential for biological contamination. Bacterial contamination is also a concern. The major sources include human and animal deposits. Nutrient runoffs compromise water quality standards. Nitrogen and phosphorus are the two major culprits mainly from agricultural activities and to a lesser extent, households. Nutrient discharges induce riverine euthrophication and affect water quality.

### 3.3.2.4 Current Stresses And Trends.

#### 3.3.2.4.1 Overview

Arising from Dominica's small size, geologic origin and topographical characteristics, freshwater resources remain extremely vulnerable to changes and variations in climate as well as to impacts from other natural and anthropogenic sources. Already, various anthropogenic influences are impacting adversely on the supply of fresh water and this is likely to be exacerbated in the future. There is also concern that early signals of a changing climate may also already be affecting Dominica's freshwater resources.

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[8] See Water Resources Assessment of Dominica, Antigua, Barbuda, St. Kitts and Nevis. United States Southern Command. US Army Corps of Engineers. December 2004.

Unregulated developments such as the impacts of quarries affect surface hydrology through degradation of water sheds and sedimentation of rivers which in turn affect water quality and availability. This problem is exacerbated by absence of a land use policy and limited monitoring by the Physical Planning Division.

Some of Dominica's major watersheds are found on private forested lands. Such areas are often cleared for agricultural and infrastructural expansion and consequently these contribute to the degradation of these watersheds. For example over the last 35 years, the development of the banana industry and construction of feeder roads have opened up access further into the higher rainfall steep lands of the interior. This has been accompanied by a large increase in the incidence of soil erosion and mudslides in the upper areas which have been well-protected by the forest cover in the past. Other consequences of this appear to be an increase in flash floods and sedimentation, and a reduction in basal flow. The information for these conclusions is largely anecdotal since river flow measurements, have only been started in selected areas in recent years.

#### 3.3.2.4.2 Pollution

Both point and non-point sources contribute to water contamination and are mainly derived from agricultural, domestic or industrial sources. There is a lack of water quality testing except those conducted on selected sources by DOWASCO. A major challenge facing DOWASCO is the need to provide effective treatment to meet WHO guidelines (adopted as national standards) for physical (turbidity) and bacteriological water quality.

#### 3.3.2.4.3 Inadequate Infrastructure

There is a lack of adequate infrastructure for water capture, storage and distribution (such as reservoir capacity, storage tanks) around the island. This also reflects the expansion of demand into higher areas. Some systems are reaching their limits both in terms of capacity and state of equipment; while others are capable of considerable expansion.

At present the sedimentation problem is dealt with by allowing the water to settle in the storage tanks. Heavy rainfall introduces silt loads into reservoirs blocking filters and lines. This interferes with supply of water and also the quality of water. Repeated periods of heavy rainfall are particularly very stressful since consumers do not have access to clean drinking tap water. This strategy is unlikely to work in the future as sedimentation periods become lengthier due to changing precipitation patterns, rather than discrete storm events, and high sediment rates add to the difficulty of giving adequate chlorination.

#### 3.3.2.4.4 High Operating Costs

Despite the high percentage of gravity operated systems, operating expenses for DOWASCO are still relatively high as compared to other regional utilities. The reason for this is the islands very rugged terrain which means that DOWASCO is forced to operate separate water systems for most communities. The rugged terrain through which the supply lines traverse and the intakes built require frequent maintenance as a result of flooding, blockages and land or rockslides. In rural areas planning restrictions are generally lax so that housing developments are occurring above water intake tanks. Since the DOWASCO distribution system is mainly gravitational in nature, water distribution becomes problematic for these new developments. Another emerging problem that DOWASCO faces is the diversion of major watercourses as a result of development activities across the island. These impact on water availability and quality depending on where they occur.

#### 3.3.2.4.5 Climate Variability and Extreme Weather Events

Dominica has a variable climate. Typically, the wet season runs from June through November with August and September being the wettest months. High water flows typically occur during those months and low flows can extend from December to May. The island's freshwater supply is dependent on rainfall cycles. Some parts of the island experience intermittent shortages due to extended dry season conditions which reduce volumes and flow rates in rivers.

The impact of natural disasters such as hurricanes and storms affects water quality and availability. For example heavy rains and tree falls during storms results in mudslides which may damage distribution lines. Heavy sedimentation results in increased turbidity. In terms of medium to long term impacts hurricanes and storms can also disrupt forest growth and density and affecting the productivity of the watershed.

### 3.3.2.5 Climate Change impacts of freshwater resources

Projections for climate change in Dominica and the Caribbean can be expected to impact on Dominica's freshwater resources. Irrespective of scenario, model or methodology used, there is a projected annual mean temperature increase for Dominica.

#### 3.3.2.5.1 General Impacts of Climate Change on Freshwater Resources

The impacts of climate change will not occur in isolation but will represent a combination of environmental impacts. Within Dominica the general impacts are likely to include:

- Changes in temporal and spatial distribution due to increased climate variability. Total annual rainfall between the east and west coast may vary with more serious water shortages on the drier west coast.
- Contamination of ground water and surface flows due to increased soil erosion and nutrient losses arising from the greater frequency of extreme rainfall events in various localities across the island. This will in turn increase water treatment costs which are likely passed on unto consumers. There is also likely to be an increased incidence of water borne diseases.
- Salinisation of groundwater recharge near the coast due to salt water intrusion and marine inundation.
- Increased hurricanes, storms and extreme rainfall events are likely to damage water distribution lines as a result of mudslides. This may have implications for water availability.

- Changes to surface hydrology due to drought related conditions will affect both humans and aquatic organisms.

#### 3.3.2.5.2 Increased Precipitation Scenarios:

With increased precipitation river volumes will expand and make more water available for consumptive and non-consumptive uses. Under increased rainfall scenarios there is expected to be an increasing direct effect on the volume of surface run-off and thus the quantities of physical debris entering water courses. Where rainfall increases just marginally the impact is likely to be less dramatic.

Changes in rainfall patterns, particularly shifts in seasonality and in intensity of rainfall events, are likely to also affect freshwater resources.

The following implications are associated with an increased rainfall scenario:

- Landslides: Some of Dominica's soils are highly erosive. Torrential rainfall frequently causes earth movements in the forms of debris flows, rockslides, land slump and landslides. During an inventory conducted in 1987 for example, more than 980 landslides were mapped. It was found that Dominica has roughly 1.2 landslides per square kilometre (De Graff, 1987**).** This could pose a serious challenge to the quality of water resources.
- Flooding: It is anticipated 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 wider river courses. 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 changes: Increased freshwater outflows will reduce the salinity of coastal waters in areas such as Layou. This can have serious consequences for fisheries and a loss of livelihoods for fishers who subsist on the harvest of anhydromous species in the inter-tidal zones between river and the sea. The influx of copious quantities of fresh water will offset salinity balances for a number of marine species. Additionally, nursery grounds may no longer support their normal biodiversity and fish stocks 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. need to examine the long term projections which point more to drying. These impacts likely will be only seasonal or a year or two and not long term.
- Water Quality: Unless there are changes in agricultural practices, zoning, stricter regulations to location choices for housing, waste disposal habits, increased precipitation will undoubtedly result in increased levels of topsoil removal, 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: where episodes of increased precipitation result from storm or other tropical systems there is a greater likelihood of likely to damage to the water

infrastructure on the island such as intakes, supply lines, reservoirs. This will contribute to higher treatment costs especially where they are located too close to large rivers, on vulnerable hillsides, or if they are within a flood plain. Municipal water supplies will therefore be threatened.

#### 3.3.2.5.3 Impacts of Decreased Precipitation

Precipitation is the main driver of variability in the water balance and changes in precipitation have important consequences for hydrology and freshwater resources. For Dominica the frequency of drought or low river and stream flows is affected by changes in seasonal distribution of rainfall, year to year variability and occurrence of prolonged droughts.

As noted above IPCC and PRECIS models project drier conditions for Dominica's future as a result of climate change. The 2001 drought experience points to some of the types of impacts – severely reduced river flows including cessation of flows at some sites, forest fires, and increased demands for water for agricultural and municipal purposes – that are likely to become more common. 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. The following scenarios are likely:

- Water abstraction for agriculture and domestic use will increase in all areas as recharge from rainfall dwindles. If this trend continues, ground sources may diminish and loss of alternatives sources would provoke immediate policy changes.
- Consumers who normally maximize rainwater storage will have to depend on DOWASCO supplies which are already stretched in some rapidly urbanizing areas.
- Base flow of rivers will drop as a consequence of the combined impacts of increased abstraction and declining input from rainfall. Where these water courses are already under immense pressure from quarries and other developments, flow volumes changes will be more critical.
- Potential impacts on the resilience of the watersheds resulting in increased medium to long term reduction in watershed productivity.

Drought conditions have already spurred some measure of adaptation and risk reduction. In particular, it has become common practice for households to obtain emergency storage tanks particularly on the drier west coast for domestic use and to supplement supplies for agricultural production. Water can become a limiting factor to vegetable farmers in the dry season where irrigation water systems do not deliver adequate supplies.

Based on the GCM and RCM data drought conditions will represent one of the principal adverse impacts on freshwater resources. Downstream effects of drought are diverse and include health, agricultural and industrial effects. Soil moisture conditions will be directly influenced by reductions in rainfall especially where accompanied by increased temperatures. The local effects of soil moisture loss will be dependent on various factors including soil types, slope, and other factors.

#### 3.3.2.5.4 Higher Temperatures

Temperatures in Dominica's freshwaters – rivers, lakes and streams – will be affected by changes in ambient temperatures. Water temperature in these systems depends on altitude, wind and solar radiation. Dominica's small rivers and streams are particularly likely to be affected by warming of air and ground temperatures. The IPCC indicates that river water temperatures will increase a slightly lesser amount than air temperature with the smallest increases expected where groundwater contributes to the catchment. Biological and chemical processes are influenced by water temperature, so that monitoring and research will be required to ascertain the extent and sensitivity of impacts of warmer temperatures on the ecology of Dominica's freshwater resources.

Evaporation from the land surface includes evaporation from open water, soil, shallow groundwater, and water stored on plants as well as transpiration through plants. The rate of evaporation is driven by meteorological conditions mediated by soil conditions and by the amount of water available. Increasing temperature generally results in an increase in potential evaporation. The IPCC TAR notes that for humid regions atmospheric moisture content is a major limitation to evaporation, so changes in humidity have a very large effect on the rate of evaporation. This would mean enhanced evaporation from Dominica's lakes, rivers, streams, and vegetation resulting in a reduction in available resources for ecosystem and anthropogenic functions.

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. Higher surface water temperatures coupled with dwindling basal flows, may alter the bio-physical parameters of rivers and wetlands sufficiently to affect (vector?) breeding cycles, offspring and parent fecundity, offspring survival and overall species resistance to environmental stresses.

#### 3.3.2.5.5 Enhanced Hurricane Intensity

The impact of hurricanes however cannot be overemphasized. Hurricanes and other tropical systems can produce high precipitation during short periods as happened with Hurricane Dean resulting in extensive destruction to watersheds and affecting their resilience and productivity as watersheds. There is anecdotal evidence that river flows in many of Dominica's rivers are yet recover to pre-Hurricane David levels in 1979. While tropical systems including storms and hurricanes are a part of the natural cycle of renewal within the topical forest eco-system, any increase in storm intensity is likely to adversely impact Dominica's watersheds and freshwater resources. .

Dominica's water supply network is also vulnerable to hurricane and storm impacts. Adverse effects arise from the impacts upon the watershed itself, as well as damage to water supply distribution networks and to equipment. The passage of Hurricane Dean in 2007 caused an estimated 3.7 million dollars worth of damage to water infrastructure of the island (Office of Disaster management Situation Report, 2007). As a result of landslide in the Red Gully area, there is an urgent need to relocate the Springfield Intake which serves over 20,000 people including the city of Roseau. This is necessary to ensure the integrity and reliability of water source for Roseau and its environs. The cost of this operation is estimated to be over EC$6,000,000.00. Other storms such as Hurricane Lenny had similar impacts on the water sector. The passage of Hurricane Omar in 2008 also adversely impacted on Dominica's water supply infrastructure.

#### 3.3.2.5.6 Sea-Level Rise and Storm Surge

Generally sea-level rise is expected to have significant consequences for the freshwater resources of a number of small islands, including many in the Caribbean. In the case of Dominica, the island's mountainous interiors and coastal areas mean that impacts associated wit h sea-level rise impacts on freshwater resources are likely to be felt primarily in the islands river estuaries and the lower reaches of its valleys. This will consist primarily of salinization of groundwater recharge near the coast due to salt water intrusion and marine inundation. Groundwater recharge near the coast does not presently constitute a source of potable water in Dominica but is used for agricultural and other purposes as well as constituting a component of the coastal ecosystem.

Salt-water intrusion will cause salinization of coastal soils and freshwater making them unsuitable for growth of many of the crops presently used in agriculture. The main impact on river estuaries is likely to be 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.

Impacts associated with storm surge are likely to be intensified by processes of sea-level rise and this will also mean greater possibility of saline water intruding further into Dominica's narrow coastal valleys as sea-levels rise. The impact of sea-level rise will be conditioned by various factors including exposure to ocean conditions, gradient, and off-shore features.

### 3.3.2.6 Adaptation Of Freshwater Resources To Climate Change

#### 3.3.2.6.1 Introduction

Adaptation to existing water supply and demand stresses constitutes an essential component of water management in Dominica and elsewhere. As the IPCC Third Assessment Report points out, water managers are therefore accustomed to adapting to changing circumstances, many of which can be regarded as analogs for future climate, and a wide range of adaptive options are available. Supply side options have been the principal instruments used but demand side responses are also increasingly being pursued. Water management is continually evolving and this evolution will also determine the extent of the impacts felt by human communities.

To date water managers have typically assumed that the natural resource base would remain constant over the medium term, and that past hydrological information provided a technical basis for assessing future resource availability. The scale of projected changes in future climate is likely to challenge such established practices and will require capabilities for flexibility in managing freshwater resources. Given the importance of water to all sectors of the economy, concerted action needs to be taken to draw up a programme of response that will engage stakeholders and develop the necessary technical and institutional capabilities to allow for sustainable management of Dominica's water resources in a context of increased rainfall variability and change.

Integrated water resource management has emerged as an approach to managing water resources in a context of changing environment with competing demands[9]. This essentially involves three major components: explicit consideration of all potential supply side and demand side actions, inclusion of all stakeholders in the decision making process, and continual monitoring and review of the situation.

#### 3.3.2.6.2 Context for Freshwater Resource Adaptation

In the Dominica context, such an approach will need to involve a combination of natural resource management activities such as reforestation and agro-forestry schemes to restore and enhance degraded watershed areas, expansion of water storage capacity, a process of land acquisition and zoning of agricultural activities to reduce adverse impacts on watersheds and contamination of sources, strengthening and implementing the necessary supporting legislation and incorporating modern engineering applications to ensure reliability of supplies and to satisfy growing demands among others.

One of the medium term goals of the Dominica Government is poverty eradication by 2015. Part of the Government's response strategy as outlined in its budgetary address and in its Growth and Social Protection Strategy 2006 focuses on ensuring affordable access to clean water. A changing climate and its impacts on the natural environment is likely to adversely affect water availability and in turn the realization of this goal.

The intention here is not to identify all the adaptations that will be required at any point in time. In reality adaptation will need to be dynamic, responding to the particular situation on the ground. The aim must therefore be to establish an enabling environment that provides an appropriate context for individual, household, community, enterprise, and national level risk reduction and adaptation. At the same time the uncertainties involved mean that adaptation policies and measures should target non-climate change concerns as well. In fact the objective should be to integrate concerns for climate change into existing and planned freshwater resource management initiatives.

[9] See Working Group II. IPCC TAR. Chapter 4.

Regardless of what scenarios may develop two principal interrelated adaptation and risk reduction measures will be required – integrated water resource management and strengthening of the national planning functions. Both measure represent risk management responses that are required for responding to existing resource management concerns and can be expected to support adaptation to climate change by allowing for proactive action. The following priorities should be seen in the context of those two overarching requirements.

#### 3.3.2.6.3 Recommendations for Risk Reduction and Adaptation for Freshwater Resources

Climate change is projected to impact on the volume and distribution of rainfall in Dominica and this will influence water availability. Additionally water resource management will also be challenged in the context of other non-climate related factors including economic activity and population growth. This will require that adaptive actions be taken to meet the growing demands for sustainable development as well as the ability of the freshwater resource and institutional mechanisms to supply that need.

Adaptation responses will need to operate at various levels. This includes measures for protection of forestry resources and for demand and supply management technologies and approaches. Both demand and supply management will involve among other things consumer behavioral changes to improve efficiency of water use, as well as management programmes aimed at development of new or existing water sources.

The following overarching policy measures will be required:

- Promotion and strengthening of collaboration between local communities, DOWASCO, Ministry of Health, Ministry of Agriculture, Forestry and the Environment and other stakeholders to develop sound and workable management strategies to protect the island's water resources.
- Development of a long term national water management plan that incorporates climate change concerns.
- Reforestation and other watershed management practices to increase the ability of watersheds and catchments to maximize water availability, as well as to reduce soil erosion and sedimentation including water conservation and restoration of degraded river banks, wetlands and water catchment sites.

These policies and measures will need to be pursued alongside continuing environmental awareness programmes and within the context of other policies and measures for responding to climate change impacts in Dominica. Of particular importance is the need to protect Dominica's freshwater resources as a part of an overall integrated national plan. Additionally the recommendations identified in section 3.3.1.6 [ Enabling risk reduction and adaptation to climate change on Forest vulnerability and adaptation to Climate Change ] above should be seen as central and complementary to those for freshwater management.

The importance of public awareness as a tool for adaptation cannot be underscored. This is true particularly because the impacts of climate change are still uncertain and concrete measures are unlikely to be taken in anticipation of these changes. Awareness therefore becomes important to sensitize the public to effect behavioral changes in order to minimize the impacts. 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 on the sector.

In Dominica and elsewhere managers and developers have relied on historical experience in the past when planning water demand, supply and distribution. With the extra uncertainty arising from a changing climate, and in particular projections for increasing variability within an overall trend to dryness, water managers will be operating in a less predictable environment and will now need to integrate climate change considerations and projections into forecasting for engineering and economic analysis.

An important institutional responsibility for sustainable development of Dominica's freshwater resources rests with the water supplier. DOWASCO's strategic plans, ongoing and completed projects, and training activities all aim to develop local capacity in response to short term and anticipated challenges. There will be a role for government to work closely with DOWASCO in strengthening its capacity on matters relating to climate change through training opportunities, information exchange and other measures.

#### 3.3.2.6.4 Freshwater Resource Adaptation

In Dominica it is likely that adaptation to changes in water availability resulting from climate change will need to be made not only by water resource planners and managers but Also by individual users of the resource. These will include households, municipal agencies, farmers, hoteliers, and industry.

Climate change is likely to present technical challenges for water planners by heightening the levels of uncertainty of future hydrological conditions. In many instances water managers will be required to make long term planning decisions before definitive patterns and trends in hydrological changes may be apparent and while important uncertainties remain as to the nature of expected changes in climate. This points to the importance of flexibility in response options adopted and of consultation with an extensive range of freshwater resource stakeholders. A programme for integrated water resource management can present a practical framework for defining and implementing sustainable water resource management in small developing island States like Dominica.

### 3.3.2.7 Conclusion

Dominica presently depends on rain-fed surface water recharges for its freshwater supplies thereby making it vulnerable to variations in rainfall. Variable rainfall already presents challenges for water managers and these conditions are likely to intensify under accepted scenarios of global climate change. Prospects for future population and economic growth and development are likely to intensify demands on existing fresh water supply systems which are already stretched in most areas.

Given the existing constraints and the many adaptation options that must be explored to ensure the sustainability of the island's water supply to climate change it is important to prioritise actions and to focus limited resources on core issues that have multi-sectoral and multiplier benefits.

Water is a multi-sectoral resource that impinges on all facets of life and livelihood including security. The overall vulnerability of the islands water sector will be a function of many interrelated factors including the degree of exposure to climate change. In recognition of the above factors a comprehensive strategy based on information exchange and consultative processes with all stakeholders is needed to develop national capacity against the anticipated impacts of climate change.

Notwithstanding the abundance of water on the island, historical evidences show that volumes in some of Dominica's major rivers have diminished in recent years particularly as a result of various kinds of human activities and climate related impacts. Being cognisant of this, a comprehensive water management conservation strategy needs to be drawn up in consultation with all stakeholders. This should encompass the preservation of wetlands and water catchment sites including through establishment of buffer zones, declaration of these sites as protected areas and where degradation has occurred, restorative work should be undertaken to re-establish ecological integrity.

### 3.3.3 CLIMATE CHANGE IMPACTS AND ADAPTATION FOR AGRICULTURE SECTOR

#### 3.3.3.1 Global Context of Agriculture and Climate Change

Agriculture is a basic activity by which humans live and survive on Earth. At the same time, agriculture is intimately linked to climate, particularly in areas dependent on rain-fed water for agriculture .Assessing the impacts of climate change on agriculture is therefore an important task. In both developed and developing countries, the influence of climate on crops and livestock persists despite irrigation, improved plant and animal hybrids, and the growing use of chemical fertilizers. The continued dependence of agricultural production on light, heat, water and other climatic factors, the dependence of much of the world's population on agricultural activities, and the significant magnitude and rapid rates of possible climate changes all combine to create the need for a comprehensive consideration of the potential impacts of climate on global agriculture.

The data generated by the PRECIS model as well as the findings of the IPCC point towards a clear warming trend, as well as changes in precipitation, and intensification of hurricane and tropical storm activity. Of particular concern for Dominica's agriculture are projections for warmer temperatures, intensified tropical weather systems, and for greater variability in rainfall.

Uncertainty remains a major consideration in assessing the impacts of climate change. This reflects both the still evolving nature of climate science as well as the limitations in data on the effects of climate change on Dominica and the Caribbean. The issues of uncertainty require that adaptation and risk reduction measures adopted are consistent with and complementary to other sustainable development goals. However while scientific evidence may still be lacking, there is empirical understanding of changes in climate already impacting agriculture. This underlines the need for early action to safeguard this vital industry.

The long term strategic objective of adaptation measures should be to integrate climate change considerations into the planning, development and implementation of virtually all aspects of sectoral growth.

Traditionally, Caribbean agriculture has been largely based on plantation crops such as sugarcane, banana, cocoa, coffee and tobacco. Notwithstanding the potential within the region for agricultural development a number of external and local factors, including climate variability and extreme weather events continue to hinder agricultural development in the region.

Unlike many other Caribbean island nations, Dominica was never a suitable site for sugarcane cultivation, as rocky and mountainous terrain made large scale plantation production impossible. Climate, fertility, and topography are favorable for tree and root crops, however, and Dominica has historically been a producer of coffee, cocoa, and citrus fruits.

### 3.3.3.2 Overview of Dominica's Agriculture

#### 3.3.3.2.1 Physical Features

According to the Land and Surveys Division, Government of the Commonwealth of Dominica, seventy percent (70%) of Dominica's land resource has been classified as unsuitable for agriculture due to the topography, the erosive nature of the soil, high erosion risk from water saturation, or the stony nature of the land itself. Table 3.4

**Table 3.3 Agricultural Suitability of Land in Dominica**

| Category | Area (ha) | National Park/Forest Reserves (ha) | Percent of Total Land |
|---|---|---|---|
| Very High Erosion Risk | 28,957 | 9,858 | 37 |
| 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 |

#### 3.3.3.2.2 Production

All of Dominica's agricultural products are vulnerable to existing climate risks. Hurricane sand tropical storms as well as associated water-logging and flooding are likely to affect most crops. The dominant crop, bananas, is particularly vulnerable to wind damage from winds of 40 mph or more, so that even the fringe impacts of passing storms can have significant impacts. Perhaps surprisingly in view of the high rainfall, crop production is also adversely affected by moisture stress during periods of extended dry weather.

In Dominica, agriculture is mainly rain fed. Precipitation and water availability influences the type of crops, farming technologies, and the season for cultivating crops. Given Dominica's topographic and climatic conditions as well as the country's principal agricultural products where precipitation is extreme there is also potential for soil loss. Conversely, drought conditions seriously affect crop development and yields.

Traditionally, the agriculture sector has been a low technology sector where a number of small farmers operate at above subsistence levels but with little capital investment and use of new technologies. However there are signs of increasing investment within the sector to improve both the quantity and quality of produce. On its own the Banana industry's contribution to GDP is larger than all other food crops combined although there has been a continuous drop in production since the early 1990s. To offset this decline, programmes aimed at diversifying the agricultural production base and seeking alternative markets have been intensified.

#### 3.3.3.2.3 Agro Sectoral linkages

Efforts have also continued to promote agricultural linkages with the country's small industrial and tourism sectors. Agriculture sector synergies with tourism provide food and raw materials for arts and crafts which sustain and promote eco-tourism. Agro-industrial linkages include soaps and cosmetics, as well as jams, jellies and other fruit products. These remain small scale in operation and face difficulty in competing with regional and international products. Given the important roles that agro-processing play in Dominica's manufacturing industry, an agro-processing policy was formulated in 2002 with the main aim of identifying measures designed at boosting agro-processing.

#### 3.3.3.2.4 Institutional Framework for Agricultural Management

The Ministry of Agriculture, Fisheries and Forestry (MoAFF) is the primary public sector institution responsible for formulating, executing, monitoring and coordinating agricultural and rural development policies. The basic mandate of the Ministry is to enhance food security, and promote and facilitate the growth and development of the agricultural sector through the sustainable utilization of human, natural and other resources.

A critical weakness in management of the agricultural sector is the absence of an Agricultural land use and land zoning policy. Nevertheless, the Government of Dominica remains committed to development of the agricultural sector and has pursued this through programmes for upgrading and rehabilitating agricultural feeder roads, the development of agricultural service stations and extension services, and increasing training and access to credit. The Ministry of Agriculture's Corporate Plan 2007/2008 seeks among other things to further integrate agricultural development with other sectors of the economy.

#### 3.3.3.2.5 Agricultural Vulnerability to Existing Climate Variability

The vulnerability of Dominica's agricultural sector is manifested in the risks presented by natural disasters and climate extremes, as well as in the sectors vulnerability to external economic shocks.

The World Bank (2001) points out that Dominica's real agricultural sector product and agriculture's share of GDP has fallen consistently with each major natural disaster with the sector failing to recover to previous levels of relative importance. Most of this decline is attributable to the crop sector and within that to bananas. As the World Bank points out, despite its vulnerability to climate variability and storms, in Dominica the banana industry has been the most resilient to weather risks due to a number of factors including existence of a guaranteed market, the quick harvest time for the fruit, and availability of crop insurance.

A number of adaptation measures have been developed for coping with climate related stresses facing Dominica's agriculture. At the policy level has been the thrust towards diversification of agricultural products away from bananas towards other crops, increasing animal production, and sourcing of new markets for agricultural products. The other major climate vulnerability for the agricultural sector relates to drought conditions. Most of Dominica's farmers continue to rely on rain-fed agriculture. This makes them particularly vulnerable to periods of extended drought as seen in production figures for 2001 and other periods of significantly slow rainfall.

### 3.3.3.2.6 Non-Climate Vulnerabilities and Risks

In addition to the important risks to agricultural production and development arising from existing climate variability and extreme events, a number of other, often interconnected, factors also highlight the sectors vulnerability. These include an aging population, increasing difficulties in accessing field labour in this labour intensive industry, complex land tenure systems, lack of a comprehensive land use policy, poor agricultural productivity reflecting low levels of technology input and limited entrepreneurial skills among farmers, the dominance of part-time farmers, and high costs of imported inputs, underdeveloped marketing structures, limited credit availability, and lack of insurance outside of the banana industry.

Major economic disruptions that have resulted from the liberalization of the UK banana marked and the collapse of the protected banana market which initially produced severe consequences on the Dominica economy. Largely unregulated extensive banana cultivation on Dominica’s steep terrain has also led to land degradation, deforestation, agrochemical pollution and biodiversity loss among other adverse environmental impacts on terrestrial, coastal and marine environments.

Dominica’s geological formation, highly variable topography and abundance of moisture create microclimatic condition on which diverse communities of plants and animals have evolved over many years. The preservation of these ecosystems are important to the sustenance of agricultural production on the island. However, deforestation, human pollution and the potential impacts of climate change continue to threaten the natural resource base of the sector.

Based on patterns of sectoral growth trends over the last few years, it is likely that sectors such as tourism and the service sectors will continue to compete with agriculture for inputs of capital, land and labour. In particular, unless national or local land use plans are devised there is likely to be an intensification of conflicts in allocating lands for agricultural or non-agricultural related developments. Potentially, population growth will demand more housing and infrastructural developments such as roads and this is likely to exacerbate land degradation, pollution and loss of agricultural production.

High energy and other costs in Dominica and within the region has in recent times become a major deterrent to the expansion of the agricultural sector on the island. In particular this has affected the cost of important agricultural inputs such as fertilizers, the profitability of the huckster trade, post harvest handling and management, and the subsequent processing of agricultural products.

### 3.3.3.3 Impacts Of Climate Change On Agriculture

#### 3.3.3.3.1 Overview of Future Scenarios

Attempts to project future conditions are necessarily subject to considerable degrees of uncertainty. This is applicable for social and economic systems as well as for the physical processes involved in influencing global climate change. The purpose of identifying scenarios is an attempt to identify likely pathways that could develop based on an assessment of existing trends, physical and biological processes, as well as guidance from past experiences.

Future changes in Dominica's socio-economic, environmental and climatic conditions are likely to result in greater pressure on the islands fragile resource base. The sustainability of the agricultural industry is directly dependent on maintenance of soil, water, and atmospheric conditions that are likely to be influenced by a combination of natural and atmospheric conditions.

A changing climate can be expected to have significant impacts on conditions affecting agriculture, including temperature and, precipitation. These conditions determine the carrying capacity of terrestrial ecosystems to produce food for the human population and domesticated animals.

In addition to the general uncertainties that pervade climate change science, it is difficult to quantify the impact of climate change on Dominica's agriculture at this time, as little or no laboratory and field scientific research has been done on the subject. In fact much of the contemporary crop response studies has been or is being conducted in temperate regions.

The assessment looks at five major components of projected changes in climate: warmer temperatures, intensified tropical storm activity, greater rainfall variability, sea-level rise, and increased CO2 atmospheric concentrations. At the same time it is important to realize that these will not emerge as separate and distinct effects but will be a apart of complex integrated effects emerging from unprecedented changes in the chemical composition of the atmosphere

#### 3.3.3.3.2 Increased Temperatures

As noted above, there is relative consistency among the global climate models as to the likely increase in global temperatures for Dominica and other Caribbean islands. Many of Dominica's tropical products (with some important exceptions likely to exist) can be expected to be relatively capable of adapting to increased temperatures projected through to the 2030s although in the absence of actual tests this is difficult to substantiate. However, closely related to temperatures will be the extent of precipitation available to prevent critical moisture loss in either plant or animal agricultural products. The extent to which higher temperatures will negatively affect agriculture is determined by a number of climatic and non-climatic factors.

The vulnerability of various crops and livestock to increased temperatures varies considerably. With projected temperature increases heat tolerance thresholds of many crops are likely to be reached and this will result in heat stress, wilting, and crop failure. Domestic crop production may fall as a result and in turn threaten food security on the island. Among the most susceptible of Dominica's principal agricultural products to higher temperatures are major crops such as bananas and root crops, as well as poultry and other livestock

Higher temperatures can also be expected to influence the growth and proliferation of various agricultural pests and of weeds. This can be compounded by the presence of invasive species well adapted to higher temperatures

#### 3.3.3.3.3 Intensified Hurricane/Tropical Storm Activity

As noted above, the impacts of powerful storms and hurricanes on the island's agricultural sector since the 1970s has been extremely significant, with the sector's performance and long term contribution to gross domestic output declining after these events. The destructive force of major storm events is able to cause widespread destruction to most agricultural products. In general the agricultural sector can be seen as extremely vulnerable to hurricanes and tropical storms. Importantly however it should also be recognized that not only direct hits from these systems, or these systems alone, are destructive to agriculture. Heavy rains associated with Tropical Waves and other tropical disturbances can cause water-logging and flooding while prolonged periods of winds below tropical storm strength can also cause damage and losses to agriculture.

#### 3.3.3.3.4 Greater Rainfall Variability

The hydrological regimes in which crops grow will undergo transformation as a result of the process of climate change. Increased convective rainfall is predicted to occur, particularly in the tropics, caused by stronger convection cells and more moisture in the air.

The GCM predictions have been interpreted to suggest that the there is a clear tendency toward drier in the annual mean, with greater consensus toward the end of the century. For the 2030's the range is from -20% to +15% and 6 of 9 runs indicate a drier Dominica. By the 2050's the range is -21% to +10% and 7 of 9 runs indicate drier conditions than the present. The RCM captures the same drying trend but is more drastic. It projects the annual rainfall to be 30%-50% less than present day amounts by the end of the century. This is consistent with the IPCC projections of a drier Caribbean by the century's end. In general the seasonality of Dominica remains the same in the future i.e. the pattern of cooler dry winter-hot wet late summers will still prevail, though monthly temperatures will be on average 2 degrees higher by the 2050's. (as indicated by the rightward shift of the polygons).

Too much precipitation can cause disease infestation in crops, while too little can be detrimental to crop yields, especially if dry periods occur during critical development stages. The amount and availability of water stored in the soil, a crucial input to crop growth, will be affected by changes in both the precipitation and seasonal and annual evapo-transpiration regimes.

In Dominica although to date there is generally an abundance of freshwater, existing problems facing agriculture include minimal storage capacity, small watersheds and uneven distribution. In the drier periods of the year, water shortages hamper agricultural production. If the climate gets drier this will adversely affect crop production. Increased irrigation can militate against this, but irrigation infrastructure is expensive to implement on the small farms that characterize Dominica's agricultural sector.

Enhanced variability of rainfall will also result in periods of above average rainfall. Under this scenario there is likely to be an increasing direct effect on surface run-off resulting in depletion of soil nutrients and higher incidence of soil borne pathogens. Given Dominica's steep and rugged topography, geological instability, and areas of denuded lands, particularly on the West Coast, the susceptibility to soil erosion is great and soil loss is likely to be a major adverse impact of heavy rainfall. Significant increases in rainfall will also cause rapid expansion of rivers leading to increased incidents of flash flooding especially in low-lying areas where most of the fertile soils and agricultural production is concentrated. High rainfall also results in damage to farm equipment and infrastructure, blocks farm access roads and subsequently the transportation and marketing of agricultural produce from hillside farms to marketing outlets.

#### 3.3.3.3.5 Sea-Level Rise

Reflecting the island's topographic conditions, very little of Dominica's agricultural production takes place in coastal areas. As a result sea-level rise is likely to affect Dominica's agricultural sector primarily through the potential for increasing salinity of the lower reaches of rivers.

#### 3.3.3.3.6 Summary of Impacts

Agriculture in Dominica remains vulnerable to a number of existing climatic conditions: many of these are likely to worsen with a changing climate. Projections for more intensified storm conditions, rainfall variability and higher temperatures are likely to present significant challenges for the sector. Historically, hurricanes, floods and other natural disasters have crippled agricultural production many times in the past requiring recovery periods to regain productivity. Adverse impacts from climate change can be expected to exacerbate soil loss, damage farm infrastructure and cause ecological disturbances which are crucial to sustaining agriculture development.

The social and economic consequences of such impacts on Dominica's agricultural sector could be severe. The sector remains the single largest source of employment with a large part-time and informal employment as well. While declining in its contribution to GDP the agricultural sector still retains an extremely important role. Additionally, the sustainability of the sector is vital to the country's efforts to advance food security. In fact Dominica's role as a major regional producer and exporter means that climate risks to the sector could have implications beyond its shores.

The next section will look at some of the policies and measures that will be required for reducing risks to the sector and advancing adaptation where possible.

### 3.3.3.4 Adaptation To Climate Change

#### 3.3.3.4.1 Introduction

Two main types of adaptation can be identified i.e. autonomous adaptation and planned adaptation. Within the agricultural sector autonomous adaptation would involve for example farm level changes to precipitation patterns by changing crops or choosing different varieties or technologies. Planned adaptation measures involve conscious policy options or response measures aimed at altering the adaptive capacity of the agricultural system.

Generally in Dominica and many other Caribbean islands adaptation measures remain a low priority due to the uncertain local impacts of climate change and the perceived long term nature of the impacts. Nevertheless the impacts of climate change continue to be manifested at all levels and will become more acute in the future. Early adaptation is important within the sector to reduce the cost of adopting long term measures. It is also likely that the awareness generated through the implementation of soft measures will gradually build capacity at all levels and given the heavy capital intensive nature of agriculture and its dependence on natural resources and weather elements, it is important to factor climate considerations early in the planning process.

#### 3.3.3.4.2 Options for Agricultural Adaptation

In the case of Dominica it is recognized that climate change can seriously impact agricultural production and threaten food security. Dominica's Climate Change Adaptation Policy report notes that risks to agriculture are likely to result in the following impacts to the agricultural sector:

- Reduced productivity in relation to fresh water biodiversity, crops, livestock and wildlife due to increased drought conditions;
- Increased soil erosion resulting in increased siltation of marine environment;
- Increased occurrence of agricultural pests;
- Changes in vegetation, deforestation and loss or degradation of habitats as a result of increased forest fires, increased hurricane intensity and earth movements (landslides);
- More frequent economic setbacks and prolonged recovery periods due to overall destruction of infrastructure and agriculture from more intense hurricanes.

The report identifies a number of adaptation options and these are presented in Table 3.4 below.

**Table 3.4 Agriculture Sector Adaptation Options for Dominica**

| Strategy and Actions | Rationale | Remarks | Institutions |
|---|---|---|---|
| Develop program for the introduction of saline, wind/storm, heat, and drought resistant crops | For research on climate change impacts as alternative types | Based on the introduction of Regionally tested and proven varieties | Division of Agriculture, CARDI, DBMC IICA, Private sector, ECU |
| Establish a system for improvement, monitoring and research of conven-tional crop and livestock production systems and processes | To determine the effects of climate change on agriculture production systems | Will involve enhancement of capacity of existing research institutions and facilities | Division of Agriculture, DBMC, Lands & Surveys Div., Ministry of Health, P.C.B., ECU, Bureau of Standards, CARDI, IICA |
| Carry-out risk assessment of vulnerable farms and infrastructure | To reduce the negative effects of climate change on agricultural production | Relocation of vulnerable farms depending on the availability of alternative lands | DBMC, ECU, Division of Agriculture, Land & Surveys Div., Office of Disaster Mgmt. |
| To implement conservation programs and improve natural resource management - agro forestry, watersheds, soils | To maintain integrity of the natural resources | A major component will be the promotion and re-introduction of wind breaks | Div. of Forestry, Division of Agriculture, ECU, DBMC, CARDI, Office of Disaster Management |
| Development of a national food security program | To guarantee food production for local consumption and export given potential negative impacts of climate change | Some initiatives already ongoing -<br>FAO preparing regional food security program;<br>SPAT – pigeon peas production | ECU, Min. of Health, DBMC, Min. of Agriculture, Food & Nutri-tion Council, FAO, Bureau of Standards, NGO |
| Development and implementation of a coordinated public education and awareness campaign on agriculture | To sensitize society and farmers in particular on the impacts of climate change on agriculture | Opportunities exist locally for mass dissemina-tion of public awareness material.<br>Deficiency in production of relevant material for broadcasting | Media houses, GIS, ECU, Fisheries Div., Forestry Div. Physical Plan-ning, Disaster Management Unit, DAIC, Min. of Educa-tion, Min. of Agriculture, and Community Development, DHTA, NGOs |
| Promotion of agricultural Diversification | To reduce the negative impact of climate change on the agricultural sector | Ongoing but needs to be intensified, given the vulnerability of the econo-mically important banana crop. However, potential conflicts with the private sector need to be resolved | Division of Agriculture, DBMC, NGOs, Private sector, Food & Nutri-sion Council, ECU |
| Introduction of appropriate production | To increase food production and | Utilization of Agro-meteorological data in | Division of Agriculture, DBMC, private sector, |

| Strategy and Actions | Rationale | Remarks | Institutions |
|---|---|---|---|
| systems and technologies for enhanced, sustainable production | maintain consistency of supply | production planning | ECU |
| Build institutional capacity for climate change responses | To strengthen linkages between climate early warning systems and agricultural manage-ment systems | Need to coordinate and integrate efforts of the different public and private sector institutions involved | ECU, Min. of Agriculture & The Environ-ment, public sector/DAIC, NGOs |

Extracted from Framework for Dominica National Climate Change Adaptation Policy

The adaptation options above retain their validity and represent a comprehensive set of measures for agriculture. Significantly, many of the adaptation and risk reduction measures identified in the Table are priority measures for addressing wider socio-economic concerns. This includes measures for agricultural diversification and improvements in land management practices. The uncertainties associated with climate science mean that efforts must be focused on dealing with existing development problems, and tackling those problems in a holistic manner that now incorporates concerns for the deleterious effects that are likely on the sector as a result of global climate change.

Nevertheless a few other critical and interrelated adaptation measures are presented below. Taken along with the measures above they provide a set of measures aimed at reducing risk to some of the main impacts of climate change.

- **Development of a Land Use Plan.** As is the case with other sectors there is a clear need for an articulated land use policy to ensure adequate protection of agricultural interests vis-à-vis other developmental concerns. This has also been recently identified as a priority by the UN FAO for Dominica following the destruction caused by Hurricane Dean.
- **Agricultural Insurance.** The success of the WINCROP scheme has highlighted the need for prompt reliable finance for rehabilitation of agricultural production following natural disasters. While the banana industry obviously presents certain unique features which enabled the WINCROP initiative, there is the need to establish comparable mechanisms for other agricultural products especially export products. Cooperation with regional agencies should be sought in developing, financing and implementing such an initiative in view of concerns about regional food security[10].
- **Protection of Genetic Resources and Intellectual Property Rights**. Dominica should move to promote protection of its biodiversity genetic resources through in situ and ex situ conservation measures. This should be aimed at ensuring survival of these resources which may themselves contain genetic properties for responding to

[10] Possible financing sources might be the Trinidad and Tobago financed Petroleum Stabilization Fund and the Venezuelan financed ALBA cooperation programme.

climatic vulnerability, human health and other issues. Where necessary actions may be required to secure legal and other proprietary control of the country's natural heritage.

- **Regional and international cooperation**. Many of the response measures required will exceed the individual capacity of Dominica. There will be the need to utilize regional centres of expertise such as universities and research institutes to advance much of the scientific analysis and testing essential for agricultural adaptation to a changing climate. Efforts must be made to ensure that these agencies now incorporate concerns relevant to the impact on regional agriculture of the regions changing climate.

#### 3.3.3.5 Conclusions

Agriculture is one of the most sensitive sectors to climate related impacts. The agriculture industry in Dominica remains the country's principal economic sector comprising vibrant crop and livestock sub-sectors and with linkages to agro-industry and tourism. Weather related impacts from hurricanes and droughts already present major challenges to agricultural development. Climate change can be expected to adversely impact on all sub-sectors of the agricultural industry. Among the critical elements for promoting adaptation to climate change for Dominica's agriculture will be land use planning, insurance, and international cooperation. While daunting in the challenges to be faced, opportunities nevertheless exist for strengthening the capability of the sector to continue to provide food production for local and export markets.

## 3.3.4 HUMAN SETTLEMENTS

### 3.3.4.1 Introduction

Globally, there is a trend towards greater levels of concentration of human populations into urban settlements. Given this concentration of human populations in various types of human settlements, the impact of climate change on much of the world's people is expected to take place at the level of cities, towns and villages.

Human settlements are here defined as man-made structures and the services that support such structures. This encompasses a wide range of settlements and includes a number of components of infrastructure that support modern human societies: buildings; energy supply; land, sea and air transport infrastructure; communications; solid and liquid waste management, and other services. In many ways human settlements bring together into one geographic focus a number of the vulnerabilities and risks associated with sectors such as health, water, coastal zones and agriculture.

### 3.3.4.2 Methodology

The approach adopted in this chapter for analyzing the likely effects of climate change impacts on human settlements in Dominica involves an outline of existing patterns of human settlement, indicating the existing stresses and difficulties facing the sector that are likely to be relevant to climate change, as well as the institutional processes for human settlement development. This is followed by an indication of possible future socio-economic and climatic scenarios that are likely to affect settlements in Dominica. An assessment of some of the principal impacts of climate change likely to affect Dominica is then provided and this is followed by an overview of risk reduction and adaptation measures that can be utilized to minimize the principal adverse impacts of climate change.

It is important to recognize that uncertainty forms a critical element of any climate change assessment. In relation to human settlements this uncertainty arises from a number of climatic and non-climatic factors including:

- Uncertainty as to the extent and timing of climate change.
- Uncertainty as to the social and economic forces that will impinge on the development and sustainability of human settlements, and
- Uncertainty as to what future public policy and other initiatives may do to affect the extent of climate impacts on Dominica's natural environment as well as on human settlements. This is particularly so since human settlements in many ways represent a coming together of various climate related risks such as health, water resources, food supply, and coastal vulnerabilities.

In that context it is important to recognize that the assessment does not represent a prediction of future climate impacts and the possible adaptations that might arise, but is rather intended as a guide for identifying some of the principal risks and vulnerabilities based on existing knowledge. As with other chapters, and consistent with the use of the UNDP Adaptation Policy Framework approach utilized in this assessment, emphasis is on identifying present risks and vulnerabilities as well as on short to medium term adaptation responses. This recognizes the inherent uncertainties noted above, as well as the importance of addressing existing sustainable development concerns in the sector as an initial response for responding to the type of projections identified by the PRECIS and IPCC projections for future climate change.

### 3.3.4.3 Human Settlements in Dominica

#### 3.3.4.3.1 Patterns of Human Settlements

Dominica's human settlements have been influenced by the country's rugged topography which has forced human settlements into the narrow coastal areas and along river valleys. Dominica's mountainous terrain means that 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 at risk to soil loss and land slippage and are generally more vulnerable to the ravages of extreme events such as hurricanes and to coastal processes.

Housing types in Dominica consist primarily of single and two storey concrete and wood with galvanize or concrete roofs. In addition to housing, human settlements in Dominica also comprise a number of commercial and small industrial facilities mainly located in the greater Roseau area, extending northwards along the island's west coast

The greater part of Dominica's road network is located on the island's narrow coastal strip very close to the shoreline and so is subject to extensive damage during storms and periods of high wave energy. The damage results from a combination of direct sea impacts on sea defenses and roads, as well as from landslides and flooding.

Dominica's electricity and water utility services provide almost complete island-wide coverage except to some remote locations.. Major elements of key infrastructure – water, electricity, and telecommunications – accompany the road along the narrow coastal strip and are at high risk to storm surge and other impacts. The disruptions caused by storm related damage have direct consequences for economic and social activity.

#### 3.3.4.3.2 Existing Human Settlements Vulnerabilities

ECLAC identifies common problems facing human settlements in Latin America and the Caribbean as:

- Inadequate liquid waste services
- Solid waste management
- Energy
- Public transportation
- Urban vulnerability to natural disasters

Vulnerability of human settlements in Dominica to existing weather and climate can be viewed in terms of risks from coastal processes, inland flooding, and landslides. A stakeholder assessment of the vulnerability of coastal settlements in Dominica by Smith Warner (2006) show that many coastal communities in Dominica are vulnerable to at least one or more of these risks (Table 3.5) A consistent feature of human settlements in Dominica is the vulnerability of roads and buildings to storm surge flooding. Inadequate planning controls are apparent in the continuing construction of buildings and other facilities in active wave inundation areas.

The stakeholder assessment provides an indication of the multiple risks that many of these coastal communities face and indicates that stakeholders highlighted poverty levels as a major factor in determining the level of vulnerability of a particular community to these weather related disaster risks. In terms of multiple risks, it is noteworthy that all of the vulnerabilities identified below for Dominica are likely to be exacerbated by climate change.

**Table 3.5 Vulnerability of Select Coastal Communities**

| Coastal processes | Inland flooding | Landslides |
|---|---|---|
| Pointe Michel/Soufriere/ Scotts Head | Layout Valley | Belleview/Pichelin/Grand Bay |
| Calibishie | Pichelin | Carib Territory |
| Thibaud | Melville Hall | Pointe Michel/Soufriere/ Scotts Head |
| Grand Bay/Dubuc/Fond St. Jean | Calibishie | Carholm/Layou |
| Mahaut | Dublanc | Calibishie |
| Layout | Roseau Valley | |
| Dublanc/Bioche | Thibaud | |
| | Toucarie | |
| | Rosalie | |

Source . Smith Warner International. 2006

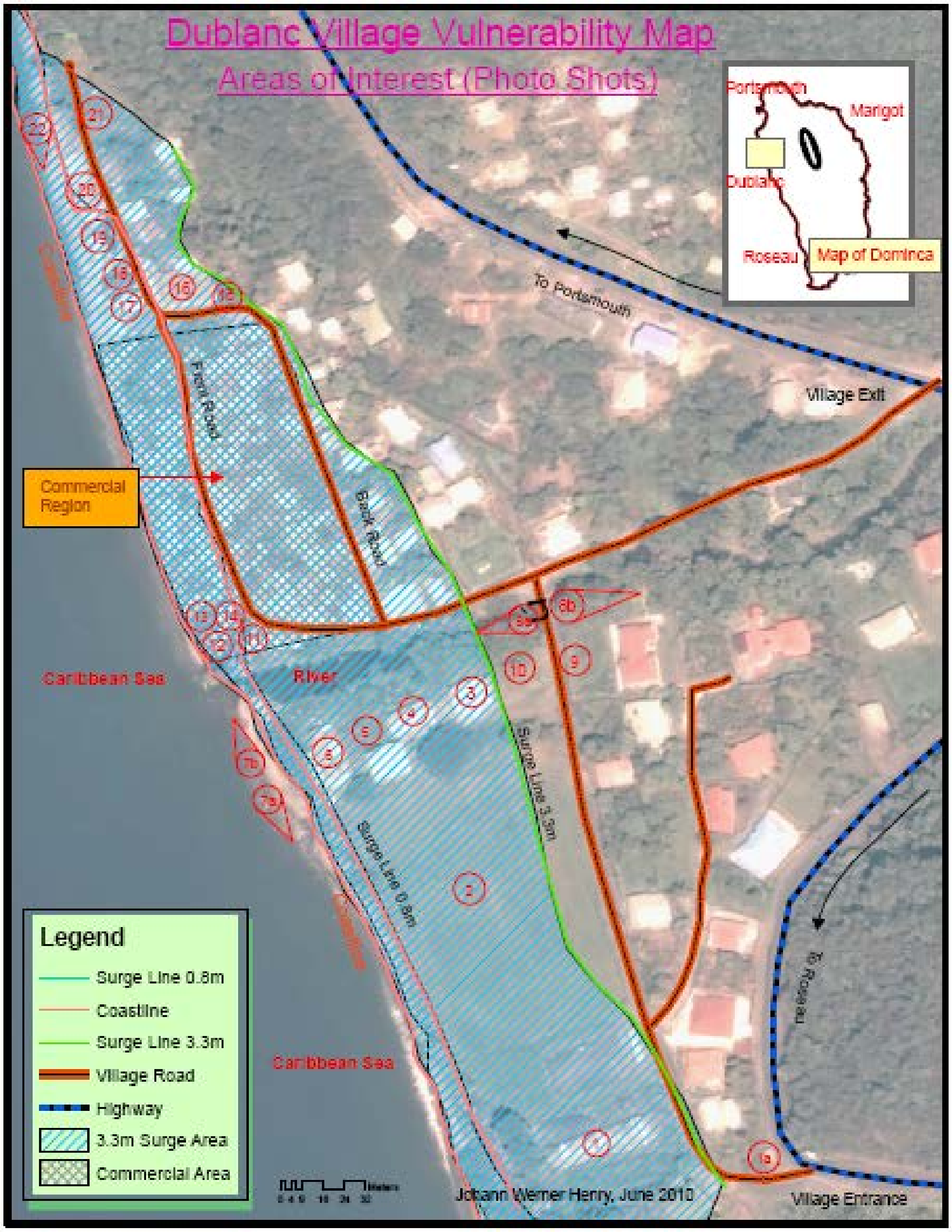
The assessment also identified the major towns and communities, all of which are important population centers, that are most vulnerable to existing natural disasters (Table 3.6) . A vulnerability Map prepared for the Dublanc village indicate the how highly vulnerable the village is to sea surges of 3.3 meters(Figure 3.8). This is typical scenario for most of the coastal communities on the west coast of Dominica where the majority of human settlements are situated.

**Table 3.6 Most Vulnerable Coastal Towns and Villages**

| Towns | West coast villages | East coast villages |
|---|---|---|
| Roseau | Soufriere to Scotts Head | Calibishie |
| Portsmouth | Mahaut | Thibaud |
| | Layou | Dubuc to Fond St Jean |
| | Bioche | |
| | Dublanc | |
| | Toucarie | |

Source: Smith Warner International

**Figure 3.8 Dublanc Village Vulnerability Map**




**Source: Guye 2010**

### 3.3.4.3.3 Institutional Arrangements for Human Settlements

Institutional responsibilities for human settlements reside primarily with the Physical Planning Department. This agency is charged with responsibility for regulation and control of physical development activities in Dominica as well as for long term planning and monitoring. However technical constraints of staff and resources means that much of the agency's focus is on development review and approval with limited capacity for monitoring and for long term development planning.

Institutional responsibilities for human settlements reside primarily with the Physical Planning Department. This agency is charged with responsibility for regulation and control of physical development activities in Dominica as well as for long term planning and monitoring. The Department is governed by the Physical Planning Act of 2002 which provides for the "the orderly and progressive development of land in both urban and rural areas and to preserve and improve the amenities thereof; for the grant of permission to develop land and for other powers of control over the use of land; for the regulation of the construction of buildings and related matters; to confer additional powers in respect of the acquisition and development of land for planning purposes and for other matters connected therewith". The Act represents a modern and comprehensive legislative tool for development planning including the incorporation of environmental concerns, public participation, and the ability to require Environmental Impact Assessments (EIA). Dominica has developed a National Disaster Plan which was adopted in 2001. While focused primarily on emergency response and preparedness, the document also highlights incorporation of risk reduction into the disaster management cycle. The country's small Office of Disaster Management coordinates disaster management activities including providing advice to the Physical Planning Department

#### 3.3.4.4 Scenarios For Human Settlements And Climate Change

##### 3.3.4.4.1 Introduction

Prospects for future sustainable development of human settlements in Dominica will be determined by a combination of non-climatic and climatic factors. It is quite possible that non climatic factors could be equally, if not more significant, than climatic factors in determining development pathways for human settlements. The critical concern is the need to recognize and begin to identify some of the other factors that may also be occurring at the same time as human induced changes in climate. These factors can be expected to influence the extent of the impacts received as well as the type of adaptation and risk reduction responses that are required.

A number of factors can be expected to affect human settlements development in Dominica. These include:

- Population growth
- Poverty levels
- Rural-urban drift, and
- Migration patterns

Many of these will be outside of the direct influence of policy makers in Dominica. For example poverty levels will be influenced by global economic conditions, and will themselves influence issues like the extent of rural – urban drift. International economic conditions will also impact the nature and extent of return migration to Dominica and the amount of migration out of Dominica.

Dominica's topography means that settlements are primarily forced into available sloping and flat lands in coastal areas and valleys. Efforts are underway to promote expansion of human settlements outside of existing population centres. This process is supported by public policy and by private sector initiative. Among factors spurring development of expanded settlements are returning migrants from metropolitan countries, rising housing costs and an increasingly urbanized population.

Urban populations generally receive a higher level of public services than rural communities including in such areas as health care, transportation and communications, and access to recreational facilities. However such communities are also generally at higher risk for certain types of adverse impacts from existing weather events such as flooding. Urban populations also display greater vulnerability to certain types of environmental concerns such as inadequate solid and liquid waste management, and in the case of Dominica and the Caribbean, greater risk from the dengue carrying *aedes aegypti* mosquito.

Expansion of settlements will invariably take place into forested or agricultural lands given Dominica's topographic and land use profile. This invariably presents challenges for soil erosion, watershed quality and related issues and concerns. These developments can themselves affect urbanized areas and other settlements in terms of flooding, drought and other factors.

The absence of an official Development Plan severely restricts the ability to regulate development in a holistic manner particularly in view of the extent of privately owned lands, and the limited technical capacity to monitor and oversee development activities. Overall, the long term trend can be expected to be further development and expansion of urbanized settlements with some degree of adverse effects on coastal and terrestrial ecosystems.

#### 3.3.4.4.2 Climate Change Scenarios

In the case of climate scenarios these are based primarily on the results of the PRECIS model described in section 3.2 [Climate Scenario trend and Projections] at the beginning of the chapter. Projected changes in climate affecting Dominica as a result of global climate change can be expected to have significant impacts on human settlements.

### 3.3.4.5 Impacts Of Climate Change

#### 3.3.4.5.1 Introduction

The projections of climatic scenarios combined with the effects of the non-climatic factors outlined above will present important challenges for human settlements in Dominica. As noted above human settlements in many ways represent a culmination of many of the sectoral vulnerabilities that exist, reflecting impacts from coastal zone, health, freshwater, and other sectors. Because human settlements are also centres for socio-economic activity various direct and indirect impacts can be identified. These indirect impacts will include impacts on economic resources and competitiveness, with possible impacts even in areas such as political and social structures. Within the urban settlement context there are also likely to be a number of vulnerable and high risk groups – the elderly, homeless people, persons with disabilities etc – where the lack of a social safety net enhances the risk factors from stresses associated with a changing climate.

Much of Dominica's infrastructure that supports other vital economic sectors occupies the coastal zone due to constraints arising from the country's rugged interior. Climate change is expected to pose several challenges that may impact on transportation and communication such as the closure of roads, airports and sea ports from flooding or landslides. Housing and settlements are built along the coast right up to the water's edge in many communities and will be at high risk from coastal flooding due to storm surges sea level rise in the future. At the same time, the implementation of setback policies is difficult given the shortage of flat lands in Dominica. The experience of eastward moving hurricanes Lenny in 1999 and Omar in 2008 demonstrates the vulnerability of coastal developments in Roseau to coastal storm surge.

The islands major hotels and potential hotel developments are all within the coastal zone or in some parts subject to riverine flooding. The likely impacts on the tourist sector such damage to hotel, road, sea and air port closures due to likely increase in hurricane activity means that loss of revenue from decrease tourism activities could affect the islands economy in immeasurable ways.

### 3.3.4.5.2 Increased Temperature

PRECIS and IPCC projections for climate change in the Caribbean are most definitive for temperature projections. These projections point to important increases in daytime and nighttime temperatures, reducing incidence of cool days and nights, and seeing a greater warming of the traditionally cooler winter months. The IPCC TAR notes that 'the impact of climate change on health in human settlements is a complicated mechanism that involves the interaction of physical attributes of settlements and precursors for direct effects of heat stress, vector borne diseases such as malaria, and enteric diseases such as cholera.

Settlements also provide disease vectors and organisms with habitats in the form of standing water, garbage, and sheltered spaces. Flooding can flush organisms into water supplies, causing disease outbreaks. Heavy rainfall in normally dry areas leads to rapid increases in rodent populations as do warm conditions. In 2006, Dominica recorded 6 cases of Leptospirosis. In 2010 the amount of cases increased to 14 (compared to as little as one case in previous years). In January 2011, the Ministry of Health informed the public that there is an increase prevalence of Leptospirosis. By September of 2011, the amount of reported cases had increased to 32. Although not confirmed, the recent increases in cases of Leptospirosis can be attributed to the increase in rodent population and water/food contamination caused by heavier than normal rainfall occurring during the dry period.

Built up areas generally can be expected to attract and retain higher temperatures than forested or other natural landscapes. While Dominica's urban and built up areas are too small to create “urban heat island effect”, warming along the lines as projected by PRECIS and IPCC estimates could result in an urban micro-climate in Roseau and environs increasingly characterized by slightly warmer temperatures than surrounding areas particularly during periods of prolonged warm weather such as an El Nino event.

Warming can be expected to increase demand for space cooling in buildings which will have implications for energy demand. Higher temperatures also increase cost of business operations by increasing costs of climate control in buildings. Lower income communities, particularly vulnerable groups such as the elderly, are particularly at risk in these densely concentrated urban settlements. Demand for cooling during warm spells could jeopardize the ability of electric utility suppliers to meet higher than normal peak demands. Providing space cooling will have financial costs.

The principal impacts of warmer temperatures are likely to be reflected in health impacts.

#### 3.3.4.5.3 Sea-Level Rise

Sea-level rise is likely to be another significant effect of global climate change on the Caribbean with IPCC estimates of 5 mm annual increases by 2050. This will affect storm surge and coastal erosion and is particularly important in Dominica where such a high proportion of human settlements are along the coastline.

It is generally recognized that settlements in coastal lowlands are especially vulnerable to risks resulting from climate change particularly where, as in Dominica, these coastal lowlands are densely settled and with significant physical limits to expansion. While this zone covers only a small percentage of Dominica’s land area it contains a significant proportion of the country’s population and vital infrastructure. As noted above coastal settlements in Dominica already display extremely high levels of vulnerability and risk to storm surge and wave action. Such vulnerabilities can be expected to increase as the value of assets within these vulnerable coastal areas increases and as sea levels rise.

The pattern of coastal settlements and infrastructure placement within areas of wave action – houses, roads, public utilities, airports, tourism infrastructure, industrial and commercial activities – means that projections for more intense storm activity and sea-level rise can be expected to have major adverse impacts on socio-economic activity.

The projected impacts of sea-level rise, changes in atmospheric conditions resulting from global warming on coastal infrastructure point towards a reduction in the functioning and safety of coastal infrastructure including harbours, fishing ports, drainage and sewerage systems, oil distribution facilities, and coastal protection facilities.

#### 3.3.4.5.4 Intensified Hurricane Activity

The important uncertainties that characterize climate change are apparent in the projections for hurricane activity in Dominica and the rest of Caribbean. While there is a general view that the intensity or strength of hurricanes is likely to increase driven by warmer oceanic conditions, there is less consensus as to whether there will also be an increase in the number of hurricanes and other tropical systems. In actuality human settlements, in Dominica and elsewhere, are damaged or destroyed by wind force, storm surges, landslides and flooding. Public utilities such as overhead power lines, water and gas distribution lines, bridges, culverts and drainage systems are also subject to severe damage. Fallen trees, wind driven rain and flying debris can also cause considerable damage to human life and to property.

The threat to public health emerges in the aftermath of events when conditions such as water contamination or shortages, flooding and damage to sanitation facilities may favor the spread of disease.

Hurricane-force winds can easily destroy or damage poorly constructed buildings. At the same time extensive damage to trees, towers, water and underground utility lines, and fallen poles cause considerable disruptions to socio-economic activity. High-rise buildings are particularly vulnerable to hurricane-force winds, particularly at the higher levels since wind speed tends to increase with height. Hurricanes also produce tornadoes that add to the storm's destructive power.

Intense rainfall is not directly related to the wind speed of tropical cyclones. In fact, some of the greatest rainfall amounts occur from weaker storms that drift slowly or stall over an area. Historically, and throughout the hurricane belt, more lives are lost to flooding caused by storm related rainfall than from any other source.

Given the wide ranging and destructive nature of hurricane impacts on human settlements, any intensification of these events is likely to present significant adverse implications for the sustainability of human settlements in Dominica.

#### 3.3.4.5.5 Greater Rainfall Variability

The two effects of this are likely to be flooding in scenarios of intense rainfall and greater water scarcity in scenarios of reduced rainfall. Much of the impacts of flooding will be similar to those experienced from hurricane or other rain events. This includes possible loss of life from flood waters, significant health risks including dengue and food borne illnesses, and damage to property and infrastructure. There is also some evidence of a shift in rainfall patterns towards heavier rainfall events and with a larger proportion of rain falling during those events. This increases the risk of flooding as natural and manmade drainage systems are unable to cope with the large volumes of water during a short period of time.

The risks associated with an increasingly dry climate will in many ways represent a new paradigm for risk management for human settlements. Under historic, and current, climate conditions impacts from drought conditions have largely been restricted to the agricultural sector, with human settlements in most instances receiving only temporary disruptions to water supplies. Projected trends towards drier conditions mean that emerging difficulties particularly during extended dry season conditions could begin to affect human settlements more substantially than presently

### 3.3.4.6 Adaptation and Risk Reduction

#### 3.3.4.6.1 Introduction

For human settlements, adaptation to climate change refers to efforts aimed at minimizing adverse impacts of climate change and if possible to exploit any beneficial side effects of a changing climate. Generally speaking, in many ways man-made systems are likely to be better able to adapt to changes in climate than are natural systems. However, for Dominica's human settlements planners in public and private sectors, issues of climate change must now be added to the range of other concerns that they must consider. However the long term nature of climate change impacts, as well as the uncertainties associated with it, means that measures for addressing future climate concerns should be relevant to existing sustainable development issues and concerns.

Climate change considerations will require that Dominica seek to strengthen existing approaches as well as devise new ones to meet the new challenges likely to arise from the type of impacts identified above. Both hard technologies such as infrastructure and soft technologies such as regulation and awareness are likely to be required.

#### 3.3.4.6.2 Adaptation Frameworks for Risk Reduction in Human Settlements

Various efforts at identification of risk reduction and adaptation policies and measures have been completed for human settlements at the global level. The Secretariat of the UNFCCC has identified the following broad elements of adaptation and risk reduction (Table 3.7).

**Table 3.7 Human Settlements Technologies for Adaptation to Climate Change**

| **Hard Technologies** | **Soft Technologies** |
|---|---|
| ***a. Building sector*** | |
| • Lay out cities to improve efficiency of combined heat and power systems and optimize use of solar energy.<br>• Minimize paved surfaces and plant trees to moderate urban heat and to reduce energy required for air conditioning. | • Limit development on flood plains and land-slide prone areas.<br>• Establish appropriate building codes and standards.<br>• Provide low-income groups with access to property. |
| ***b. Transportation*** | |
| • Cluster homes, jobs and stores<br>• Control vehicles ownership through fiscal measures such as import duties and road taxes, as well as through quotas for vehicles and electronic road pricing.<br>• Develop urban road systems. | • Promote mass public transportation.<br>• Use a comprehensive and integrated system of planning.<br>• Link urban transport to land-use patterns. |
| ***c. Industrial sector*** | |
| • Use physical barriers to protect industrial installations from flooding. | • Reduce industrial dependence on scarce resources<br>• Site industrial systems away from |

| | |
|---|---|
| | vulnerable areas. |

Source: UNFCCC Secretariat

The UNFCCC adaptation priorities point to the wide range of interventions necessary for effectively managing the adverse impacts of climate change on human settlements. This includes a number of social policy interventions which are required if vulnerabilities are to be minimized and reflect the importance of social partnerships in reducing the risks to socially disadvantaged groups.

The Government of Dominica's Adaptation Policy Framework developed in 2003 identifies various requirements for climate change adaptation for human settlements and these are presented in Table 3.8 below.

**Table 3.8 Framework for Human Settlements Adaptation in Dominica**

| **Strategy and Actions** | **Rationale** | **Priority** | **Time frame** | **Resource Needs** | **Remarks** | **Institutions** |
|---|---|---|---|---|---|---|
| Identify vulnerable settlements and produce hazard maps for them | To fill data gaps and assist in the preparation of suitable adaptation strategies | Very High | Short-term | Consultants Financial Human Institutional | Information already exist for some communities | Ministry of Agriculture & The Environ-ment, Physical Planning Div., Red Cross, ECU, Office of Disaster Man-agement, NEPO |
| Implement appropriate adaptation measures for existing vulnerable settlements and future developments including strengthened disaster management capabilities | Minimize negative impacts of climate change | Very High | Short-term | Consultants Financial Human | Resettlement/ relocation where possible is urgently required | Ministry of Agriculture & The Environ-ment, ECU, DAIC, DSA, DAPE, Min. of Communica-tions & Works, Office of Disaster Management |
| Development and implementation of integrated, sustained and coordinated public education and awareness program regarding human settlement | To sensitize the general public as to the impacts of climate change | Very High | Short-term | Financial Human Equipment | Opportunities exist locally, for mass dissemina-tion of public awareness material. Deficiency in production of relevant material for broadcasting | Assoc. of Architects, Physical Planning, Media houses, GIS, ECU, Fisheries Div., Forestry Div. |

| Strategy and Actions | Rationale | Priority | Time frame | Resource Needs | Remarks | Institutions |
|---|---|---|---|---|---|---|
| Review and strengthen existing institutional and legislative frameworks for physical planning | To identify inefficiencies, address gaps and overlaps and recommend suitable frameworks | Very High | Short-term | Consultants Financial Human | To ensure compatibility with signed Conventions. To Investigat enforcement mechanism | Ministry of Legal Affairs, Fisheries Div., Forestry Div., Division of Agriculture, ECU |
| To encourage and promote the wide use of traditional knowledge in the development of adaptive strategies | To access and incorporate knowledge of local people | High | Medium-term | Financial Human | Some traditional knowledge and techniques are currently utilized, example in construction | Min. of Communication & Works, Div. of Culture, DSA, DAPE, Draftsmen, ECU |
| To conduct research into impacts of climate change on human settlements | To obtain data for decision-making | High | Medium-term | Consultants Financial Human Institutional | Special focus to be placed on employment, transportation, utilities, energy | DAPE, DSA, ECU, Physical Planning Unit, MACC, CCCC, Min. of Com-munciations & Works, Trade Unions, DEF |
| Build institutional capacity for climate change responses | To strengthen linkages between climate early warning systems and human settlement management systems | Very High | Medium to Long-term | Financial Human | Need to integrate and coordinate efforts of the different public and private sector institutions involved – special training required | ECU, Min. of Agriculture & The Environ-ment, Min. of Health |

Source: Commonwealth of Dominica Climate Change Adaptation Policy

These recommendations provide a relatively all-encompassing approach to adaptation and risk reduction for human settlements focusing primarily on institutional and other “soft” technologies and methods.

#### 3.3.4.6.3 Recommendations for Risk Reduction and Adaptation of Human Settlements

In addition to the comprehensive approaches outlined in Table 3.9 above three other priority areas are

- strengthened physical planning,
- enhanced insurance coverage,
- and strengthening of disaster response mechanisms.

In most instances these are likely to complement the measures above and are also primarily multi-sectoral in their impacts and orientation, aimed at enabling stronger capability for responding to climate change impacts on human settlements which is itself a cross-sectoral.

The impression is very much that there is little firsthand information in the studies so far, and that the text is the result of desk review.

### 3.3.5 COASTAL ZONE CLIMATE CHANGE VULNERABILITY AND ADAPTATION

#### 3.3.5.1. Background

The coastal zone – that area where the marine and terrestrial environments are in direct contact – is of great significance to an island State such as Dominica. Islands have coastlines which are disproportionately large compared to their land area and human activities tend to be concentrated there because so much of the economy is based on or related to man's use of the sea. For Dominica, and other Caribbean island States, a large proportion of their most productive and economically important ecosystems are found in the coastal and marine environment. Similarly, population and economic centres on small islands are also located in coastal areas. In the case of Dominica limited amounts of flat land force human activity into the narrow coastal zone.

A variety of human activities impact on coastal areas, and in Dominica and elsewhere there are often conflicting uses taking place within the coastal zone. Tropical island coastal zones are characterized by a variety of physical and biological systems in close proximity and interaction. Frequently there are no obvious boundaries between adjacent systems so that materials and organisms move freely from one system to another. Processes in one area rapidly affect other areas.

#### 3.3.5.2 Methodology and Approach

This section provides an assessment of some of the possible impacts of global climate change on Dominica's coastal zone, this being defined as the area of land where the interface between oceanic and terrestrial environments occurs and which includes off-shore resources such as coral reefs. It has been argued that the entire land area of the eastern Caribbean island should be viewed as coastal. However a more restrictive approach is adopted.

In this setion indication is provided of the principal resources to be found in the coastal environment, the status of management of the coastal zone, as well as the principal stresses presently confronting sustainable development in the area. It also identifies many of the principal impacts likely to arise from the various processes of climate change, as well as risk reduction and adaptation measures that may be required as responses to the impacts of global climate change.

### 3.3.5.3 Physical features

#### 3.3.5.3.1 Topography

Dominica has 153 km (95 miles) of irregular coastline adjoining a 715 sq .km coastal shelf. Dominica's narrow coastal plain extends from the coastline to form a narrow continental shelf that measures less than 1 km in width except in the area of Marigot on the east coast where it increases to approximately 5 km. The west coast of the island is bordered by the Caribbean Sea, with the Atlantic Ocean on the east. Dominica is almost entirely composed of volcanic rocks. The principal rock types along the coast are either predominantly volcanic (basaltic lavas, andesitic tuffs, ash deposits and a few dacites) or sedimentary. The sedimentary deposits include river gravels, conglomerate and raised limestones found near the mouth of the largest rivers predominantly on the west coast. Dominica's rugged topography therefore also dominates the islands coastal areas. At the same time the availability of some areas relatively flat land along the coast, and the possibility of transportation access has facilitated human settlement in Dominica's coastal areas particularly along the more sheltered west coast.

#### 3.3.5.3.2 Coastal Zone Resources

##### 3.3.5.3.2.a Mangroves and wetlands

Mangroves are among the world's most productive and biologically diverse habitats and yet also among the most threatened (International Tropical Timber Organization, 2003) Mangroves provide a verdant link between the land and sea where they occur buffering both land and sea areas from the direct effects of the other.

In Dominica 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 (Dominica Initial National Communication, 2001). They are found at the Cabrits Swamp, Indian River Flats and Lagoon, Canefield Pool and adjacent meadows, Melville Hall and on the north coast.

##### 3.3.5.3.2.b Beaches

Dominica's geologic origin and coastal topography means that sandy beaches are limited to a few narrow pockets and are not as extensive as some of the limestone islands of the Caribbean. . Some east coast beaches are made of large boulders whilst in other cases cliff faces drop sharply into the sea. These dramatic variations of topography, accessibility, wave action and human activity have a profound effect on marine and coastal biodiversity.

According to Cambers et al (1994), the causes of beach erosion in Dominica are complex and seem to be:

- Anthropogenic causes: Sand mining for construction or building too close to the shoreline. With the shortage of flat land in Dominica, development is extended right up to the water line, thus offsetting many geomorphological coastal processes. While no clear relationship exist between beach mining and the amount of erosion, most of the sites experiencing the highest erosion rates are among those that were beach mined ( Cambers et al 1994).

- Natural causes: High wave energy experienced during tropical storms, hurricanes and winter swells. This normally occurs in the hurricane season which normally starts from June to November every year and the winter swell periods between November to April. These are formed by intense low pressures systems in the Atlantic Ocean. Such waves travel south as swells to affect the eastern Caribbean islands including Dominica. They particularly cause erosion along Dominica's north, west and east coast (Cambers *et al*, 1994).

### 3.3.5.3.2.c River Estuaries

Many small rivers and streams drain from the mountainous interior to the more gentle coastal planes or in some cases cascade from the cliff tops into the sea. Where the coastal gradient is more undulating, the sea enters the river for some significant distance inland forming large pools of brackish water and inter tidal habitats of varying degrees of salinity.

### 3.3.5.3.2d Coral Reefs

Coral reef formation along the coastal waters of Dominica has not been extensive owing to the islands' relatively narrow coastal shelf especially on the west coast. The east coast however has a broader coastal shelf and as a result there are larger expanses of corals and marked differences between the species found there in comparison to those on the west coast although there are some similar species as well.

Coral plays an important role in coastal stability, and serve as fish breeding and nursery grounds for many pelagic species, silt trap and nutrient exporters. Some of the major stresses on the coral population of Dominica include:

- Sedimentation due quarry impacts particularly along the west coast
- Coral bleaching attributed to sea surface temperature changes
- Degradation from wave action especially as a result of storms and hurricanes

### 3.3.5.3.2e Coastal Sea Grass Beds

These are not extensive features of the islands' coastal waters given the sub marine topography; however, isolated patches are common in some areas.

### 3.3.5.3.2.f Crustaceans, Porifera, echinoderms and molluscs

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 shrimps and four species of lobster. Beach development and sea wall defenses along the coast have restricted beach access for land crabs or in some cases disturb their natural habitats.

#### 3.3.5.3.2.g Seabirds

Twenty-seven (27) species of seabird have been recorded in Dominica's coastal waters (Biodiversity Strategy and Action Plan (BSAP), 2001-2005)

### 3.3.5.4 Institutional Arrangements For Coastal Zone Management

No single agency has responsibility for the management of the coastal environment. Rather this is dispersed among a number of agencies including Physical Planning, Fisheries, Public Works, Health and Agriculture. There is no integrated coastal zone management plan and therefore regulations regarding coastal development are developed by many sector. In practical terms the agency with the greatest degree of exposure to management of the coastal zone is the Fisheries Division which is involved in national efforts for monitoring of coastal and marine resources, as well as the actual management of fisheries and other living marine resources. The Commonwealth of Dominica has established three Marine Reserves to preserve and protect the marine environment for all users. There is one reserve each in the Northern, Central and south-western coastal areas. The Dominica Marine Reserve Service has been developed with the support of the Fisheries Division to provide an effective management body to protect promote and educate about the marine environment on the west of the island.

These reserves are all primarily fisheries driven, protecting valuable nursery grounds and spawning areas, in conjunction with the important dive tourism sector. At all stages of the process, attempts at local area management are being implemented, thereby ensuring that critical stakeholders and marine resource users are active partners in the protection process. User fees are employed as a levy to ensure maintenance of the system; from dive boat moorings maintenance to paying warden stipends.

### 3.3.5.5 Sustainable Development Issues In The Coastal Zone

#### 3.3.5.5.1 Existing Vulnerabilities

As noted above coastal ecosystems are among the most productive and diverse habitat on the island. Dominica's communication infrastructure is concentrated within the coastal zone together with its major urban centers, key institutions, and commercial activities. Its naturally deep coastal waters support its vital water borne commerce including cruise ship and cargo vessel trade.

Population and development trends in Dominica indicate a continued coastal orientation in human settlement. Natural stress factors, disasters, storm surges and the anticipated rise in sea level and increased variability in temperature are likely to exacerbate the problem and increase the stress on these coastal environments and ultimately diminish their natural resilience.

The unavailability of flat land is a constraining factor to the sustainable management of Dominica's coastal resources. Nearly all of the islands' communication infrastructures such as air and sea ports, roads and telecommunications networks are found exclusively along the coastal peripheries as well as housing developments, schools, churches, and other important services

Policy regulating coastal development is largely sectoral and in some cases nonexistent. There is no national development plan for Dominica. Consequently development along the coast has been haphazard and unregulated.

#### 3.3.5.5.2 Beaches

Dominica's coastal resources fulfill a multitude of functions. Although long term data on coastal changes is not available, visual evidence indicate erosion marked by the passage of storms and hurricanes. Damage to infrastructure such as the undermining of highways in numerous locations on the island is evident at and has had to be protected by extensive gabion systems.

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#### 3.3.5.5.3 Impacts from Quarry Operations

There are 12 quarries in varying degrees of operating capacity predominantly located on the western coastline of Dominica. as presently operated, quarries are a major threat to the sustainability of coastal systems and to the diverse near shore ecosystems that depend on them. To date, while little quantitative data has been gathered on quarry impacts local technicians have identified a number of adverse impacts on the marine and riverine ecosystems near the coast. Top-soil erosion and subsequent deposition are by far the most obvious impacts of quarries particularly in the wet period or after heavy precipitation.

Quarries are also significant sources of pollutants to the coastal, river and marine environment. Waste oils from engine repairs of major quarry equipment, scrap metal, tires are common and they threaten a number of marine ecosystems in Dominica. Vessels in the transport trade also dispose garbage, untreated sewage and sediments in the sea.

#### 3.3.5.5.4 Current Adaptive Capacity and Strategies within the Coastal Zone

The people of Dominica in numerous ways have over the centuries developed and maintained lifestyles that enabled them to adapt to their natural environment including to the weather and climatic conditions in the coastal environment. This traditional knowledge, practices and cultures, where they still exist, are relevant particularly in the face of accelerated climate change brought about by global warming and sea level rise. A comprehensive response strategy to climate variability and change will among other things integrate indigenous knowledge with scientific applications in such a way so as to be socially acceptable, environmentally compatible and economically feasible for small communities.

The significance of existing adaptation measures should not be underestimated. In particular while considerable efforts are still required, Dominica already enjoys a high degree of public awareness of environmental issues and concerns. While adaptation to climate related stresses in the coastal zone has taken place over the years, the continuing damage sustained by natural features such as coral reefs and beaches, as well as the high levels of vulnerability experienced by human settlements and infrastructure in coastal areas, indicates that considerable weaknesses continue to exist.

Existing policies and measures for management of the important coastal zone include:

- Regulation of physical development through the Physical Planning Division which, although with only limited surveillance capacity, has the legal power to regulate development along the coast.

- In many areas where coastal erosion have been severe or likely, sea defenses, gabion baskets, revetments, boulders and such like have been used by the Ministry of Communication and Works to curb the effects of wave erosion, protection of property and life and to minimize coastal change.

- Set back policies for coastal developments as for the other members of the OECS have been enforced though less so in Dominica due to the shortage of flat land.

- Various workshops and training session funded under the USAID Caribbean Open Trade Support Programme have provided hands- on assistance to quarry developers

- A number of interest groups such as the Dominica Youth Environmental Organization, the Dominica Watersports Association, periodically sensitize the public on environmental issues or otherwise engage in beach cleanup campaigns.

#### 3.3.5.6 Projected Impacts of Climate Change On The Coastal Zone

##### 3.3.5.6.1Socio-Economic Scenarios

The general practice is to also identify possible/likely environmental trends independent of climate change. This approach is not attempted here since it is recognized that anthropogenic climate change is a current reality. Since climate change is concerned with both long and short term impacts, it is necessary to attempt to outline what future conditions, distinct from climate change, are likely to be. In fact socio-economic conditions play an important role in determining key aspects of vulnerability and risk to climate change. It is therefore important to be cognizant of wider trends and developments that can be expected to be occurring alongside changes in climatic conditions.

Traditionally, there has been a coastward migration of people particularly to the administrative districts of Roseau and Portsmouth in search of better economic opportunities. This coastward migratory trend is likely to continue and to exert pressures on the coastal zone for housing, commercial, institutional, and infrastructural development.

Continued dependence on coastal facilities and resources will likely mean increased pollution of coastal and marine areas from land based sources with accompanying negative impacts on coastal and marine biodiversity. Other negative environmental trends including deforestation and consequential problems of sedimentation on reefs, and sea grass beds etc can also be expected to continue, if at lower rates as anticipated legislative provisions and enhanced awareness reduce some of the impacts.

In summary the Dominica coastline in 2015, 2030 and 2050 is likely to see increasing pressures arising from existing and expanded population centers as well as from impacts occurring in the island's interiors which impact on the island's coastal and marine environment. These stresses are separate and distinct from any stresses associated with climate change, and represent pressures arising from processes of demographic growth and economic activity. Such pressures can in many instances be expected to decrease the resilience of various coastal ecosystems to climate change.

#### 3.3.5.6.2 Potential Climate Change Impacts on Mangrove Ecosystems

The proximity of Dominica's limited mangroves ecosystems to the sea makes them extremely vulnerable to sea level rise. Sea level rise will lead to salt water intrusion of mangrove systems. Such salinity changes will likely affect habitat parameters for flora and fauna there and also retard rates of seedling regeneration leading to a gradual landward retreat of mangrove stands and eventually diminishing the buffering capacity of plants closest to the water's edge.

Temperature increase is expected to have an indirect impact rather a direct one.
Precipitation maintains the salinity/fresh water ecological balance of mangrove systems. Any substantial decrease such as a value greater than 20% is likely to create salinity stresses for mangroves and affect their growth rates. Some climate models show such reductions in precipitation are likely by the 2030s. Such conditions would present clear danger to the continued existence of these mangroves as would lesser temperature increases, especially where accompanied by other stresses.

Wave action with greater destruction potential is also likely to have an impact. Sedimentation resulting from the above will affect regeneration of seedlings and aquatic habitats and the elevation changes from sedimentation accumulation can cause a seaward shift of mangrove systems.

#### 3.3.5.6.3 Potential Impacts on Coral Reef Ecosystems

Various studies have indicated that coral species around the Caribbean are living at temperature levels near their maximum thresholds. Signs of coral bleaching have already been seen in the reefs around Dominica. High sustained temperatures (1 to 2 degrees higher than above ambient for several months) due to climate change are therefore likely to result in the further bleaching of an already stressed ecosystem. Prolonged bleaching will lead to death of corals. In addition temperature can impair the reproductive mechanisms of coral, leading to increased mortality (*IPCC, 1997*). A degradation of reefs systems will impact on coastal pelagics leading to loss of fishing banks or induce migration of fish species.

Increased and/or intensified hurricanes and storm activity resulting from climate change is also likely to cause reef degradation, loss of species diversity and longer recovery times. The recent passage of Hurricane Dean in 2007 caused tremendous damage to coral reef systems on the west and east coast of Dominica (Fisheries Division, 2007). This underscores the vulnerability of the reef systems to the impact of storms. Sea level rise as well can induce vertical rather than horizontal coral growth and greater cycles of sediment turbulent patterns which would stress corals as they settle on them.

Signs of coral bleaching have already been seen in the reefs around Dominica. Studies done by the Fisheries Division in 1998, reported that approximately fifteen percent (15%) of the coral species shows some sign of bleaching ranging from minor to severe (*Guiste, 2000, and other personal communications*). High sustained temperatures (1 to 2 degrees higher than above ambient for several months) due to climate change are therefore likely to result in the further bleaching of an already stressed ecosystem

A GEF/IWCAM (2000) report noted that sedimentation caused by poor agricultural practices, sand and gravel excavation and poor land management on steep slopes in general are the single most important cause of death of coral reefs in Dominica. Periodic nutrient, pesticide and over fishing are also major threats. Thus the impacts of hurricanes on stressed coral systems will potentially have a longer and more lasting impact

**3.3.5.6.4 Potential Impacts on Sea Grass.**

Sea-grass beds are the largest organism built habitats of Dominica. Dominica’s underwater topographic features means that throughout Dominican waters, sea-grass beds in Dominica tend to be narrow ranging from 90 - 200 m in width.

Intensified hurricane activity will also have adverse consequences for sea-grass beds. While hurricane and storm activity are a natural part of the oceanic cycle to which sea-grass beds are well adapted, stormy sea conditions during storms and hurricanes does result in removal of sea-grass vegetation. An intensification in frequency and strength could severely disrupt if not destroy these limited resources by not allowing adequate time for recovery.

It is likely that an increase in precipitation would increase sediment loads on the sea grass beds in these locations. Likewise, increase runoffs due to higher precipitation rates from agriculture holdings and quarries could introduce greater volumes of nitrates, phosphate and other nutrients into the marine environment leading to eutrophication. On the other hand, higher sea surface temperatures could induce photosynthesis rates of sea grass populations and offset losses due to sedimentation.

It is not well understood how sediment loads on the ocean floor will impact on the turtle population in Dominica but it is suspected that continuous sedimentation of the ocean floor will inhibit sea grass growth and consequently diminish the foods source for these creatures and eliminate some of their habitats.

### 3.3.5.6.5 Potential Impacts on Beaches

Beaches are the most dynamic features of the coast and are subjected to considerable change from human and natural events. Dominica's narrow beaches are particularly at risk to storm surge and sea-level rise. Many beaches are already experiencing rapid rates of erosion. In many instances existing beaches are likely to disappear completely under the combination of existing land-based stresses, rapid erosion arising from sea surge during storm, and from sea-level rise.

Given Dominica's coastal geomorphology, it is expected that beach changes on the west coast could be more severe than on the east coast.
Against this background it is expected the sea level rise will have the following impacts:

- Erosion due sediment loss as a result of greater anticipated destructive potential of breaking waves. Hurricane impacts have shown that most of Dominica's beaches suffer net sediment loss (Camber et al, 1994) and recover very slowly from such disturbances.
- Beach accretion is also possible for some beaches as evidenced in data collected by Camber et al (1994).
- Shoreline recessions in most parts from sediment losses due to more frequent and prolong inundation periods.
- Loss of beach space will impact on the recreational use of beach for both local and tourists
- Loss of nesting sites for sea turtles, birds, crabs and other flora species along the beach line.

The impact of hurricanes alone cannot be underscored.. The anticipated increase in frequency and severity of hurricanes in the future and reduced recovery times for coastal systems means that these changes could be dramatic.

### 3.3.5.6.6 Integrated Impacts

The above sections indicate likely severe impacts on Dominica's important coastal resources from climate change. At the same time it is important to highlight the issues of uncertainty and the integrated nature of the impacts. Existing uncertainties mean that the precise scope and range of impacts cannot be identified at this stage. Similarly it is necessary to recognize that impacts such as warmer temperatures and storm surge cannot be viewed as disparate but should rather be viewed as a suite of impacts that will effectively place new strains on coastal resources. In particular, the issue of uncertainty means that adaptation and risk management tools and approaches adopted should be consistent with meeting existing risks and vulnerabilities while recognizing the potential effects for global climate change.

### 3.3.5.7 Policies And Measures For Risk Reduction And Adaptation

Human and ecological systems adapt to the negative effects of climate change and climate variability, through a combination of technological and behavioral adjustment. The IPCC's Second Assessment Report (SAR) has identified Retreat, Accommodation and Protection as the three principal basic response strategies for sea level rise and they are applicable to the range of other impacts likely from climate change. The SAR also identifies the six main biophysical adverse effects of sea-level rise as increased flood frequency, erosion, inundation, rising water-tables, salt water intrusion and biological effects.

Given the anticipated impacts of climate change on the coastal sector of Dominica it is important to formulate appropriate adaptation responses. The ultimate objective of adaptation activities and programmes should be the integration of climate change considerations into the planning, development and implementation of virtually all aspects of development within the coastal zone.

Technologies which help reduce the impacts of climate change can themselves cause other problems. This is especially so for coastal zone adaptation technologies where the complex and dynamic nature of natural ecosystems are so apparent. Many of the technologies incorporated within, or needed to implement managed retreat from, accommodation to, or protection from rising sea levels can have adverse socio-economic and/or environmental consequences, even when diligently executed. Most hard structures such as sea-walls will have deleterious effects on coastal flora and fauna, and few if any coastal adaptation technologies will have no negative side effects. In certain circumstances these unintended consequences can outweigh the benefits of the adaptation technology.

The resistance and resilience of an ecosystem will determine how well it copes with anthropogenic stresses. As the WWF points out in relation to tropical coastal ecosystems "conservation efforts can enhance resistance and resilience to climate change by alleviating the overall pressures on the system, and giving it more flexibility to mobilize its natural defenses".

The WWF report on resilience highlights the challenges facing Dominica's efforts to manage its coastal resources in the wake of climate change, since many of the WWF recommendations, such as establishing buffer zones and expanding protected areas, cannot be realized due to spatial constraints. In reality many of the impacts in the coastal zone cannot be managed by action within Dominica as they emanate from global climate changes.

Dominica has in fact achieved considerable progress in management of its coastal resources through the establishment of its marine protected areas. A framework therefore exists for building on the patterns of cooperation with coastal communities and resource users for the optimal level of resource management. In this context the two critical interrelated elements of risk reduction and adaptation are for planned coastal development to promote short, medium, and long term action to reduce impacts in the coastal zone; and policies and measures for strengthening of the mechanisms responsible management of the coastal zone.

### 3.3.5.7.1 Coastal Adaptation Technologies

Existing coastal technologies that have been used to deal with climate variability in coastal zones and implementation of integrated coastal zone management can also be applied to accomplish each of the four main steps to adapt to climate change. These include (i) information development and awareness raising, (ii) planning and design, (iii) implementation, and (iv) monitoring and evaluation. Important data gathering technologies to describe coastal characteristics and processes include in-situ and airborne and satellite-based remote sensing systems.

A large number of effective protection technologies are available, such as dikes, seawalls, and beach nourishment. These also include traditional, indigenous, non-western technologies, such as coconut-leaf walls, coconut-fibre stone units. Technologies which are incorporated within a managed retreat strategy include rolling easements, set-back zones, and moveable structures. An accommodation strategy would employ technologies such as early warning systems for hazards, rain/waste-water management, and desalination. A number of technologies which have emerged to exchange knowledge and information to support integrated coastal zone management may also be applied to evaluate the effectiveness of coastal adaptation strategies. Therefore, extra efforts should focus on promoting, adjusting, and transferring existing technologies, rather than on the development of new technologies.
Many barriers to effective transfer of coastal adaptation technologies are site-specific and require site-specific solutions. Four major general barriers exist: (i) lack of data, information and knowledge to identify adaptation needs and appropriate technologies, (ii) lack of local capacity and consequent dependence of customers on suppliers of technology for operation, maintenance and duplication, (iii) disconnected organizational and

### 3.3.5.7.2 Planned Coastal Development

Present mechanisms for management of human settlement and development in and around the coastal zone are inadequate for dealing with existing levels of risk and will be woefully lacking to cope with even more extensive impacts likely under scenarios of climate change. Adaptation to climate change within the coastal zone will be based on one of the retreat, accommodate, or protect options. The implications of these have been outlined in the Dominica Draft Adaptation Policy document and are outlined in the Table 3.9 below.

**Table 3.9 Adaptation Options for Climate Change Within the Coastal Zone**

| Response | Proposed Adaptation Measures |
|---|---|
| Coastal Retreat measures | • Gradual withdrawal of incentives, subsidies and services in areas where climate change impacts is likely to be severe and where measures aimed at curbing the problem will be unsustainable.<br>• Develop and implement a comprehensive public education, awareness and training programmes for conservation of coastal and marine resources/biodiversity in these areas.<br>• Restricting all neighbouring developments in critical areas of affected coast.<br>• Develop measures to restore or “replace” damaged or destroyed coastal ecosystems and resources to regain natural resilience. |

| | |
|---|---|
| Accommodate | ▪ Protection of ecosystems; identify and designate protection status to coastal areas at risk such as environmentally sensitive areas.<br><br>▪ Coastal zoning and implementing land use codes and building standards above maximum surge levels. Enforce such standards on refurbished structures in at risk areas.<br>▪ Increase monitoring of coastal zones and data gathering to complete comprehensive hazard maps for Dominica<br><br>▪ Cooperation and capacity-building needs strengthened aimed at increasing awareness, understanding and skills relating to coastal systems<br>▪ Insurance coverage for all new and existing structures within impact zones supported by government policy.<br><br>▪ Involve community participation in coastal zone management and strengthen all relevant agencies, stakeholders and to enforce legislation.<br><br>▪ Diversify the economic base of Dominica to reduce pressures on coastal resources. |
| Protect | ▪ Enforcement of building standards and set back policy for development along the coast including a freeze on new quarry development<br>▪ Where construction is necessary along impact zones, foundation constructed below predicted erosion and floor elevation is above storm surge<br><br>▪ Insurance coverage to new and existing facilities in hazard impact zones<br>▪ Foster increases awareness and knowledge on the part of the general public regarding Climate Change impacts on the coastal and marine environment.<br><br>▪ Develop a comprehensive coastal zone management plan for Dominica.<br>▪ Construct sea wall, revetments or gabion baskets to protect existing coastal structures.<br>▪ Place a ban on sand mining and limit coral disturbances through increase monitoring of quarry activities<br><br>▪ Beach nourishment practiced where the beach erosion is acute but remains a vital asset to the tourists or locals or nesting sites to turtles. |

Adopted and modified from Drigo, 2002

Underlying all this is the need for a coastal zone management plan, as a component of a wider national land use plan. Within this, particular attention must be paid to the use of coastal setbacks. Coastal setback provisions ensure that development is prohibited in a protected zone adjacent to the waters edge[4]. Owing to the potential adverse impacts of climate change, setback policies must be designed to ensure that new developments are sustainable (Cambers, 1997).

### 3.3.5.7.3 Strengthened Capability for Coastal Zone Management

Projections for increase storm and hurricane frequency and severity as well as sustained higher temperatures and rainfall events for the Caribbean mean that disaster management and response will be an increasingly significant element of the national response to climate change. For Dominica, the high concentration of infrastructural development within the coastal zone is critical and will warrant collaboration at all levels. Disaster management and response activities can be envisaged at three (3) distinct but inter-related levels: community action, emergency response, and longer term hazard management/risk reduction measures (Drigo, 2002). Possible applicable measure to Dominica is outlined below.

**Table 3.10 Management and Adaptation to Hazards in the Coastal Zone**

| Response | Adaptation Measure |
|---|---|
| Community level action | ▪ Ongoing public awareness<br>▪ Community enhancement and risk reduction projects.<br>▪ Strengthening local institutions and human resource capabilities for emergency action |
| Emergency preparedness | ▪ Communications and logistics management set up.<br>▪ Emergency shelter identified, equipped and secured<br>▪ All building in the storm surge be evacuated by category 3 or higher storms<br>▪ Search and rescue capabilities developed nationally;<br>▪ Public awareness programmes increased.<br>▪ Access to heavy machinery for road clearance |
| Hazard management | ▪ Land use planning policies enforced;<br>▪ Zoning and enforcement of coastal setback policies<br>▪ Hazard resistant construction practices;<br>▪ Avoid new development in the storm surge or zone of coastal erosion<br>▪ Strengthened legislative and institutional capabilities of National Disaster Office. |

Adapted from Drigo (2003)

Given the scale of the challenge, adaptation responses to these emerging problems will need to engage collaborative efforts at all levels in such a manner so as to be environmentally sound, socially equitable and culturally appropriate.
Impacts are likely to be particularly severe from rising sea-levels and intensified hurricane/tropical storm effects. Impacts from these elements of a changing climate are likely to threaten the very survival of many of the natural resources of the coastal zone as well as posing threats for the human settlements and infrastructure present in coastal areas.

Adaptation measures possible are wide ranging and span a variety of hard and soft technologies. Underlying all of these measures is the need to enhance resilience of the natural systems as a first line of defense against climate change effects. Additionally important is the need to implement sound planning for coastal areas. In fact given Dominica’s small size, a system of island wide resource and physical planning is necessary that incorporates measures for coastal setbacks and other development control measures. Ultimately, the sustainable development of the coastal zone will be a critical component of Dominica’s efforts to respond to the immense challenges presented by global climate change.

## 3.3.6 FISHERIES VULNERABILITY AND ADAPTATION TO CLIMATE CHANGE

### 3.3.6.1 Introduction

Historically Dominica's topographical features have been a constraining factor to its physical development concentrating human settlements primarily into coastal areas. However the resultant strong community coastal interface which exists has helped to sustain a small fisheries sector for many years.
Some of the most common species identified in the fish landings around the island are many species of Groupers and Snappers, Squirrel Fish, Black Bar Soldier Fish, Shrimp, Goatfish, Grunts, many species of Wrasse, Parrot Fish, Lobster and File Fish (Fisheries Division 2007).

Further offshore in waters of about 200m to 300m in depth, very large groupers and snappers abound. These are deep slope species and are relatively under-exploited in Dominica. Coastal pelagics are found in the water column above the reef ecosystems. There are four species of turtle found in Dominican waters (National Biodiversity Action Plan, 2001-2005). The coastal waters of Dominica present a haven for many marine mammals. Several species of whales and dolphins have been observed during studies conducted by the Fisheries Department in collaboration with Woodshole Oceanographic Institute. Dominica has developed a small but important whale-watching industry where day trips are organized for visitors and locals.

### 3.3.6.6 Fisheries Development

Dominica's fisheries sector is relatively small (1.8% of GDP) but is important as a source of protein and food, employment, and has tremendous potential for growth and development. In 2006, the fisheries sub-sector maintained a contribution of 12.1 % to the overall agricultural production (National Budget, 2007) and it remains extremely important to the food security and rural employment in Dominica . Though artisanal in nature, the sector employs just over 3100 people, 996 on a full time basis. The majority of these fishers are opportunistic farmers, operating on a part time and on a subsistence level, targeting various species within a 12 miles territorial sea limit. However with the introduction of Fish Aggregation Devices (FADs) in the late 1990s greater exploitation to a 45 miles radius is possible for pelagic species.

Estimated total fish catch has ranged from over 3 million pounds in 2000 to 1.1 million pounds in 2004. In recent times the characteristics and dynamics of the industry have shifted to constitute a greater emphasis on offshore pelagic species of tuna and marlin. Interviews with the Fisheries Division staff and personal communication with fishers have indicated that coastal pelagics catch volumes have been decreasing slowly over the last five years particularly as a result of quarrying on the west coast

### 3.3.6.7 Institutional Arrangements for Fisheries

The responsibility for the management of fisheries and their habitats falls within the domain of several ministries. However the principal agency charged with the responsibility for the management of fisheries and marine resources is the Fisheries Division. The Division faces several constraints in pursuit of its sustainable fisheries goals particularly a lack of funds and human resources to implement its policy objectives to name a few. Several pieces of legislation and other regulatory instruments govern the management of fisheries and marine resources of Dominica. Foremost is the Fisheries Act of 1987 which mandates the development of a Fisheries Management Plan (FMP) for the management of the country's fisheries. Accordingly, the Fisheries Division prepares an annual work plan geared towards promoting sustainable fisheries management for the island. This has allowed for the establishment of marine protected areas and in particular, the Soufriere Scotts Head Marine Reserve (SSMR) to the south of the island, an area demarcated for its unique biological diversity and for the preservation of the islands' unique coral life forms.

A number of non-governmental and community based organizations are also involved in activities often directly, or indirectly, related to fisheries. These include Invest Dominica (formerly 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. The establishment of the fisheries cooperatives has long become an integral part of the sector. In 2009, the National Fishers Cooperative was formed by the unification of the eight (8) formerly registered fisheries cooperatives on the island though only a few are fully functional, through which developmental policies emerge and as a mechanism for implementing strategic initiatives of the Fisheries Division.

### 3.3.6.8 Fisheries Sector Stresses

While considerable potential clearly exists for development of fisheries, sustainable appreciable growth of the sector will be dependent on a number of factors, including capital and human resource capability to embrace new advanced fishing technologies.

Other factors affecting the fisheries sector are:

- Extensive habitat degradation from multiple factors such as the impacts of quarries, ghost fishing and a lack of sufficient surveillance of Dominica's Exclusive Economic Zone. Sedimentation, resulting from quarry operations is the single largest cause of death of coral reefs. Soil erosion caused by bad agricultural practices, poor land use management on steep slopes and the construction of feeder roads also cause sedimentation of coral reefs.
- Domination of the sector by part-time fishers whose average 2.35 opportunistic fishing days per week is grossly inadequate (GSPS, 2006) for large scale development of the industry.
- Indiscriminate dumping of debris and soil along coastal sites which stress near shore habitats and coastal pelagics populations, some of which are showing signs of decline.

- Exploitation of some species (lobster, conch, turtles) is believed to be nearing sustainable thresholds levels. This has 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.

The development of shoreline and sea defense structures contributes significantly to loss of coastal biodiversity in Dominica. These structures replace valuable habitats and alter the pattern of sediment and nutrient transport.). Currently, sediment input via coastal construction and dumping, solid waste (degradable and non-degradable) and fishing pressure are principal adverse man-made disturbances to Dominica’s fisheries.

Coastal fishing communities in Dominica have adapted to challenges facing the industry in the past in a number of ways. Improvements to the fisheries infrastructure, introduction of new technologies and greater level of government support at nearly all levels have better placed the sector to cushion the impacts of adverse weather conditions or changes being brought about by external shocks.

### 3.3.6.5. Climate Change Impacts On Fisheries

The IPCC’s Third Assessment Report (TAR) forecasts that while climate change is not likely to have a major impact on global fisheries production it is recognized that a number of small-island States are likely to be affected by distribution and abundance of fisheries resources. It also notes that other anthropogenic stresses such as pollution and over-fishing are also likely to have major impacts on these resources. The IPCC also point out that the mobility of fish also makes it difficult to estimate future changes in marine fish resources.

Nevertheless at least five elements of a changing climate may be expected to impact on Dominica’s fisheries. These are:

- Increased sea temperatures
- Intensified hurricane activity
- Changes in oceanic circulation
- Acidification of the oceans
- Sea-level rise.

At the same time it is important to realize that such a “sectoral” assessment has inherent weaknesses in that impacts can be expected to be experienced cumulatively rather than as separate components as well as being influenced by other non-climate related developments and trends

#### 3.3.6.5.1Increased Sea Surface Temperatures

Temperature is a pervasive environmental factor with direct effects on nearly all aspects of the ecology, physiology and behavior of marine life. While there is increasing scientific understanding of the inter-relationships between warming and some specific species, there is less understanding of the indirect effects at the ecosystem level.

In Dominica researchers at the Institute for Tropical Marine Ecology have recorded coral bleaching events in Dominica during 2003, 2004, 2005, and 2006. The bleaching event of 2005, the warmest year of sea surface temperatures for the Caribbean, was particularly severe resulting in the bleaching affecting an estimated 90% of Dominica's corals. Bleaching episodes also appear to result in a reduction of the shrinking in size and reduction in diversity of the corals.

There may also be a link between ocean temperatures and the population dynamics of various fisheries. Breeding in many species of cetaceans may be timed to coincide with periods of maximum availability of prey either for the lactating mother or for the weaning calf. Significant changes in environmental conditions, such as warming, that alter prey availability are likely to result in a mismatch in synchrony between predator and prey. Migratory cetaceans, such as whales and dolphins, that travel long distances may be particularly vulnerable to this mismatch. Such inter-relationships are likely to be of concern to Dominica where whale watching forms an important part of the country's tourism offering.

#### 3.3.6.5.2 Intensified Hurricane Activity

Projections for more intense hurricane activity will also have considerable implications for Dominica's fisheries. The fisheries sector is already extremely vulnerable to hurricane impacts. There are no naturally secure harbours and fisheries infrastructure is squeezed in between the coasts and settlements or cliffs

The types of impacts that are associated with hurricane activity on fisheries are demonstrated by the passage of Hurricane Dean in 2006. Significant damage to the sub-sector resulted from storm surges and high winds that ravaged boat sheds, destroyed fishing boats and equipment and rendered a number of landing sites inaccessible to fishers.

**Table 3.11 Hurricane Dean Impact on Fisheries Sector 2007**

| Property | Quantity damage or lost | Value |
|---|---|---|
| Pots | 1134 | 226,200 |
| Outboard motor | 15 | 115, 820 |
| Boat shed | 30 | 88,200 |
| Fishing boats | 21 | 136,600 |
| Building | 11 | 188,500 |
| Locker rooms | 7 | 51, 400 |
| Others | 13 | 80,400 |
| **Total** | | **887,120** |

Source: Fisheries Division Assessment Report on impacts of Hurricane Dean, 2007

Considerable coastal degradation occurred as a result of high seas, and a large amount of silt, mud and debris that was brought down by the rivers and other surface runoff. It has been observed that the current management of land based quarrying activities is adversely affecting fishing activities on the west coast due to high runoff levels into the sea. High rainfall level also increases the runoff of agro-chemicals from agricultural areas into the sea that results in algal bloom with the corresponding growth of algae that kills fish life

In addition to direct destruction to the mangroves, coral reefs, and sea-grass beds that provide the basis for nearshore artisanal fisheries tropical storm systems produce inland stresses that also affect fisheries coastal habitats. The scenario of more frequent and/or intense hurricane activity will interfere with the prospects for recovery of these natural.

### 3.3.6.5.3 Changes in Ocean Circulation

Ocean currents redistribute ocean water of different temperatures to different parts of the globe. This helps maintain the temperature of the planet in check. Most of the heat from the equator, which spends every single day in direct sunlight, is redistributed by ocean currents to colder regions of the earth. However, as a result of global warming due to an increase in atmospheric CO2 concentration, global temperatures, both ocean and surface, are steadily increasing.

The Antilles Current is a warm water current that flows northwesterly past the island chain that separates the Caribbean Sea and the Atlantic Ocean. The current results from the flow of the Atlantic North Equatorial Current. This current completes the clockwise- cycle or convection that is located in the Atlantic Ocean. It is used by many fishermen across the Caribbean Islands to fish.

The effects of changes in the circulation of currents are likely to be significant for fisheries and could dramatically alter the oceans ecology with potentially devastating consequences for fisheries in Dominica and elsewhere. Among the possible effects of such shifts would be decreased salinity and density. In such scenarios variations in fish catches are likely due to changes in migratory patterns that would arise from such a significant change in the oceans environment.

### 3.3.6.5.4 Ocean Acidification

The Earth’s ocean absorbs approximately 1/3rd of the $CO_2$ emitted to the atmosphere from the burning of fossil fuels. However, as the $CO_2$ dissolves in seawater, the pH of the water decreases a process known as "acidification". This alteration in the oceans chemical composition is proceeding at relatively rapid rates and since the oceans have never experienced such a rapid acidification, it is not clear if ecosystems have the ability to adapt to these changes.

An increasing acidification of Dominica’s coastal waters will have significance for the islands limited coral reefs and for the small nearshore fisheries of these already stressed systems. Ocean acidification would also impact on the various shell-fish and other marine organisms that are an integral part of these coastal ecosystems. While shell-fish fisheries comprise only a small proportion of the domestic catch, they do represent high value items and are an important niche in the island ecosystem.

### 3.3.6.5.5 Sea-level Rise

Given Dominica's topographic profile and the nature of its fishery resource, issues relating to sea-level rise are not likely to have as adverse short term effects as is likely with other projected elements of a changing climate such as hurricanes and warmer temperatures. Nevertheless, sea-level rise can be expected to impact Dominica's fisheries in direct and indirect ways. Firstly there will likely be inundation of some of the areas that provide habitats for certain forms of marine life. Areas presently used for landing and beaching vessels, as well as for other fisheries infrastructure will likely be affected by rising sea-levels.

### 3.3.6.5.6 Summary of Impacts of Climate Change

Dominica's fisheries are likely to display a number of vulnerabilities to some of the projected effects of climate change. Nearshore fisheries, already stressed by pollution and over-fishing, will be impacted in a number of areas by warmer seas, intensified hurricane activity and other impacts. At the same time Dominica's migratory and pelagic fisheries, also at risk globally from over fishing and other anthropogenic impacts, will also be affected by shifts in currents, impacts on food supply, warmer oceans and other direct and indirect impacts from a changing climate.

These changes will present challenges for fisheries stakeholders – fishermen and women, resource managers, and consumers – as they seek out ways of promoting he sustainability and viability of the resource in the context of a rapidly changing global climate.

### 3.3.6.6. Recommendations for Adaptation and Risk Reduction

Efforts for risk reduction and adaptation of the fisheries sector to respond to adverse effects are complicated by the fact that the primary habitat for Dominica's fisheries resources – the ocean – is a global common property resource and therefore effectively outside of the management capability of Dominica's fisheries stakeholders. At the same time it is clear that a number of anthropogenic impacts are already adversely affecting the sustainability of Dominica's fisheries. These impacts threaten many of Dominica's fishery resources and can be expected to intensify many of the impacts of climate change.

A further complicating factor in devising adaptation or risk reduction measures for fisheries is the level of uncertainty that exists as to the dynamics of the fisheries, the specifics of the impacts likely from climate change, and the effects of a changing climate on the fishery resource

Based on the nature of the risks presented by climate change recommendations for adaptation within the fisheries sector can be characterized in three categories. These involve:

1. *Measures for enhancing the sustainability of fisheries ecosystems.* Healthy marine ecosystems will be in a stronger position to withstand the early projected impacts of a changing climate than those that are already overstressed. Efforts should therefore aim to minimize those adverse efforts that are already being experienced and which reduce ecosystem resilience. It is clear that land based sources of pollution presently

constitute a significant source of risk to the sustainability of a number of Dominica's fisheries habitats

2. *Measures for strengthening the capacity of fishers to meet the challenges presented by climate change*. Dominica's largely artisanal, low capital fishing industry is particularly vulnerable to existing weather as seen in the often annual damage to fisheries infrastructure from hurricane activity. If the sector is to survive a number of structural changes are likely to be required.
3. *Measures for promoting international action to reduce climate change impacts on the atmosphere and oceans.* The international character of the oceans that comprise the primary habitat for Dominica's fisheries, means that efforts for adaptation are only likely to be successful over the long term where there is concerted international action to reduce the present outpouring of greenhouse gases into the atmosphere

## 3.3.7 CONCLUSION

### 3.3.7.1 Adaptation and Risk Reduction

A review of the potential impacts of climate change reveals that a number of Dominica's existing vulnerabilities to current climatic conditions are likely to be exacerbated by many of the projected changes in regional and global climate. Across all sectors, a number of adverse impacts are likely to be felt, influenced by such critical climatic parameters as temperature, rainfall, and extreme events.

Dominica's history, its economic structures, patterns of human settlement, and other aspects of its socio-economic development have been profoundly influenced by the country's mountainous topography. In particular the country's rugged terrain has resulted in population centres and economic activity being located in coastal communities. Agricultural and other encroachment into forested interior lands tends to result in soil erosion, land slippages and other disturbances to the country's rich forest resources. Other human impacts including solid and liquid waste disposal, quarrying, and fisheries directly and indirectly affect the country's fragile marine ecosystem resulting in degradation of habitats and loss of species diversity.

### 3.3.7.2 Priorities for Adaptation and Risk Reduction

In many cases autonomous adaptations will take place requiring very little intervention by governments. However there are also likely to be many instances where autonomous action will not occur. Reasons for this include limited understanding of climate change effects, cultural and other constraints, and inadequate technical and financial resources for effecting risk reduction and adaptation measures. Against this background, governments will have a critical role in:

- Providing information to decision makers at all levels.
- Providing technical and financial resources for adaptation and risk reduction efforts.

- Ensuring that adaptation and risk reduction policies and measure are consistent with wider social, economic and environmental goals, and
- Actions to protect government investments in infrastructure, buildings etc.

### 3.3.7.3Incorporating Risk Reduction and Adaptation into Development

The pervasive nature of the likely impacts of climate change means that the optimal adaptation approaches are likely to be those that are anticipatory and facilitate inclusion of adaptation. In this regard three strategies can be identified to enable integration of climate change adaptation concerns into development activities;

- Incorporating climate change concerns into new development proposals;
- Developing proposals that are specifically aimed at climate change risk reduction and adaptation.
- Developing proposals for strengthening institutional and technical capacity for climate change response.

Incorporating climate change considerations into development activity is critical for a number of important reasons. Firstly, there will be continuing pressure for development activity.

There are three types of proposals that can be considered in terms of climate change risk reduction and adaptation. The first type involves primarily development projects such as infrastructure, housing, tourism, and agriculture. The second type of project involves initiatives developed specifically for climate change. These include coastal protection, development of drought tolerant crops and animals, and reforestation projects. The third types of projects are initiatives for strengthening the national capacity for responding to the various effects of climate change. This should involve institutional development, climate science monitoring and training, technical awareness and training, and public awareness.
Public awareness will be the critical factor in determining the success or otherwise of risk reduction efforts. This must be seen as an ongoing process, much of which will be autonomous of official efforts. Stakeholder involvement and participation in risk reduction and adaptation response will also be critical. Ultimately, meaningful adaptation to the projected impacts of climate change will require that policy makers in private and public sectors, as well as the general populace, are attuned to the sustainability concerns that will arise as a result of a changing climate.

An important consideration is to recognize the urgency for immediate action. Climate change is not a future scenario but a current event with almost daily scientific reassessments of the immediacy of the risks presented. Adaptation policies and measure must therefore be viewed as a priority and therefore integrated into decision-making at virtually all levels.

# 4 GREENHOUSE GAS MITIGATION ASSESSMENTS

## 4.1 Introduction

This chapter provides the greenhouse gas mitigation assessment for Dominica by presenting a national-level analysis of the impacts of various technologies and practices that affect greenhouse gas emissions. The assessment provides policy makers with an evaluation of those technologies and practices that can a) affect GHG emissions, b) identify policies and programs that could enhance their adoption, and c) contribute to national development objectives. This mitigation assessment should be followed by more detailed evaluation of specific policies, programs, or projects designed to encourage implementation of selected technologies and practices.

The scope of this assessment covers projections of GHGs for the period 2009 to 2030 and uses historical data for the period 2000 (the base year) to 2008 in order to calibrate where feasible, the bases for the projections. Three scenarios are developed to project emissions – a Reference Scenario and two other scenarios (Scenario 2 and Scenario 3) characterised primarily by increasingly aggressive mitigation measures. The Reference Scenario only includes activities and projects that are currently under way and does not include any additional GHG mitigation.

The other scenarios describe various possible and plausible energy uses and development strategies and activities that are required to satisfy the demand for energy based on population growth and national development goals. Various mitigation options (technologies and measures that can affect GHG emissions) are included in these scenarios.

## 4.2 GHG Emissions And Mitigation Opportunities

The potential opportunities for reductions in Dominica's GHG emissions in part can be determined by examination of the GHG emission inventory. The GHG emissions for 2000 to 2005 show that $CO_2$ dominated the emissions (383 Gg). Most $CO_2$ emissions (~97%) were from the energy sector. Emissions of methane ($CH_4$) were 1.6 Gg or 33.0 Gg $CO_2$ equivalents ($CO_2e$) when the global warming potential for $CH_4$ is taken into account. $CH_4$ emissions are from agriculture (50%), the waste sector (43%) and the remainder from forestry and energy sectors. In view of the dominance of $CO_2$ emissions from the energy sector mitigation opportunities will be examined only for the energy sector but it will be also equally important to maintain the sinks (forestry) in Dominica.

## 4.3 Energy Sector Resource Profile

Dominica has no known primary petroleum or coal reserves and imports all of its petroleum requirements. Use of solar energy is negligible (water heaters). There is limited use of wood and charcoal for domestic use (cooking) and commercial activities (e.g., bay oil production). Other petroleum fuels imported are liquefied petroleum gas (LPG) used for domestic cooking and in commercial establishments, gasoline for transportation and diesel for transportation and industrial use.

The $CO_2$ emissions between 2000 and 2005 from the energy sector (Chapter 2) show that emissions from transportation range from 39 to 44% while that from electricity generation ranges from 29% to 35%. Between them transportation and electricity generation account for just over 69% to 80% of the $CO_2$ emissions.

The key national policies that are relevant to mitigation are those associated with the sectors that affect GHG emissions or are potentially affected by climate change. These sectors are energy (electricity production and associated demand categories namely, transportation) and waste management. The growing importance and emphasis on the tourism sector warrants separate consideration although many energy use aspects of the tourism sector are included in the demand for electricity and fuel consumption.
The key policies, programs and plans are:

- Climate Change Adaptation Policy
- Sustainable Energy Plan and National Energy Policy
- Energy Development Programme for Dominica
- Dominica Tourism Master Plan 2005 – 2015 and the Sustainable Tourism Policy and Marketing Strategy (2005-2009)

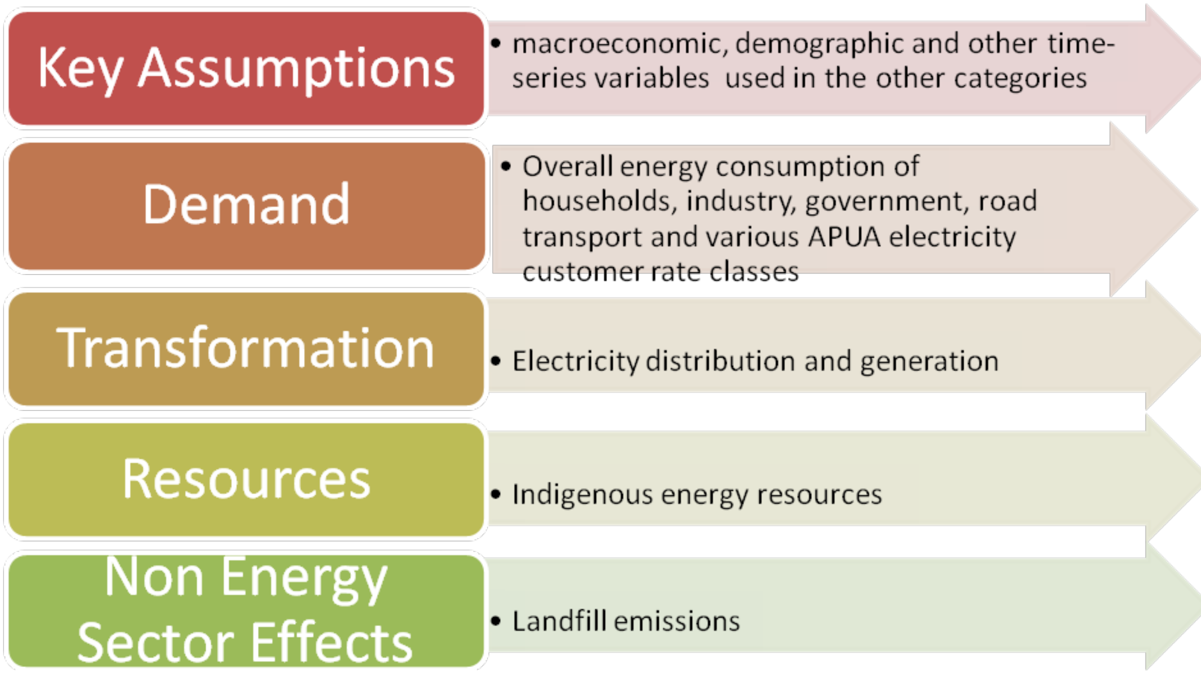
As is the case with other small island states, Dominica contributes negligibly to global GHG emissions and in fact is a net absorber, but is disproportionately affected by climate change impacts. The climate change adaptation policy is therefore important to set the national planning and development context for adaptation to climate change.

### 4.4 Methodology For The Mitigation Assessment

The mitigation analysis used the Long-Range Energy Alternatives Planning System (LEAP) model www.energycommunity.org and examined the demand, transformation, resources and non-energy sector emissions and effects. LEAP is a scenario-based energy-environment modelling tool based on comprehensive accounting of how energy is consumed, converted and produced in a given region or economy under a range of alternative assumptions. Scenarios are self-consistent story lines of how a future energy system might evolve over time in a particular socio-economic setting and under a particular set of policy options defined for example by specific projects and measures. Scenarios in LEAP can be compared to assess their energy requirements, environmental impacts and social costs and benefits.

The base year used in this analysis is 2000 - the same year used for compilation of the national GHG emission inventory and is the year preferred by UNFCCC for reporting the SNC. The first projection year for all scenarios was 2009 and the last 2030. Historical data between 2000 and 2008 were used in the so called Current Account (LEAP model terminology). Projections for the years 2009 to 2035 were made for three groups of scenarios: the Reference Scenario and two others called Scenario 2 and Scenario 3. The input data for the LEAP model are grouped into five categories called modules (see Figure 4-1).

**Figure 4-1 Modules in the LEAP Model**




The subcategories or branches in each of these modules were determined by the level of detailed data that were available. The subcategories in the model are shown in Table 4-1. The information sources for the data used in the five modules are described below:

**Table 4-1 Subcategories in the Five Modules in the LEAP Model Input Data**

| Key Assumptions | Demand | Transformation | Resources | Non-Energy Sector Effects |
|---|---|---|---|---|
| Population<br>Household Size<br>Population growth rate | • Transportation (Seven classes of vehicles plus off road vehicles)<br>• Commercial<br>• Hotel<br>• Domestic<br>(Cooking, Lighting, Refrigeration, Television, Washing machine, All other)<br>• Industrial<br>• Street lighting | • Transmission & Distribution<br>• Loss reduction<br>• Electricity Generation<br>(Hydro, Thermal, Geothermal, Wind, Municipal solid waste, Photovoltaic (distributed)) | Primary<br>Wind<br>Geothermal<br>Solar<br>Municipal Waste<br>Biomass | Landfill emissions |

## 4.5 Information Sources

Since the emission sources that are considered in the mitigation assessment are limited to the energy sector, the information required for the mitigation assessment consists of electricity generation and the associated demands for electricity and other petroleum fuels. Industrial activity in Dominica is limited and energy use is primarily in the form of electricity and diesel fuel use. The demand for energy was therefore broken down into the categories for which data are available (electricity demand for household, government, industrial, commercial customers) and fuels used in transportation. GHG emissions associated with agriculture and forestry sectors are small and the potential for mitigation in these sectors is limited and were therefore excluded from the analysis.

The key information sources included the CSO and DOMLEC.

## 4.6 Modules used in the Analysis

### 4.6.1 Key Assumptions Module

This module contains macroeconomic (GDP and GDP growth rate) and demographic (population, population growth rate, household size) data. Historical and projected gross domestic product (GDP) data were obtained or derived from data published by the CSO and the IMF staff reports.

### 4.6.2. Demand Module

The demand module requires activity and energy intensity data such that the product of the two gives the energy consumption. The demand module was broken down into various “branches” namely, domestic households, commercial, hotel, industry, street lighting and transport. These branches were selected because fuel and electricity use and other activity data are available for them and/or subcategories within them. The methodologies applied for the various demand branches are described below. Additional details for future activity and energy intensity information are provided in the following section on scenarios.

### 4.6.3 Transformation Module

The transformation module includes electricity generation and charcoal production. In 2002 charcoal was used for cooking in 5% of households and wood was used in 13% of households Caribbean Development Bank (2003b ). Charcoal production was estimated from these data.

### 4.6.4. Resources Module

The indigenous energy resources available in Dominica are charcoal, solar energy, wind and municipal waste but currently there is very limited use of these resources.

Charcoal and fuel wood are used for cooking by 5% and 13% of households respectively in 2002 (Caribbean Development Bank, 2003b). There is also very limited commercial use of wood in bakeries. Data on fuel wood use and charcoal production are not compiled and estimates are subject to large uncertainties. Use of wood and charcoal is expected to decline further. Mitigation scenarios include use of solar, wind and municipal solid waste. Expanded use of solar water heating for example in hotels would reduce the need for energy derived from fossil fuel combustion.

### 4.6.5. Non-Energy Sector Effects

The methane generated from landfill emissions is the only significant non-$CO_2$ GHG emission. Simple projections of these emissions were made based on population growth.

## 4.7 Scenarios

Three groups of scenarios were defined: *Reference*, *S2* and *S3*. The main features of the scenarios are as follows.

The *Reference* scenario does not have any mitigation measures.

The *S2* and *S3* scenarios include progressively aggressive mitigation measures for electricity consumption. The mitigation measures for the reduction in electricity demand include more efficient appliances, additional penetration of compact fluorescent (CFL) bulbs for lighting, solar water heating for hotels and residences and more efficient air conditioning (hotels).

Mitigation measures for transportation in the *S2* and *S3* scenarios are based on whether there are no hybrid vehicles but a mix of gasoline/diesel together with LPG (*S2*) in which there are hybrid vehicles (S2Hyb). *S3* is subdivided into *S3* and *S3HYB*.

All scenarios assume the construction of a 7.5 MW medium speed diesel plant in 2011 for electricity generation.

The *S2* and S2HYB scenarios assume the following electricity generation mix:

- 2 MW distributed photovoltaic (PV) systems between 2012 and 2030
- 5 MW wind in 2015
- 20 MW of geothermal in 2015
- 1.5 MW Energy from municipal waste in 2015

The *S3* scenarios assume:

- 5 MW distributed PV between 2012 and 2030
- 5 MW wind in 2015 and an additional 5 MW in 2020
- 15 MW geothermal plant by 2015 and a total of 120 MW by 2020 with Interisland connections to Martinique and Guadeloupe and 100 MW exported in 2020
- 1.5 MW Energy from municipal waste in 2015; additional 1.5 MW in 2020

The ongoing transmission loss reduction program is assumed for all scenarios (losses reduced from 12.1% in 2008 to 10% in 2015). Tables 4-2 and 4-3 summarise the assumptions in developing the mitigation scenarios for the demand and transformations modules.

**Table 4.2 Scenarios for the Demand and Non-Energy Sector Effects**

| Category | Reference (REF) | Scenario 2 (*S2, S2Hyb*) | Scenario 3 (*S3, S3Hyb*) |
|---|---|---|---|
| Key Parameters | | | |
| Population | Growth at 0.4% | Same as Reference | Same as Reference |
| Household size | Decreasing from 2.709 in 2008 to 2.5 in 2030. | Same as Reference | Same as Reference |
| GDP Growth rate | Real GDP growth of 3% after 2010. | Same as Reference | Same as Reference |
| Demand | | | |
| Households (HH) | Assume to be the same as residential customers | Number of households based on population and household size (above) | Number of households based on population and household size (above) |
| Domestic (Residential Customers) | Growth at 2.8% from 2009, 1.8% from 2015, 0.8% from 2020, 0% from 2025<br>Note: Percentages of households (HH) with cooking, lighting, refrigerators, TVs and washing machines from Poverty Assessment Survey | Same as Reference | Same as Reference |
| Cooking | LPG from 79% of HH in 2010 to 91% in 2015;<br>Charcoal: from 5% of HH in 2010 to 1% in 2015<br>Firewood: from 13% in 2010 to 3% in 2015 | Same as reference | Same as reference |
| Refrigeration | No energy efficient refrigerators.<br>Note – recent imports used to determine growth in number of refrigerators.<br>Penetration from 88% in 2010 to 98% in 2015 | Penetration same as reference<br>[% of HH with more energy efficient refrigerators increases from 0% in 2012 to 30% in 2020, and 40% in 2030.] | Penetration same as reference<br>[% of HH with more energy efficient refrigerators increases from 0% in 2012 to 40% in 2020, and 60% in 2030.] |
| Lighting | CFLs in use (distributed to all residences during 2007 so assume penetration of 50% in 2007 and 90% as of 2008). No LED | Introduction of LED lighting after 2015 (10% of HH by 2020).] | Introduction of LED lighting after 2012 to 45% of HH by 2030 at the expense of CFL which decrease from 90% of HH in 2012 to 45% of HH by 2030 and |

| Category | Reference (REF) | Scenario 2 (*S2*, *S2Hyb*) | Scenario 3 (*S3*, *S3Hyb*) |
|---|---|---|---|
| | | | incandescent which decrease from 10% of HH in 2012 to 5% by 2030. ] |
| Washing machines | Assume 2008 penetration rate (53% of HH) remains the same | Penetration to 80% of HH by 2015<br>[50% of new fridges are more energy efficient (i.e., 13% of HH)] | Penetration to 90% of HH by 2015<br>[50% of new fridges are more energy efficient (i.e., 18% of HH)]] |
| TV, stereo, radio | Penetration rate remains same (84% for TVs, etc.) | Penetration to 90% of HH by 2015<br>[More energy efficient TVs after 2015 - 10% penetration by 2030] | Penetration to 95% of HH by 2015<br>[More energy efficient TVs after 2015 - 15% penetration by 2030] |
| All other | Includes items such as air conditioners whose penetration rates are unknown as well as other small appliances.<br>Assume current penetration rates remain the same<br>Energy efficiency – no change | [Assume 10% reduction in energy efficiency by 2030] | [Assume 20% reduction in energy efficiency by 2030] |
| Commercial | Electrical energy and LPG fuel used (Note: poor data for LPG use)<br>Growth rate (customers) 3% to 2015; 1% to 2030<br>No change in energy intensity | Growth rate same as reference<br>Reduction in electricity and LPG use: 10% by 2015; 15% by 2030 due to efficient HVAC and additional solar water heating | Growth rate same as reference<br>Reduction in electricity and LPG use: 15% by 2015; 25% by 2030 due to efficient HVAC and additional solar water heating] |
| Industry | Electrical energy and diesel fuel used<br>Growth rate (customers) 3% to 2015; 1% to 2030<br>No change in energy intensity | Growth rate same as reference<br>10% Reduction in overall energy by 2015 and 15% by 2030 due to energy conservation measures (education) Flat after. | Growth rate same as reference<br>15% Reduction in overall energy by 2015 and 25% by 2030 due to energy conservation measures (education) Flat after. |
| Hotel | Electrical energy and LPG fuel used<br>(Note: poor data for LPG use)<br>Growth rate (customers) 5% to 2015; 2% to 2030<br>No change in energy intensity | Growth rate same as reference<br>10% Reduction in overall energy use by 2015 and 15% by 2030 due to energy conservation measures (education) Flat after. | Growth rate same as reference<br>15% Reduction in overall energy use by 2015 and 25% by 2030 due to energy conservation measures (education) Flat after. |
| Street lighting | Growth rate (customers) 5% to 2015; | Growth rate same as reference | Growth rate same as reference |

| Category | Reference (REF) | Scenario 2 (*S2*, *S2Hyb*) | Scenario 3 (*S3*, *S3Hyb*) |
|---|---|---|---|
| | 2% to 2030 | Efficient street lighting from 0% in 2015 to 10% in 2030<br>[Efficient street lighting is 4x more efficient than existing] | Efficient street lighting from 0% in 2015 to 20% in 2030<br>[Efficient street lighting is 4x more efficient than existing] |
| DOMLEC Own use | No change | 5% reduction in use by 2015 and 10% by 2030 | 10% reduction in use by 2015 and 15% by 2030 |
| Transportation | | | |
| Fleet divided into 7 vehicle classes (LDGV, LDDV, LDGT, LDDT, HDGV, HDDV, MC) plus off road. Separate marine category also.<br>Historical assignment of vehicle stocks to vehicle classes based on vehicle inspections data and sales based on import data.<br>Note – no CNG but LPG instead for LDVs. No mitigation for MC.<br>Assumed annual mileage accumulation rates or vehicle miles travelled (VMT) are included for comment since no data are available. | | | |
| Growth in fleet | 1% to 2012, 0.5% to 2020, 0.1% to 2035 | Improved mass transit<br>Import restrictions and tax incentives to promote more fuel efficient vehicles and hybrids | Improved mass transit<br>Import restrictions and tax incentives to promote more fuel efficient vehicles and hybrids |
| Fuels | Only gasoline and diesel. E10, biodiesel and low sulphur diesel and gasoline not considered | | |
| Vehicle Class<br>VKT<br>{VMT} | | | |
| LDGV<br>12875 km<br>{8000 mi | All gasoline | *S2* LPG: 15% of LDGV by 2020<br>*S2Hyb*rid: 20% of Hybrid vehicles by 2020 | *S3* LPG: 30% of fleet by 2030<br>S3Hyb: Hybrid: 15% by 2020; 25% by 2030 |
| LDDV<br>12875 km<br>{8000 mi} | All diesel | *S2*; LPG: 15% of LDDV by 2020<br>*S2Hyb*rid: 15% of Hybrid vehicles by 2020 | *S3*; LPG: 15% by 2020; 25% of fleet by 2030<br>S3Hyb; 15% by 2020; 25% of fleet by 2030 |
| LDGT<br>14484 km<br>{9000 mi}<br>12875 km LPG<br>{8000 mi LPG} | All gasoline | *S2*; LPG: 15% of LDGT by 2020<br>*S2Hyb*rid: 15% of by 2020 | *S3*; LPG: 15% by 2020; 25% of fleet by 2030<br>*S3Hyb*: Hybrid: 15% by 2020; 25% of fleet by 2030 |
| LDDT<br>14484 km | All diesel | LPG: 15% of LDDT by 2020<br>*S2Hyb*: 10% of Hybrid vehicles by 2020 | LPG: 30% of fleet by 2030<br>*S3Hyb*: 20% of fleet Hybrid by 2030 |

| Category | Reference (REF) | Scenario 2 (*S2*, *S2Hyb*) | Scenario 3 (*S3*, *S3Hyb*) |
|---|---|---|---|
| {9000 mi} | | | |
| HDGV<br>14484 km<br>{9000 mi} | All gasoline | *S2* & *S2Hyb*; LPG: 15% of HDGV by 2020 | *S3*& S3Hyb; LPG: 15% by 2020; 35% of fleet by 2030 |
| HDDV<br>14484 km<br>{9000 mi} | All diesel | *S2* & *S2Hyb*; LPG: 15% of HDDV by 2020 | *S3* & *S3Hyb*; LPG: 15% by 2020, 30% by 2030 |
| MC<br>8047 km<br>{5000 mi} | All gasoline | No change | No change |
| Off Road (includes tractors, rollers, forklifts etc.)<br>6437 km<br>{4000 mi} | Assumed 40% gasoline; 20% LPG; 40% diesel | No change | No change |
| Non-Energy Sector Effects | | | |
| Landfill Emissions | MSW to landfills based on population growth projections | Diversion of ~40%? of MSW to landfills after 2015 | Diversion of ~80%? MSW to landfills after 2015 |

E10 – Gasoline with 10% ethanol.

Energy intensity is the annual energy use per appliance or per unit activity

**Table 4.3 Scenarios for Transformation and Energy Resources**

| Transformation Category | Reference (REF) | Scenario 2 (*S2*) | Scenario 3 (*S3*, *S3HYB*) |
|---|---|---|---|
| Transmission & Distribution | | | |
| Electricity Distribution | Losses reduced from 12% in 2008 to 8% in 2015 | Same as Reference | Same as Reference |
| Electricity Generation | | | |
| Additional thermal plants<br>HFO Diesel | 7.5 MW in 2011 | 7.5 MW in 2011 | 7.5 MW in 2011 |
| Distributed photovoltaic | None | 1.5 MW by 2015 | 2 MW by 2015; 5 MW by 2030 |
| Wind | None | 5 MW in 2015 | 5 MW in 2015, 10 MW total in 2025 |
| MSW Waste to Energy | None | 0.75 MW in 2015 | 0.75 total MW in 2020 |
| Geothermal | None | 10 MW by 2015; 10 MW in 2017 | 20 MW by 2015; additional 100 MW in 2020 |
| Hydro | | | |
| Retirements & Export | | Retire Fond Cole 2015 | Retire Fond Cole 2015<br>Retire Portsmouth 2020<br>Export 565 GWh starting in 2020 |

## 4.8 Data Gaps

The energy use and hence GHG emissions are greatest for the transport and electricity generation sectors. There is excellent data available for the amount of fuel used for electricity generation, however data on the amount of each type of fuel used for the transportation and other sectors is limited. This is particularly true for the transportation sector. The analysis is constrained by the following:

- Current data collection does not include a sectoral breakdown by type of fuel used (i.e., into domestic, commercial, industry, hotel, agriculture/forestry/fishing by each type of fuel). These breakdowns are needed especially for diesel and LPG use. Current estimates were derived from data obtained from the CEIS which could not be verified independently.
- There is no reliable data on the numbers of vehicles by weight class and fuel type in the on-road fleet. Estimates were made based on import data (which include a breakdown of vehicles by fuel) between 2000 and 2008 but these data are subject to considerable uncertainty.
- Cost data for mitigation options and for some processes were not always available and hence costs were not modeled.
- Projections related to HFC emissions are not included

## 4.9 Results

### 4.9.1 Scope Of Results Presented

The results of the analysis will focus on presenting the **environmental loadings** (GHG emissions) and the **energy demand** broken down by demand and transformation categories and branches within the categories where appropriate.

LEAP allows presentation of the emissions either a) where they occur in the various branches (demand, transformation and non-energy sector effects) or b) by allocating the emissions in the transformation categories back to the demand branches. Alternative b) gives the final energy demand (or final environmental loadings) by allocating emissions used by various appliances and/or categories in proportion of the average mix of supply side (electricity generating) processes and the associated emissions. The presentation of the **environmental loadings** for all three scenario projections includes the current account period (2000 to 2008) so that comparisons can be made with the GHG emissions inventory and/or energy consumption over this period.

### 4.9.2 Overview of Projections

#### 4.9.2.1 Overview of Final Energy Demand Projections

The energy demand projects can be shown as either primary or final units. The primary energy demand indicates the primary energy sources (e.g., hydro, wood, charcoal) that are required. Energy demand in final units show the type of energy actually used to satisfy the demand.

The final energy demand for all scenarios is shown in Figure 4-2. The Reference scenario has the highest demand – again because there are no mitigation measures – compared to the *S2* or *S3* scenarios. The differences in the final energy demand are highlighted in Figure 4-3 which shows the **differences** relative to the Reference scenario. The peak electricity generation capacity for the various scenarios is shown in Figure 4-4.

#### 4.9.2.2 Overview of Environmental Loadings

The environmental loadings are expressed as the mass of GHG emissions either as individual GHGs or as the GWPs for one or more GHGs expressed in CO2 equivalents (CO2e). The results presented here will be for non-biogenic $CO_2$ only since biogenic $CO_2$ removals or emissions (e.g., from forests or burning of biomass) are not included in the mitigation assessment. The non-$CO_2$ GHGs (nitrous oxide and methane) are very small relative to $CO_2$ and are included only in the case of methane since one mitigation option entails the use of landfill gases for power generation.

The overall non-biogenic emissions for the various scenarios are shown in Figure 4-5. Also included in Figure 4-5 are the $CO_2$ emissions obtained in the emission inventory. The inventory emissions are 7 to 11% lower than those calculated in the Reference scenario (current accounts) between 2000 and 2005. The agreement is reasonable given the challenges in estimating emissions from the transportation sector (which are likely overestimated in LEAP).

Figure 4.2 Final Energy Demand for Dominica, All Scenarios

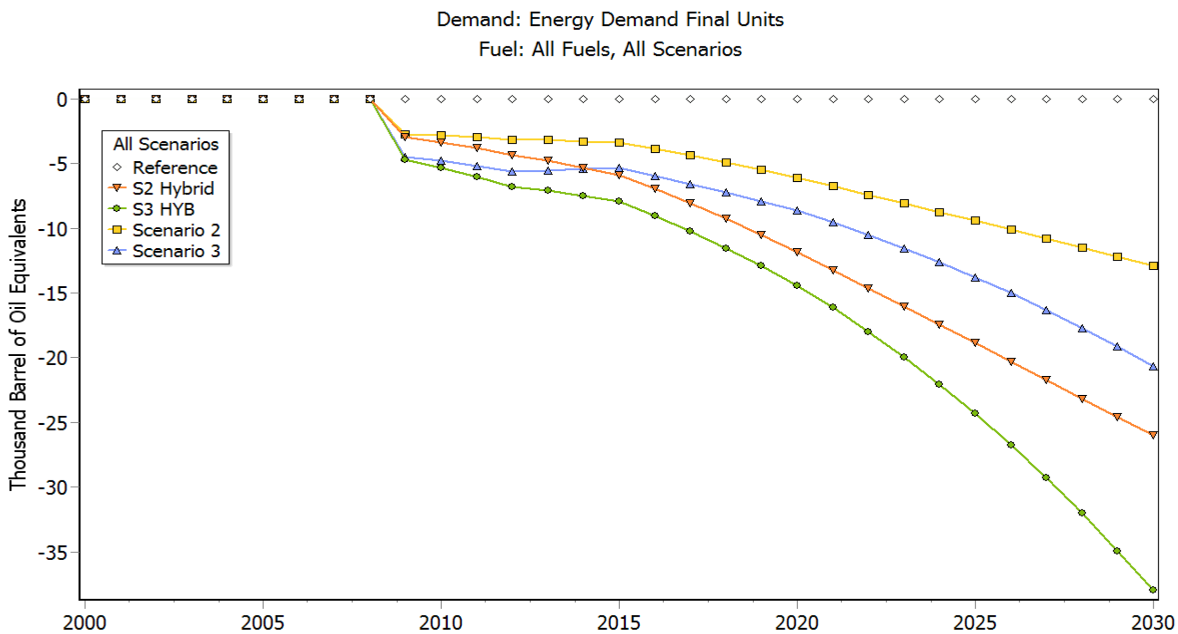



**Figure 4.3 Final Energy Demand for Dominica, All Scenarios, Relative to the Reference Scenario**

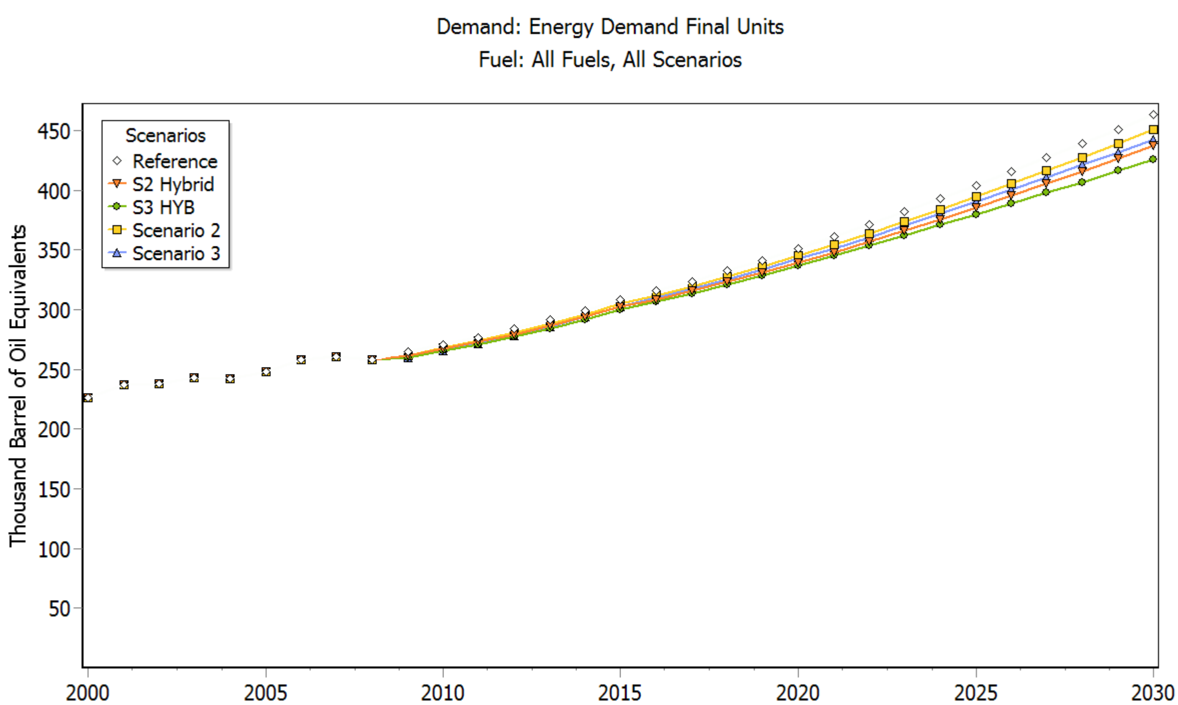


**Figure 4.4 Electricity Generating Capacities: All Scenarios**

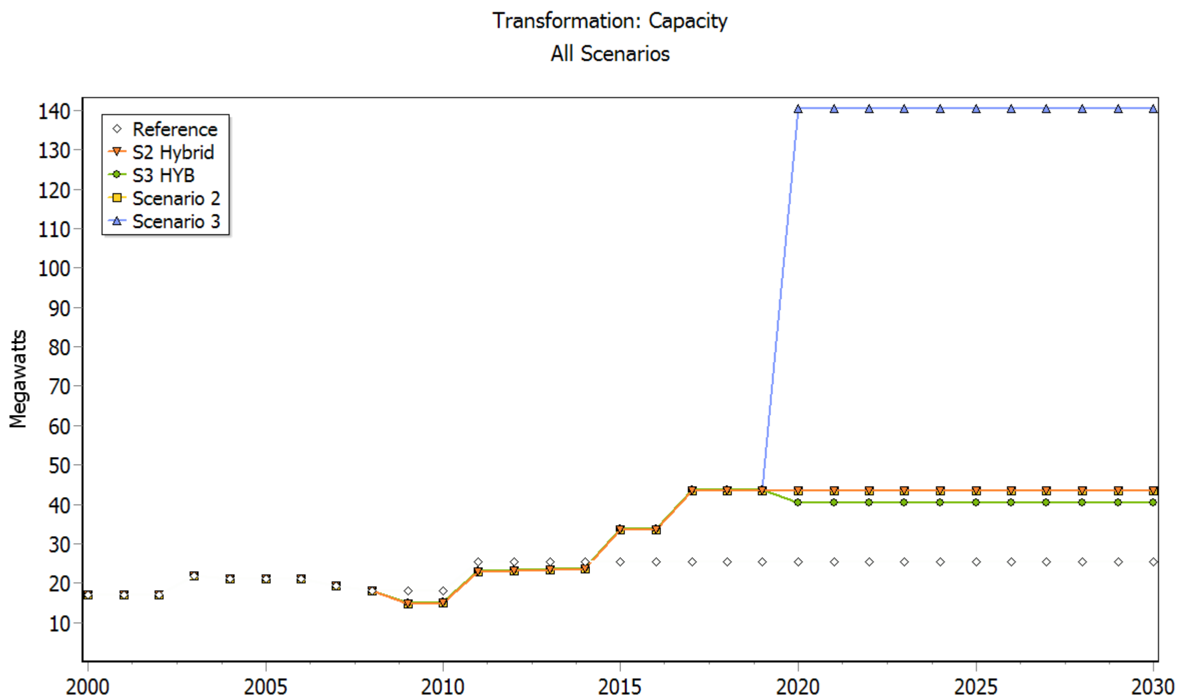
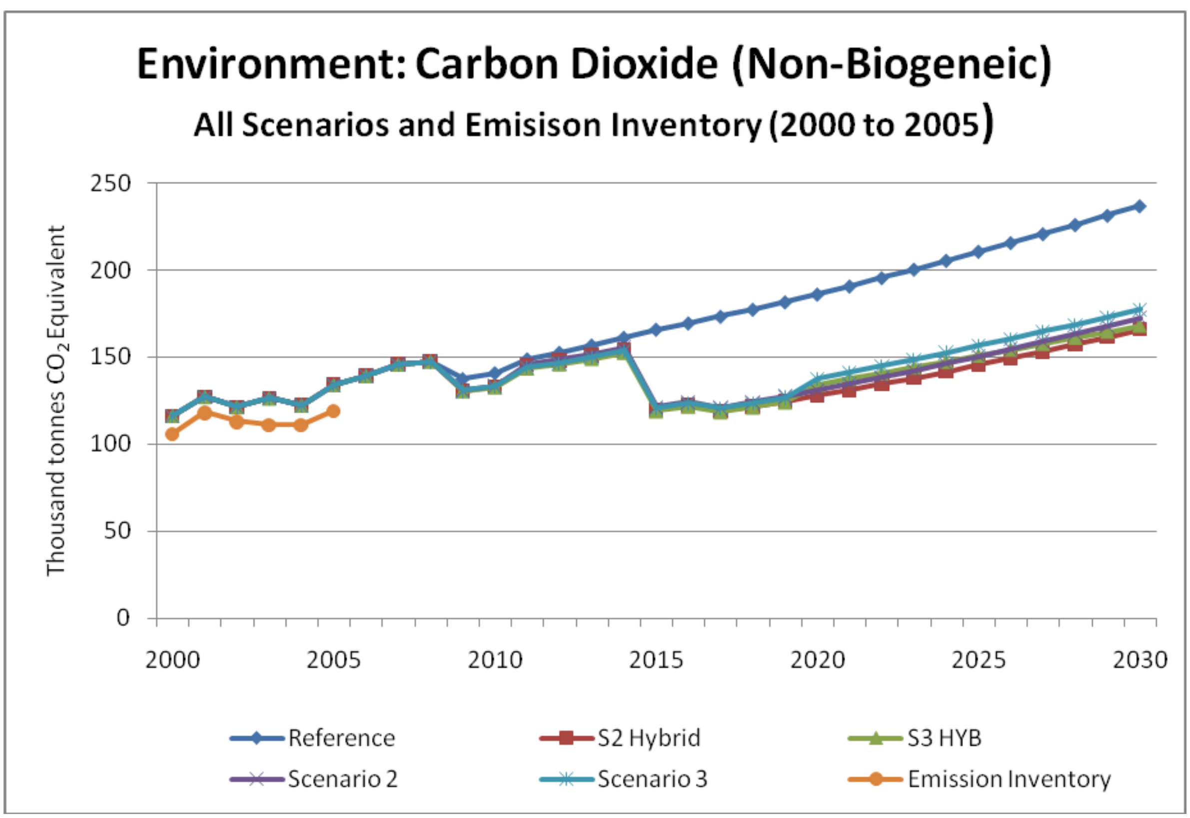



**Figure 4.5 Non-Biogenic Carbon Dioxide Emissions for Dominica: All Scenarios**



The emission's projections for the Reference scenario are higher than the others since no mitigation measures are included in the Reference scenario. The emissions for scenarios *S2Hyb* and *S3Hyb* (involving hybrid motor vehicles) are lower than the corresponding *S2* and *S3* scenarios (because emissions from hybrid vehicles are lower than those using regular fuels (gasoline or LPG)). In 2025, the total GHG emissions are projected to decrease by 6% and 8% for *S2* and S2Hyb and by 0% and 2% for *S3* and S3Hyb; but to increase by 15% and 11% in 2030 for *S2* and *S2Hyb* and by 15% and 20% for *S3* and S3Hyb - in all cases relative to the Reference scenario in 2000 (see Table 4-4). The increases after 2020 are due primarily to increases in residential and commercial LPG use and gasoline use.

The introduction of geothermal electricity in scenarios *S2* and *S3* account for their lower emissions in the *S2* and *S3* scenarios. It should be noted that since geothermal energy has no $CO_2$ emissions the introduction of additional geothermal emissions in *S3* have no additional impact on $CO_2$ emissions. The general increase in emissions from ~2020 is due to increased growth in emissions from various subsectors.

**Table 4.4 Summary of Changes in Dominica's GHG Emissions**

| Scenario | Gg $CO_2$ | | | % Change Relative to 2000 | | |
|---|---|---|---|---|---|---|
| | 2000 | 2025 | 2030 | 2000 | 2025 | 2030 |
| Reference | 115 | 173 | 206 | 0 | 51 | 79 |
| Scenario 2 | 115 | 108 | 132 | 0 | -6 | 15 |
| *S2Hyb*rid | 115 | 106 | 127 | 0 | -8 | 11 |
| Scenario 3 | 115 | 115 | 138 | 0 | 0 | 20 |
| *S3Hyb*rid | 115 | 113 | 132 | 0 | -2 | 15 |

### 4.9.2.3 Detailed Analysis of Selected Environmental Loadings

The emissions in the demand branches (transportation, domestic, commercial, lighting, hotel, industrial, street lighting and DOMLEC own use) are considered in the following sections. The branches in the demand category reflect the breakdown of electricity customers. Reporting of electricity sales to street lighting customers was discontinued in 2005 and because of this they are not discussed further.

#### 4.9.2.3.1 Transportation Branch

The data available for the on and off road fleet comprised the number of vehicle registrations by various types that unfortunately did not indicate the type of fuel used (gasoline or diesel) and had limited information related to the weight of vehicles. [Estimates of vehicle emissions are based on the type of fuel, the associated fuel economy for vehicles based on various weight classes and annual vehicle mileage.] Also lacking was the amount of diesel fuel used by the on-road fleet (i.e., fuel sold to service stations). Although the total gasoline sales were available, some of the gasoline is likely used for marine activities.

The available vehicle registration data (for 2000 to 2008) were categorised into seven (7) vehicle classes by making estimates of the fuel type and weight class for the available data. These data which are subject to much uncertainty are shown in Table 4-5

**Table 4. 5 Assignment of Vehicle Registrations to Vehicle Weight Classes**

| Vehicle Class# | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|
| LDGV | 7974 | 8846 | 9413 | 9956 | 10638 | 11435 | 12064 | 12725 | 13093 |
| LDDV | 654.5 | 693 | 727 | 754 | 776.5 | 806 | 842.5 | 879 | 902.5 |
| LDGT | 654.5 | 693 | 727 | 754 | 776.5 | 806 | 842.5 | 879 | 902.5 |
| LDDT | 1310 | 1419 | 1514 | 1609 | 1752 | 1950 | 2081 | 2236 | 2345 |
| HDGV | 212 | 227.2 | 241.2 | 253.2 | 271.6 | 300.4 | 326.8 | 357.2 | 370.4 |
| HDDV | 482 | 524.8 | 557.8 | 585.8 | 630.4 | 682.6 | 745.2 | 815.8 | 854.6 |
| MC | 435 | 526 | 655 | 774 | 850 | 925 | 1009 | 1107 | 1181 |
| Misc & Off Road | 65 | 73 | 78 | 86 | 92 | 100 | 107 | 121 | 133 |
| Total | 11787 | 13002 | 13913 | 14772 | 15787 | 17005 | 18018 | 19120 | 19782 |

#Vehicle Classes

| | | | |
|---|---|---|---|
| LDGV | Light duty gasoline vehicles | LDDV | Light Duty diesel vehicles LDDT |
| LDGT | Light duty gasoline trucks | LDDT | Light duty diesel trucks |
| HDDV | Heavy duty diesel vehicles | HDGV | Heavy duty gasoline vehicles |
| MC | Motor cycles | Misc & Off Road | Tractors, rollers, forklifts etc. |

Mitigation measures for transportation entailed the introduction of LPG in *S2* and *S3* and hybrid vehicles in *S2Hyb* and *S3Hyb*. The *S2* scenario has 15% of the fleet (except motor cycles and the Off Road and Miscellaneous categories) using LPG by 2020 while for the *S3* scenarios thee percentage with LPG is increased to 25% by 2030. The *S2Hyb* and *S3Hyb* scenarios are similar except that the corresponding hybrid-fuelled vehicles are used instead of LPG. The impacts of these mitigation measures on non-biogenic $CO_2$ emissions for the transportation branch are shown in Figures 4-6 (showing the absolute emissions) and 4-7 (showing emission reductions relative to the reference scenario). The percentage reductions in **transportation** emissions relative to 2008 are shown in Table 4-6.

**Figure 4. 6 Non-Biogenic Carbon Dioxide Emissions for Dominica: Transportation Branch, All Scenarios**

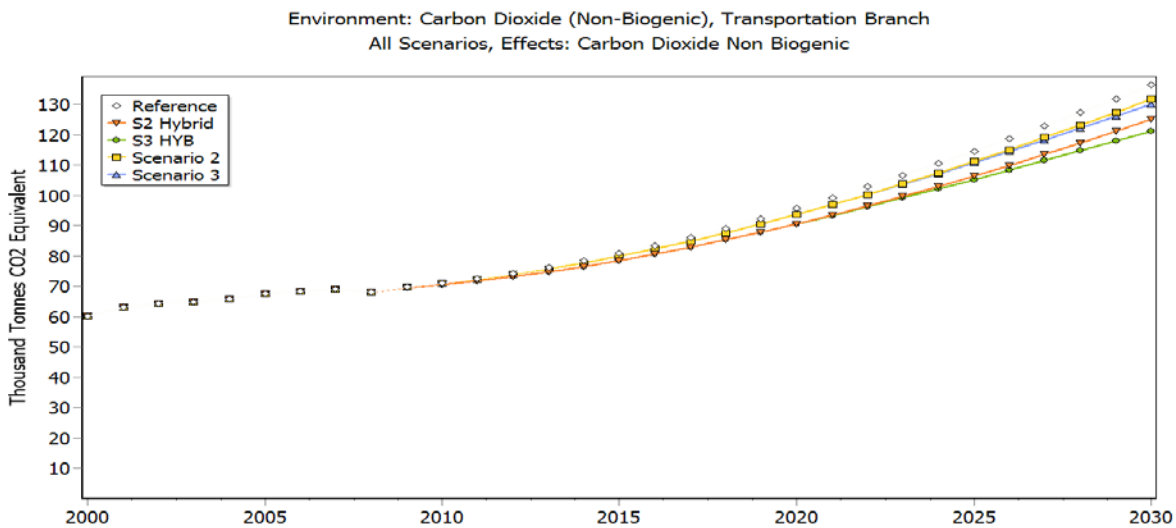



**Figure 4. 7 Non-Biogenic Carbon Dioxide Emissions for Dominica: Transportation Branch, All Scenarios Relative to the Reference Scenario**

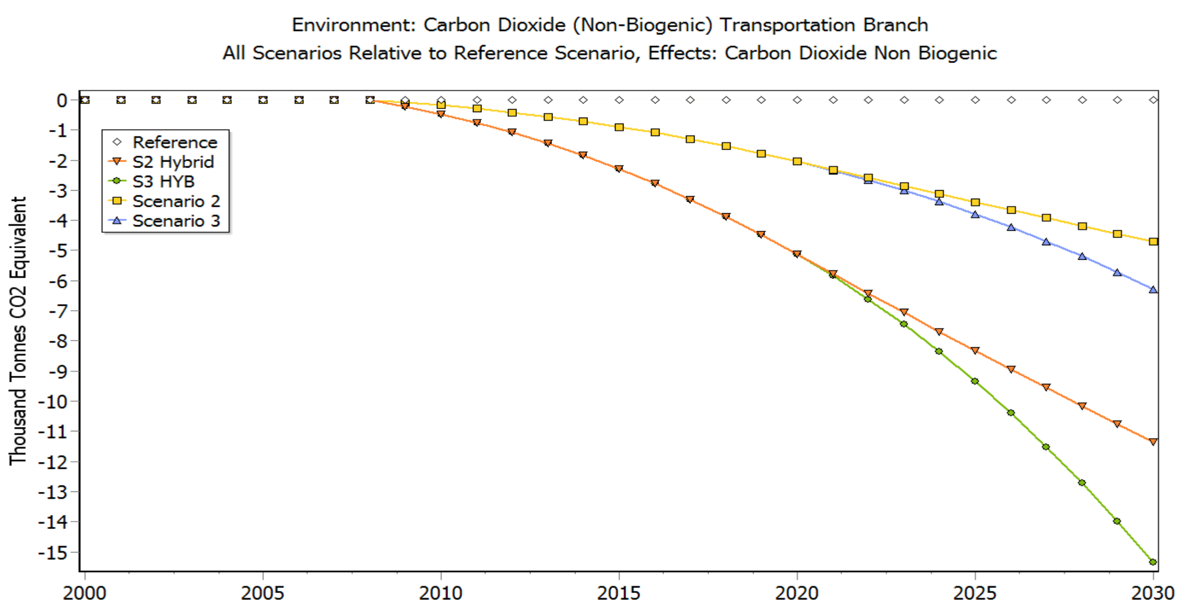



**Table 4. 6 Percentage Reductions in Transportation Emissions Relative to 2008**

| Scenario | Percentage Reductions from 2008 | |
|---|---|---|
| | 2020 | 2030 |
| Scenario 2 | 3 | 6.9 |
| *S2Hybrid* | 7.5 | 17 |
| Scenario 3 | 3 | 9.2 |
| *S3HYB* | 7.5 | 23 |

#### 4.9.2.3.2 Domestic Emissions

$CO_2$ emissions from the domestic branch are driven by increases in the number of residential customers which is taken as a proxy for the number of households. The increase in domestic customers was assumed to follow the rate of population increase (0.4%). Increase demand for electricity is also driven by increases in the percentages of household acquiring appliances such as televisions (TVs), refrigerators, washing machines etc.

The mitigation measures proposed for the domestic sector are based on adoption of more energy efficient appliances (TVs, refrigerators) and adoption of LED lighting after 2020. These could be achieved by adoption of import policies that require energy efficient appliances (e.g., by adopting Energy Star standards). No mitigation measures are proposed for cooking but the percentages of households using wood and charcoal were assumed to decrease. Use of charcoal and wood for cooking was assumed in all scenarios to decrease from 5% of households in 2010 to 1% by 2015 (charcoal) and from 13% in 2010 to 3% by 2015 (wood).

Since distribution of compact fluorescent bulbs in Dominica took place during 2007 it was assumed the effective saturation (percentage of houses with CFL bulbs) of CFL bulbs was 50% in 2007 and 90% thereafter. As a result there is limited scope for additional energy savings from CFL bulbs. LED lighting was assumed to take place after 2015 (by which time the costs may be more competitive) and reach 10% saturation by 2020 in *S2* and 45% by 2030 in *S3* scenarios.

The $CO_2$ emissions from the domestic branch subcategories that use electricity are estimated by allocating the $CO_2$ that would be used to generate the electricity. These are illustrated in Figure 4-8 where the impact of geothermal electricity generation (after 2014) is evident. Between 2009 and 2014 the impact of mitigation measures is negligible since they are counteracted by the increases in the number of customers.

The relative contributions from the various sub-branches in the domestic branch to $CO_2$ emissions are illustrated in Figures 4-9 (for the reference scenario) and 4-10 for *S3*. These show that cooking accounts for most of the emissions. For scenario *S3*, once geothermal energy is used to generate electricity the allocated emissions for non-cooking activities are all but eliminated.

**Figure 4. 8 Environmental Loadings for Residential Demand Category: All Scenarios, Non Biogenic $CO_2$ Allocated to Demands**

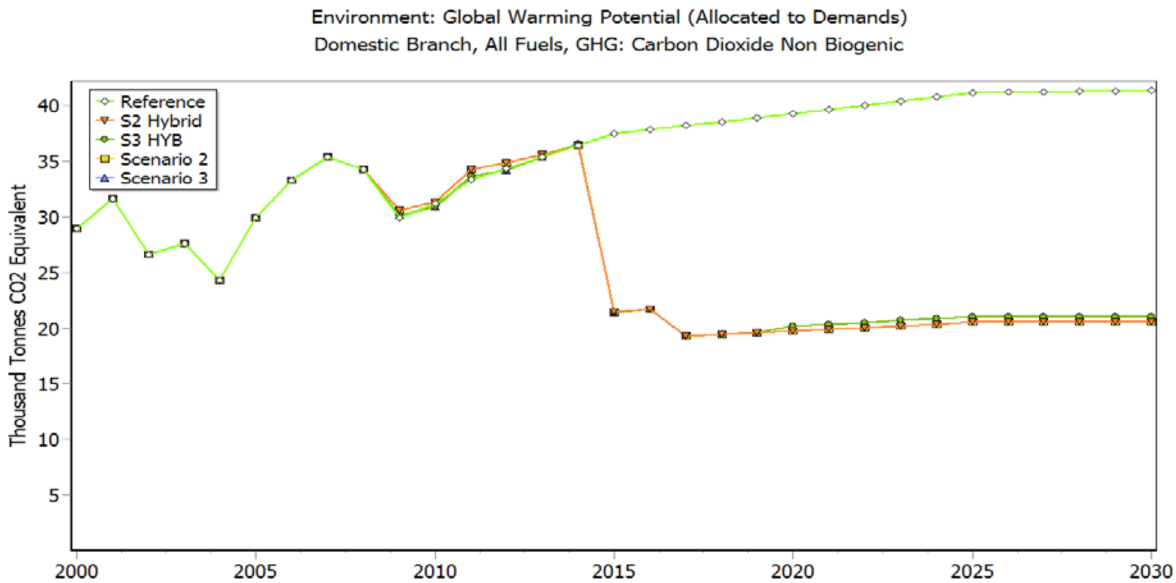



**Figure4.9 Environmental Loadings for Residential Demand Category Sub Branches: Reference Scenario, Non Biogenic $CO_2$ Allocated to Demands**

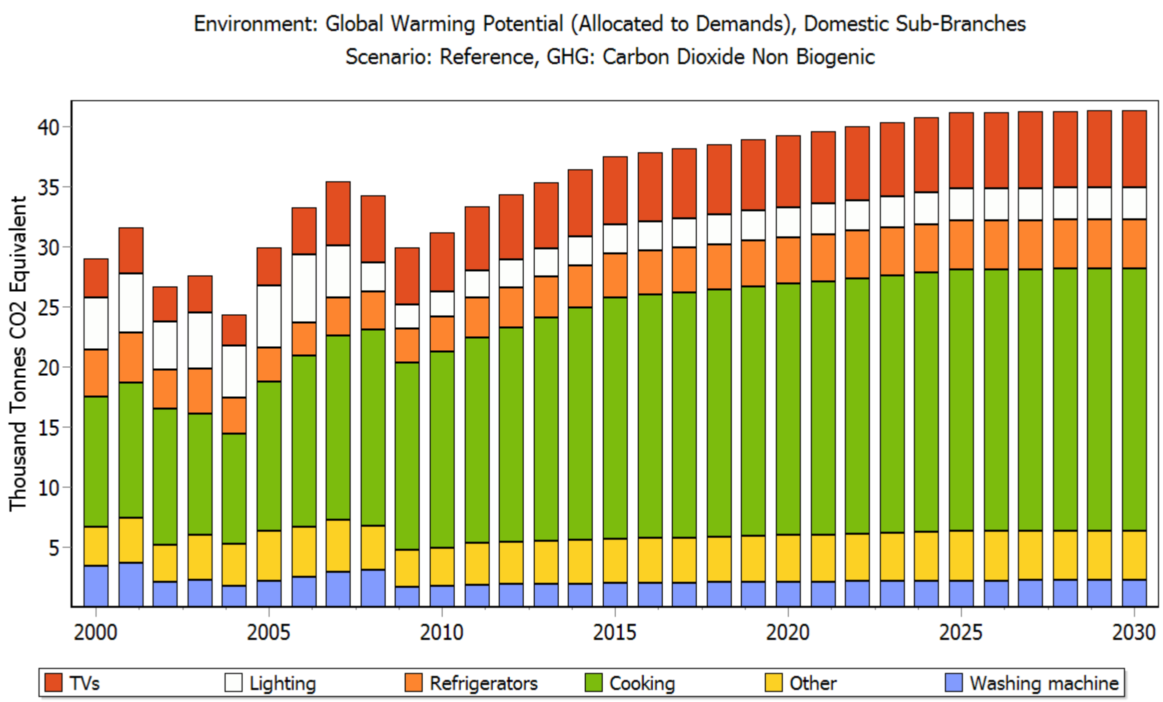
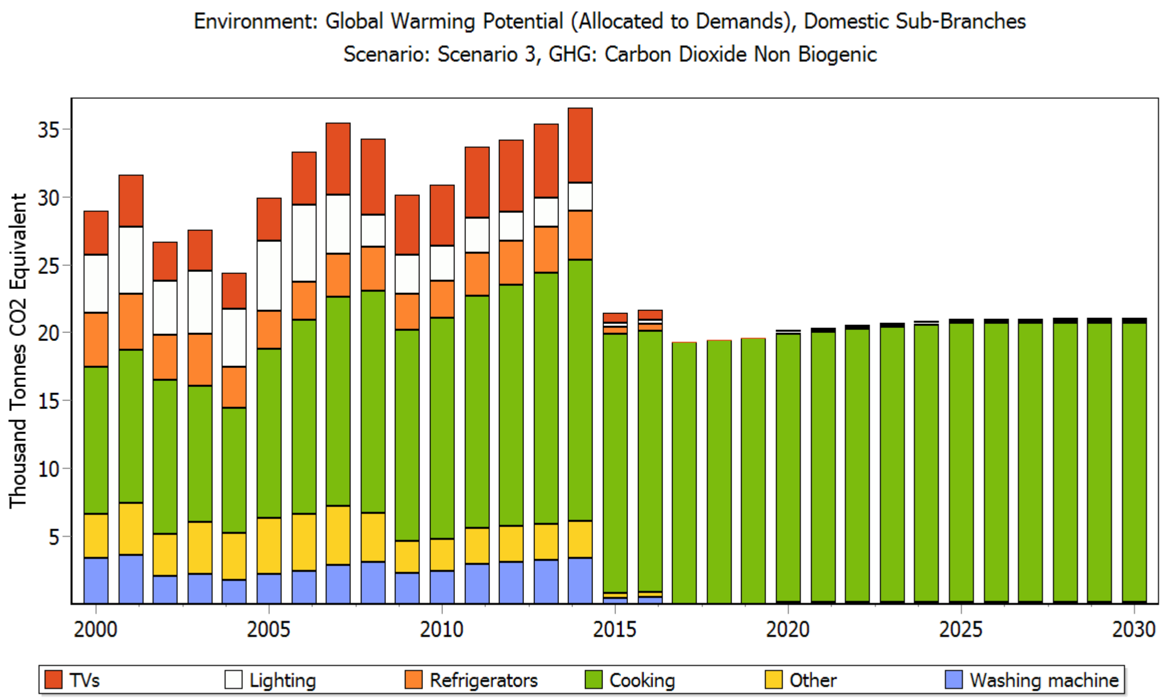


**Figure 4. 10 Environmental Loadings for Residential Demand Category Sub Branches: Scenario S3, Non Biogenic $CO_2$ Allocated to Demands**




### 4.9.2.3.3 Commercial, Hotel and Industrial

The customers in these branches use primarily electricity as well as smaller amounts LPG (Commercial and Hotel) or diesel (Industrial). The growth in the numbers of Commercial and Industrial customers was assumed to be 3% to 2015 and 1% to 2030 and for hotels 5% to 2015 and 2% to 2030.

The mitigation measures proposed for these branches are based on general public education for energy conservation and introduction of additional solar water heating and more efficient air conditioning. Information on the numbers, sizes and types of refrigerant used would have allowed proposal of more specific mitigation measures.
The projected non-biogenic emissions from these branches are shown in Figures 4-11 to 4-13 for respectively Commercial, Hotel and Industrial customers. Since the amounts of energy derived from fuels (LPG or diesel) increase from commercial to industrial customers the impact of allocated emissions is least for the industrial branch.

### 4.9.2.3.4 DOMLEC Own Use

The projected non-biogenic emissions from DOMLEC Own Use branch is shown in Figure 4-14. Since electricity is the only energy source used the impact of geothermal electricity generation for scenarios *S2* and *S3* are marked. It was assumed that the energy conservation (mitigation) measures would result in a 5% reduction in electricity use by 2015 and 10% by 2030.

## 4.10 TRANSFORMATION

The transformation categories consist of transmission (of electricity) and transformation (electricity generation and charcoal production) activities.
Although the emissions directly associated with these activities are allocated to demand categories it is instructive to indicate the emissions directly associated with these activities. The LEAP model produces electricity outputs to match the demand based (among other things) on the load shape, the availability of generating units and the order of dispatch etc.
It should be noted that the analysis here made no effort to produce a least cost generation mix and hence the added generation capacity resulted in higher than normal reserve margins.

### 4.10.1.1 Transmission

DOMLEC's proposed transmission reduction target (losses reduced from 12% in 2008 to 8% in 2015) was assumed in all scenarios but transmission losses for export were not taken into consideration.

### 4.10.1.2 Electricity Generation

Capacity additions for the three scenarios Reference, *S2* & *S2Hyb* and *S3* & *S3Hyb* are respectively shown in Figure 4-15 to 4-17. Retirements are shown in Figure 4-18 (all scenarios). Emissions from electricity generation arise mainly from diesel fuelled generators and in some scenarios form landfill gas combustion. The emissions for all scenarios are shown in Figure 4-19.

**Figure 4. 11 Environmental Loadings for Commercial Demand Branch, All Scenarios, Non Biogenic CO2 Allocated to Demands**

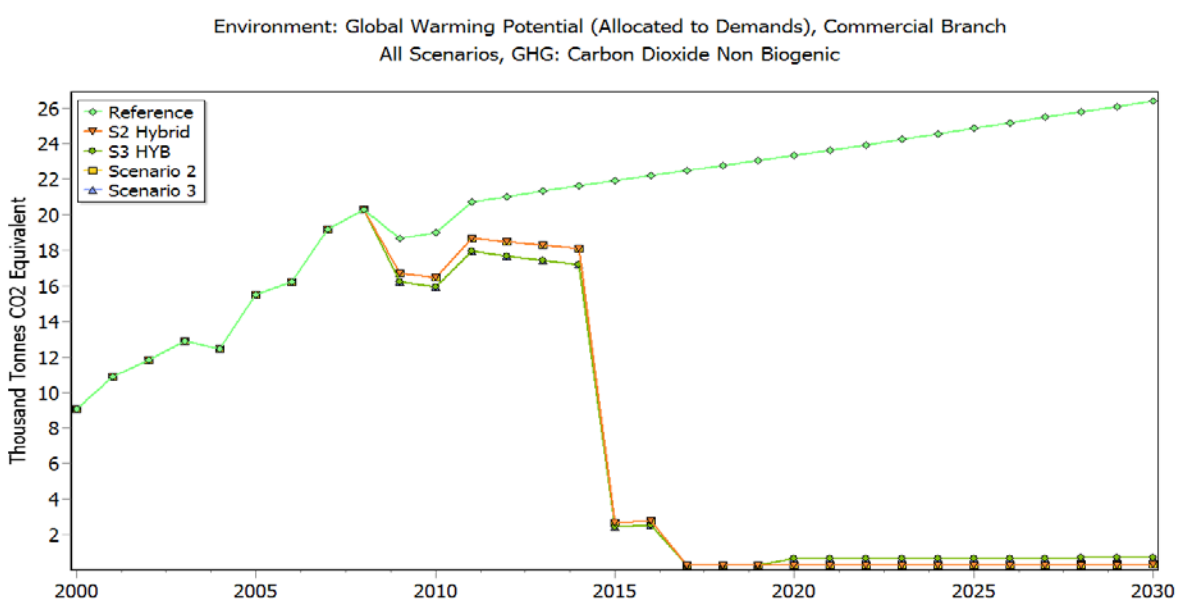


**Figure 4. 12 Environmental Loadings for Hotel Demand Branch, All Scenarios, Non Biogenic $CO_2$ Allocated to Demands**

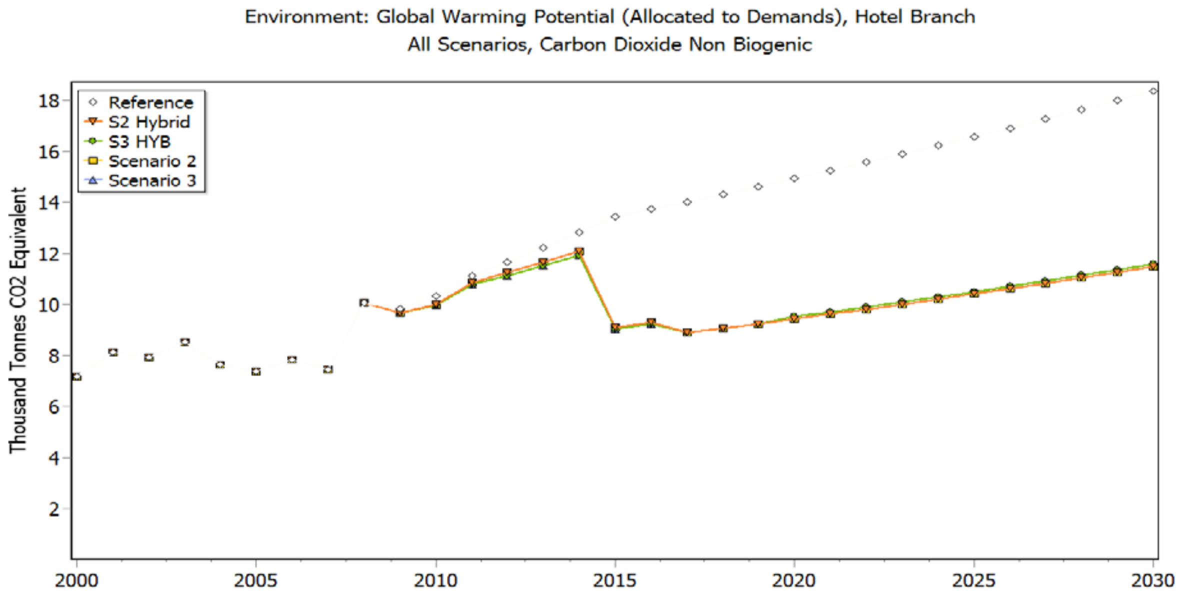



**Figure 4. 33 Environmental Loadings for Industrial Demand Branch, All Scenarios, Non Biogenic $CO_2$ Allocated to Demands**

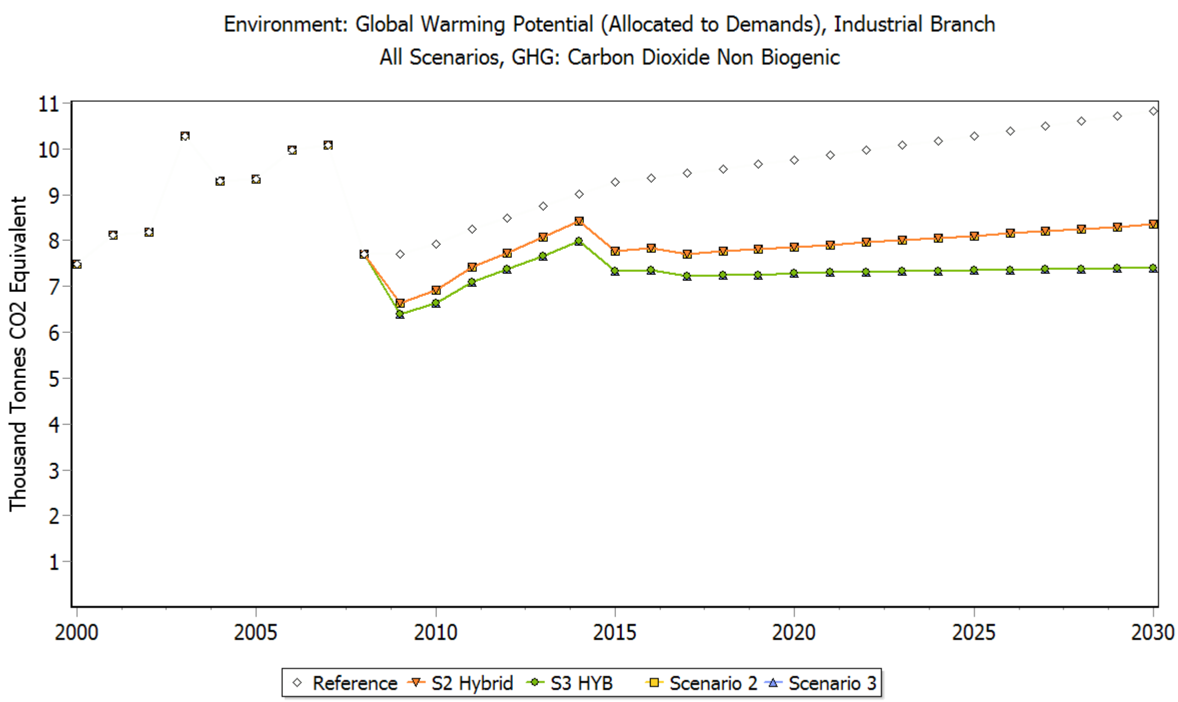


**Figure 4.14 Environmental Loadings for DOMLEC Own Use Demand Branch, All Scenarios, Non Biogenic $CO_2$ Allocated to Demands**

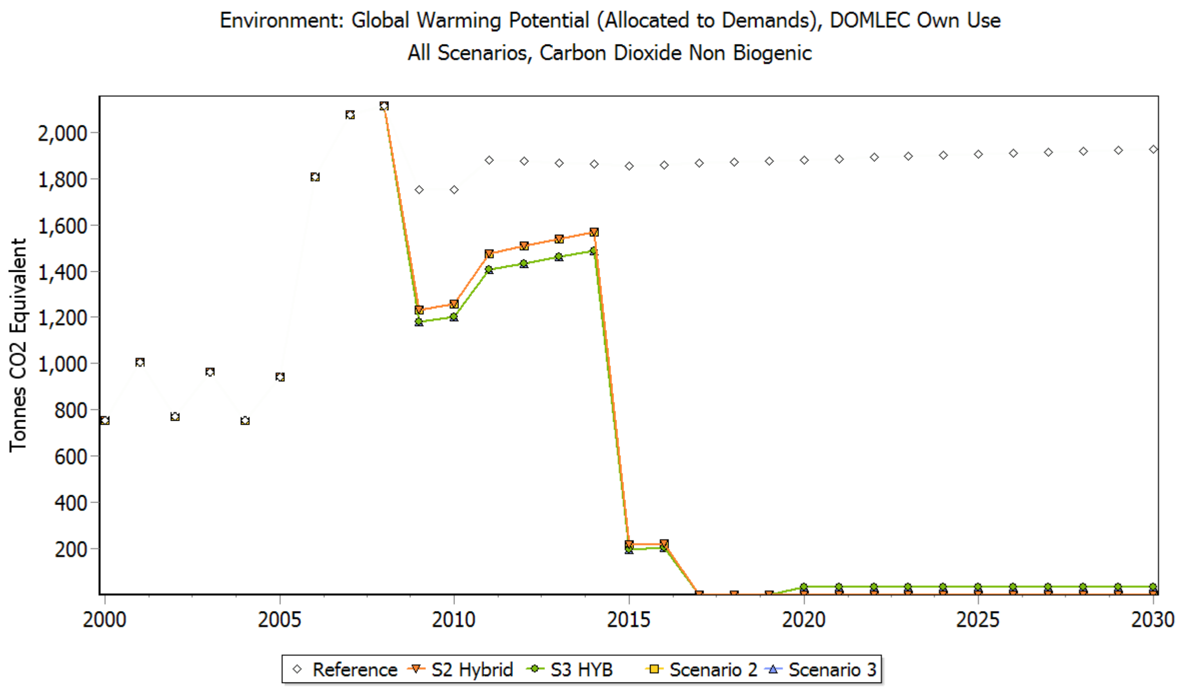



**Figure 4. 15 Transformation: Electricity Generation Capacity Added: Reference Scenario**

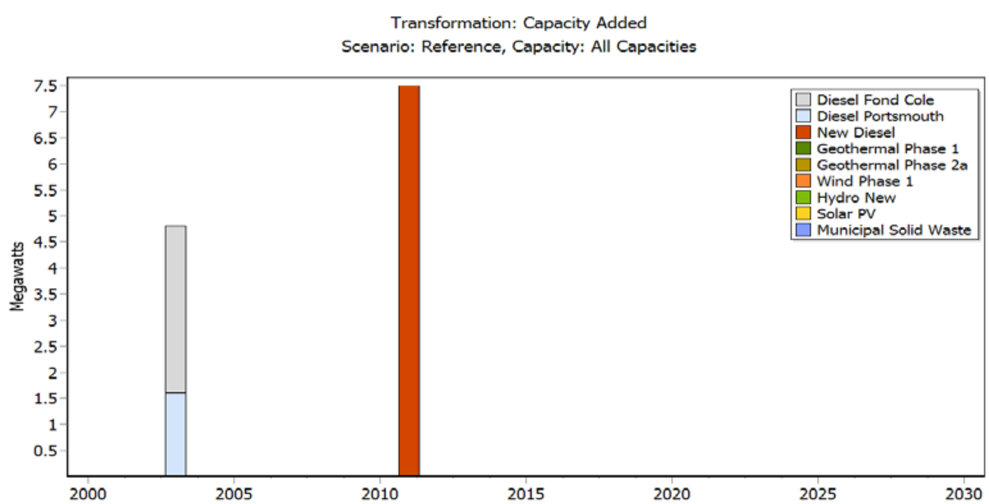


**Figure 4. 16 Transformation: Electricity Generation Capacity Added: Scenarios S2 and S2Hyb**

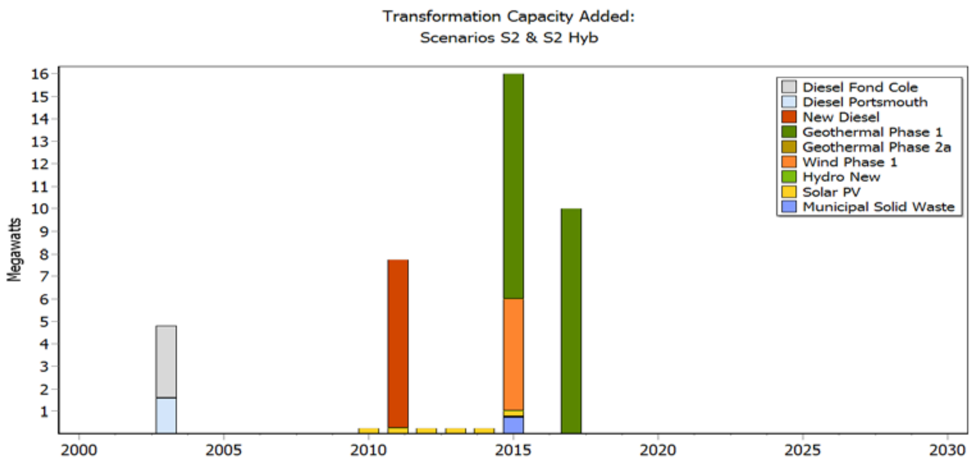



**Figure 4. 17 Transformation: Electricity Generation Capacity Added: Scenarios S3 and S3Hyb**

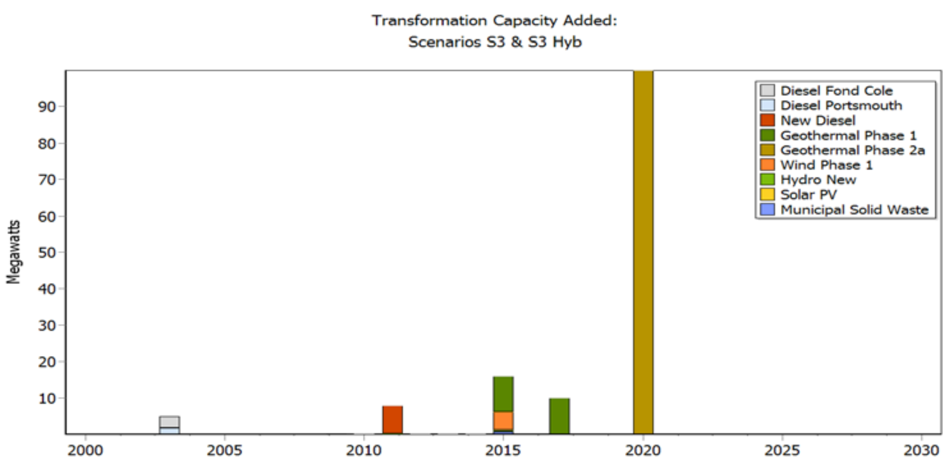


**Figure 4. 18 Transformation: Power Plant Retirements: All Scenarios**

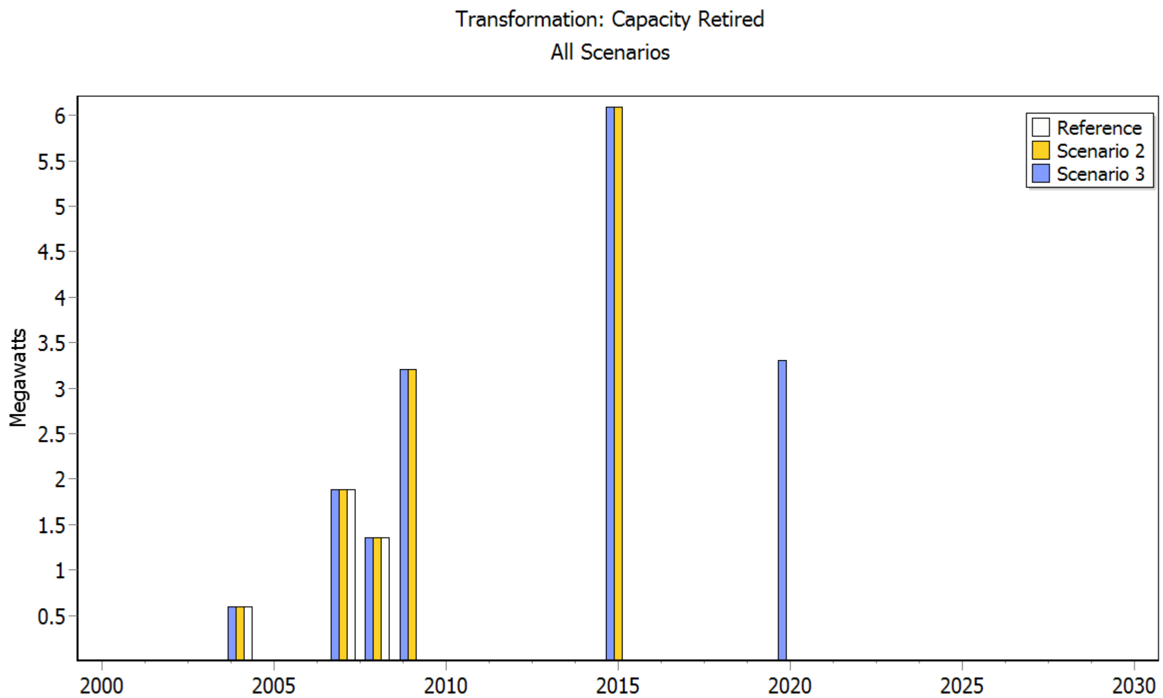
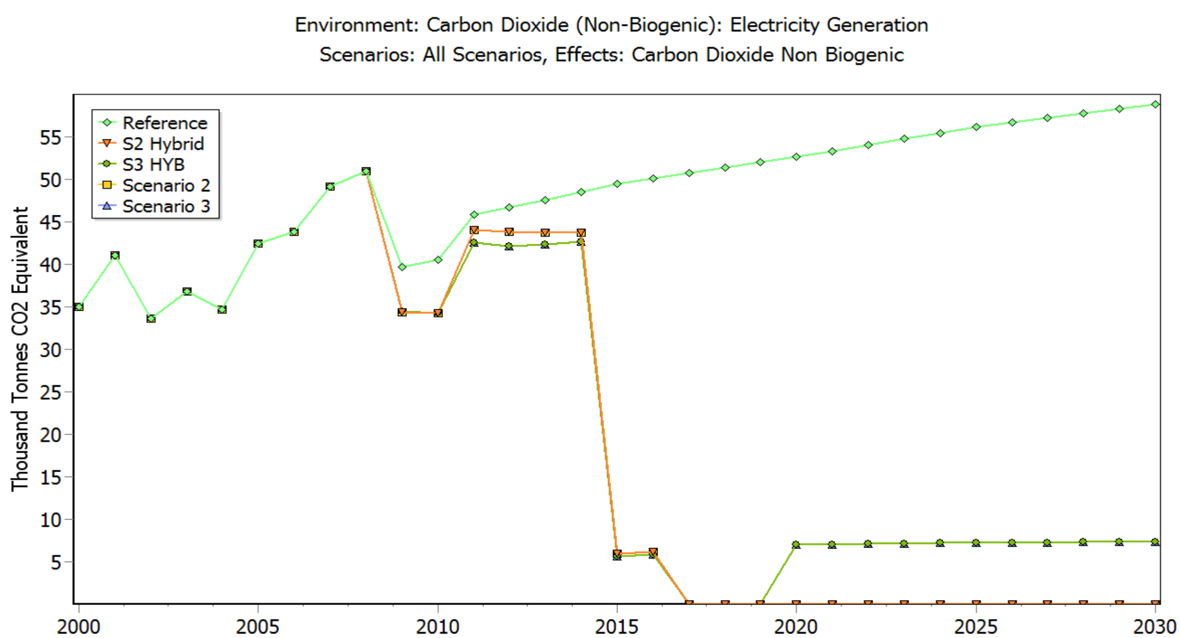



**Figure 4.19 Environmental Loadings for Electricity Generation Branch, All Scenarios, Non Biogenic $CO_2$**



## 4.11 MITIGATION ACTIVITIES FOR IMPLEMENTATION

This section describes the responsibilities and plans for the main energy sector institutions that could be involved in the implementation of mitigation activities; indicates the main requirements for implementing mitigation measures; and identifies some of the gaps, and provides specific recommendations for implementing some of the mitigation measures.

### 4.11.1. Energy Sector And Related Institutions

#### 4.11.1.1 Ministry of Public Works, Energy & Ports

This ministry's portfolio includes responsibility for monitoring and coordinating activities in the air and sea ports, maritime, electricity, and water sectors and in the operations of the Postal Services. The Energy Unit within the ministry coordinates activities related to the development and expansion of electricity production and distribution, including the development of renewable energy sources such as geothermal, solar, photovoltaic, wind energy and hydro energy, and the supply and provision of public lighting.

The Ministry's plans include support to restore and possibly expand the generation capacity of the Padu hydro electricity generation station from 1.8 to 3 MW. The Ministry also encourages other investments for the expansion of hydro electric capacity and photovoltaic (solar) electric systems for domestic, commercial and institutional use.

#### 4.11.1.2 Independent Regulatory Commission (IRC)

The IRC which was established by the Electricity Supply Act No. 10 of 2006 is designed to encourage the expansion of electricity supply to Dominica where this is economic and cost effective and in the public interest and to generally encourage the operation and development of a safe, efficient and economical electricity sector in Dominica. The IRC is to ensure the security and efficiency of the supply of electricity, and facilitate the promotion of sustainable and fair competition in the sector, while protecting the interest of all classes of consumers of electricity in Dominica.

The stated functions of the IRC are as follows:

- Encouraging wider availability of electricity supply throughout Dominica.
- Ensuring that all reasonable demands for electricity are met
- Promoting efficiency in the generation, transmission, distribution, supply and use of electricity
- Establishing technical standards applicable to providing electricity service or equipment installed on customer's premises
- Protecting the interests of consumers
- Facilitating competition in the electricity sector
- Enabling the financial viability of efficient licensees

- Issuing, monitoring and amending licenses and collecting license and other fees
- Establishing and monitoring standards by which the efficiency of the service provision can be evaluated
- Inspecting and testing electrical plant and equipment owned by licensees as well as consumers
- Protecting the health and safety of all persons affected by the operations of the sector
- Protecting the national environment
- Advising the Minister on all issues relevant to the electricity sector
- Promoting wider regional cooperation in the regulation and operation of the electricity sector

The Act requires the IRC to be independent in the performance of its functions and duties, and not be subject to the direction and control of the Government or of any person, corporation or authority, except that the Commission shall have due regard to the public interest and overall Government policy as embodied in the legislation.

#### 4.11.1.3. Dominica Electric Power Company DOMLEC

DOMLEC is a privately owned company (WRB Enterprises and Dominica Social Security) that had been solely responsible for the generation, transmission, distribution and sale to customers. The Electricity Supply Act (2006) requires the IRC to determine the conditions, under which entities are licensed to generate, transmit and distribute electricity.

DOMLEC operates three hydro-electric power stations (Laudat, Trafalgar and Padu) and two diesel power stations (Fond Cole and Sugar Loaf). All generation sources are linked via 11 kV inter-connectors and, in some instances, via 11 kV distribution feeders. The secondary distribution voltage is 230/400V. The transmission and distribution (T&D) network, comprising 368 km of 11 kV and 922 km of low voltage overhead lines, serves about 98% of the island's population.

### 4.11.2. Implementation Of Mitigation Measures

The mitigation measures considered in this analysis address both the demand and supply of energy. The transportation (54%), domestic (18.5%) and industrial (13.6%) sectors which together account for 86% of the energy demand in 2008 will provide most of the opportunities for mitigation.

The proposed mitigation measures related to demand aim to:

- reduce the emissions from transportation by changing the vehicle fleet to include alternate fuelled ( LPG and diesel) vehicles and hybrids which will be more fuel efficient. Specific policies will need to be developed to promote and encourage the use of such vehicles; and

- reduce electricity use in the domestic sector specifically by adopting more energy efficient appliances and in other sectors more generally through more efficient air conditioning, increased use of solar water heating and public education.

It is noted that transportation is recognized as a sector of concern and additional measures such as public education and public transport and traffic flow related measures (although not estimated in this report) will provide additional transportation sector emissions reductions. Specific policies will be needed to promote the use of alternate fuelled vehicles.

The proposed GHG mitigation measures for the reduction in electricity demand are based on adoption of more energy efficient household appliances and commercial/industrial equipment (air conditioning) and use of solar water heating to replace electric or gas-fired water heating. Specific policies will be needed to promote and track the importation of such appliances and equipment. These should include adapting/adopting or developing energy efficiency standards for consumer and industrial electrical equipment (e.g. by adopting the Energy Star program) and base import duties for such equipment in part on energy efficiency standards.

Mitigation measures in the energy supply are centred on the development and introduction of geothermal energy as well as other alternate and renewable energy supplies (wind, distributed photovoltaic, hydro and energy from municipal solid waste). The enabling environment for these initiatives is being addressed in the National Energy Policy and the Sustainable Energy Plan. It is noted however that to date no specific mention has been made of carbon trading and the potential to derive benefits from implementing the planned renewable energy projects. The enabling environment for carbon trading therefore needs to be addressed through the establishment of a DNA and appropriate supporting institutions and if necessary legislation.

Successful implementation of the mitigation measures will *inter alia* depend on:

- Introduction of policies to encourage alternative fuelled (LPG) and/or hybrid vehicles.
- Development of policies and programmes designed to influence market behaviour towards adopting more efficient use in energy across all sectors
- The provision of tax and other incentives/disincentives for the development and use of innovative technologies that improve/worsen efficiency
- Development of a policy and institutions that will enable carbon emissions trading
- Strengthening the institutional capacities in the energy and environment sectors
- Promotion of strategic partnerships between the public and private sectors to finance and develop small and large scale renewable energy projects and implementation of more efficient energy end use technologies

### 4.11.3 Energy Development Programme

The Government's objectives for the energy sector among other things highlights minimizing of the cost of energy, diversify energy sources, reduce the reliance on fossil fuels, and conserve energy, while at the same time, reducing emissions of Greenhouse gases. The short-term goal is to have at least 25% of all electricity generated in Dominica from renewable sources by the year 2010, while encouraging and promoting the need for energy efficiency and energy security. It is expected that the National Energy Policy and the Sustainable Energy Plan will comprehensively address the framework within which GHG mitigation will take place.

#### 4.11.3.1 National Energy Policy

The National Energy Policy will articulate government's position with regards to the governance of the energy sector, and shall provide guidance on areas such as: Regulation, Legal Aspects, Pricing and taxation; Safety and Industry Standards, Power expansion planning/development, Public-Private Partnerships/Engagements, Trading and Export and Capacity Building; It will also address Self Generation, Independent Power Production, Net Metering, Development of indigenous sources of renewable energy – *geothermal; hydro; solar; wind; biomass...*, Service standards, Tariffs, Energy Efficiency, Environmental Aspects and Universal access to electricity

#### 4.11.3.2 Sustainable Energy Plan

The Sustainable Energy Plan will, together with the National Energy Policy:

- Lay out a strategy by which the energy production and use in Dominica may be transformed, becoming more economically and environmentally sustainable, while enhancing the electricity generation mix.
- Ensure the existence of adequate energy supplies at affordable rates to sustain economic development, while meeting current and projected power demand.
- Provide for stable, reliable, and affordable electricity supplies for all customers.
- Reduce the cost of electricity for consumers
- Enhance the security of energy supply and use for all sectors of the economy.
- Allow reasonable incomes for businesses engaged in the local energy sector, while attracting international investment where appropriate –tourism; manufacturing; agro-processing...
- Creation of new job opportunities for Dominicans.
- Promote energy efficiency and conservation at all levels of the economy in order to achieve optimum economic use of renewable and non-renewable sources of energy.
- Protect the local and global environment by maximizing the use of renewable-energy and energy-efficiency alternatives where viable. This is especially relevant in Dominica as much of the renewable energy generation may take place in nature

preserves or rain forest areas. It is essential that this be done in a manner that does not threaten biodiversity, forestation levels, and other environmental aspects.

- Promote the generation of income through energy exports produced from renewable energy sources (esp. geothermal resources).
- Contribute to improving the Balance of Payments accounts for Dominica.

#### 4.11.3.3 Ongoing Initiatives

The Ministry of Public Utilities, Energy and Ports, is providing support to restore, and possibly expand the hydro electricity generation stations that will have the capacity to increase the generation from 1.8 to three (3) megawatts of electricity at one particular plant. Dominica has already installed hydro electricity capacity of 7.6 MW. The Ministry also encourages other investments for the expansion of hydro electric capacity, and the installation of photovoltaic (solar) electric systems for domestic, commercial, and institutional use.

Initiatives have identified some 7 to 9 wind sites on the island with the view for further development of wind farms. However there is need to move to collect the requisite data.

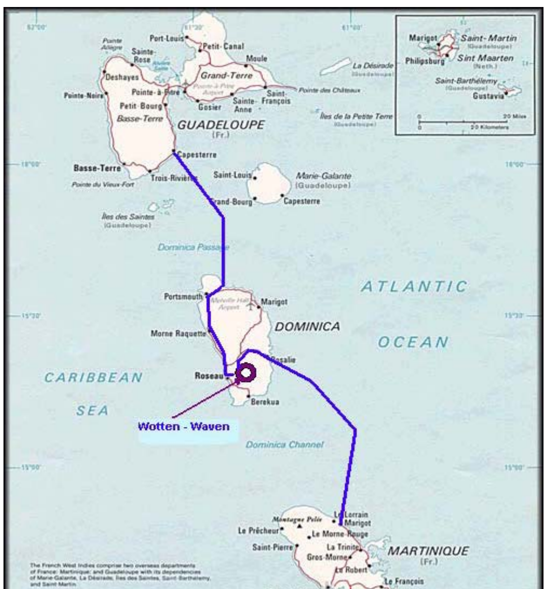



**Figure 4.20 Proposed electricity supply link between Dominica, Martinique and Guadeloupe (Fadelle 2009)**

Dominica participates in the OAS/GTZ GeoCaraibe initiative which is looking at quantifying the resources and development of geothermal energy in which is looking at development of geothermal energy in St Kitts, Dominica, and St Lucia. At present Dominica is actively undertaking a project that will seek to exploit its geothermal resources for generating cleaner and lower cost electricity. With support from the Government of France and the European Union, through the Regional Council of Guadeloupe, a three (3) year geothermal resource development programme is underway.

This programme will determine and characterize Dominica‘s geothermal resource and set the stage for investments in geothermal energy generation plants or commercialization of the resource. The project plans to generate 20 MW of electricity for local consumption and export of 40 MW of electricity to each of the French departments of Guadeloupe and Martinique via submarine cables. (Figure 4.20)

A draft geothermal bill to look at regulation and legislation of the sector is in its advance stage

## 4.12 Gaps

The implementation of GHG mitigation measures will be facilitated by filling the following institutional & policy and information related gaps.

### 4.12.1. Institutional and Policy Related Gaps

Dominica's National Energy Policy and Sustainable Energy Plan are currently being formulated with technical assistance from CARICOM, in association with the OAS and the German Technical Assistance (GTZ). Alternative Energy Legislation and Regulations are also being drafted with assistance from the World Bank funded Growth and Social Protection Technical Assistance Project (GSPTA). The legislation is intended to provide the legal and regulatory framework for the development of alternative energy technology, including hydropower, solar, wind, and geothermal energy, and any other form of renewable energy in Dominica. Dominica's Sustainable Development Plan relies heavily on projects to develop geothermal energy and other renewable energy resources (e.g., wind, PV) and alternate energy sources. These projects provide the basis for the proposed GHG mitigation measures and as such could take advantage of the UNFCCC's Kyoto Protocol.

### 4.12.2 Information Gaps

There are a number of information gaps that are barriers to reliable determination of the mitigation potential and monitoring progress of mitigation measures. Dominica's reliance on imported fossil fuels for transportation and most of its electricity generation has made it vulnerable to shocks to the economy (e.g., higher electricity, gasoline and diesel fuels costs) caused by higher fossil fuel prices. Gaps in the transportation and domestic energy demand sectors have severely limited the reliability of mitigation measures in these sectors. These are the very demand sectors that not only have high GHG emissions but also afford best opportunities for mitigation. There are also some information gaps in the electricity and fuel demand for the hotel, industrial and commercial sectors. In general there is adequate information for energy transformation (i.e., electricity generation).

## 4.13 Recommendations

The following recommendations are proposed to address information and policy gaps and build capacity in order to facilitate the implementation of mitigation measures.

- Complete the Sustainable Development Plan and National Energy Policy
- Revise the bases for tax/customs duties so that they are based on vehicle weight class and fuel type (not cc rating)
- Implement import and other policies to promote the introduction of alternate fuelled vehicles (LPG and/or hybrids)
- Develop and implement the regulatory framework to allow carbon trading to take place. This should include legislation establishing the DNR and associated

entities and specification of the trading modalities for local and international entities (e.g., licensing, certification or regulation of such entities, owning certified emission reductions (CERs) and Verifiable Emissions Reductions (VERs) etc.)

- Build capacity to support carbon trading
- Enhance the import classifications of motor vehicles and electrical appliances and equipment to clearly distinguish between various categories of vehicles (based on fuel and vehicle weight) and appliances (based on technology and ranges of energy use). Examples are as follows:
  - Motor vehicles – to distinguish fuel used (i.e., diesel, gasoline, CNG, hybrid, electricity only etc.) and weight class
  - Refrigerators (range in SEER value, refrigerant (HC, HFC or HCFC)
  - TVs (based on technology and/or energy intensity)
  - Energy Star rated equipment/appliances
- Implement data collection and reporting systems to capture and report on gasoline, diesel and LPG fuel sales by sector
- Include more detailed information for the motor vehicle fleet and develop a suitable database and reporting system for the motor vehicle fleet
- Implement additional public education and other measures to increase awareness about energy conservation in all sectors.

# 5. OTHER INFORMATION CONSIDERED RELEVANT TO THE ACHIEVEMENT OF THE OBJECTIVE OF THE CONVENTION

## 5.1 INTRODUCTION

With a view to facilitating the formulation and implementation of sustainable development programmes, non-Annex I Parties are encouraged, as appropriate, to provide information on any steps they have taken to integrate climate change considerations into relevant social, economic and environmental policies and actions in accordance with Article 4, paragraph 1(f), of the Convention.

In 2005, the INC Phase II Enabling Activity was completed. It was capacity building project intended to build upon the activities completed in the context of Dominica's INC. The overall goal was to allow Dominica to extend current knowledge to facilitate the emergence of national networks and promote the integration of climate change concerns in the developing national dialogue.

The Phase II project was designed to generate the following outputs:

- Identification and submission of technology needs;
- Capacity building to assess technology needs, modalities to acquire them and absorb them, design, evaluate and host projects;
- Capacity building for participation in Systematic Observation networks; and
- Preparation of programs to address climate change improvement of emission factors.

Project implementation focused on:

- Describing the current state of national programming in each of the specified areas (technology needs, systematic observation, emission factors);
- Analysis of the strengths and weaknesses in programming; and
- Definition of priority needs for building capacity.

The following sections on Transfer of Technologies, Research and Systematic Observations relies on information mainly taken from the INC Phase II project Report

## 5.2. TRANSFER OF TECHNOLOGIES

Pursuant to decision 4/CP.7, its annex, and the implementation of Article 4, paragraph 5, of the Convention, non-Annex I Parties are encouraged, in the light of their social and economic conditions, to provide information on activities relating to the transfer of, and access to, environmentally sound technologies and know-how, the development and enhancement of endogenous capacities, technologies and know-how, and measures relating to enhancing the enabling environment for development and transfer of technologies.

Technology needs assessments are intended to identify and prioritize technologies that might be implemented within the framework of national development goals to reduce vulnerability to climate change and/or reduce greenhouse gas emissions.

Various methodological approaches have been developed for the conduct of technology needs. These methodologies emphasize consultative processes and the integration of climate change technology needs with wider national development objectives. In many instances, time and data availability concerns meant that it was not possible to observe all of the steps envisaged in the methodological approaches. However these methodologies have provided valuable reference points for conduct of the assessment.

The Dominica Assessment was prepared based on discussions with officials in Dominica and a review of relevant documentation including Dominica's INC. A first draft of the report was shared with stakeholders and the comments received incorporated into the document. As far as possible, the Assessment attempts to utilize elements of the methodologies that have been developed for technology needs assessments.

### 5.2.1 Mitigation Technologies

Both Dominica's INC and the GHG Inventory Report of 2009, point out that the country's forestry resources result in Dominica being a net sink of greenhouse gases. This means that Dominica is in fact already contributing towards measures for mitigation of the global climate. Government policy and national pride in the country's forests means that Dominica's forests can be projected to continue to make positive contributions to global greenhouse gas mitigation. However, it is uncertain how severely global climate change will itself affect the health and productivity of the country's forestry resources.

Dominica possesses a range of renewable energy sources including hydro, geothermal, solar, wind, and biomass. Many of these technologies, such as hydropower and solar are already in use and contribute to national energy output, although in the case of solar and biomass these probably represent a fraction of potential. Plans are advanced within the private sector for the introduction of wind power and geothermal sources for domestic and export markets.

As a developing country, it is important that Dominica pursues mitigation strategies and/or activities that are consistent with its wider development goals and objectives. Mitigation measures associated with these policies in the Dominica context include sustainable forest utilization and management, utilization of renewable energy resources where technically and financially viable to do so and encouraging energy conservation in transport and electricity generation, distribution and end use. Given the structure of demand for energy, *energy conservation policies and activities are likely to offer some of* *the most financially viable short-term measures for achieving mitigation while also contributing to socio-economic development for Dominica.*

### 5.2.1.1 Energy Generation

A range of potential technological options exist for mitigating climate change within the energy sector. These include the development of alternative sources as well as improved efficiency of energy use. Small market size and existing fossil fuel capabilities have historically reduced the possibility for adoption of these technologies in small countries like Dominica. Rising fuel costs, falling alternative energy costs, concerns for climate protection, and concerns for energy security have however favorably increased the viability of many of these technology options. **Table 5.1** summaries these mitigation measures and their attendant technology needs.

**Table 5.1 – Technology Needs for Energy Generation**

| Response | Mitigation Measures | Technology Needs |
|---|---|---|
| Renewable energy development to reduce and replace fossil fuel use. | ▪ Establish policy and regulatory framework for promoting renewable energy;<br>▪ Establish renewable energy data-base;<br>▪ Human resource development;<br>▪ Public awareness. | ▪ Information technologies;<br>▪ Meteorological monitoring equipment;<br>▪ Small-scale hydro;<br>▪ Wind energy technologies;<br>▪ Solar energy technologies;<br>▪ Geothermal energy technologies.<br>▪ Baseline data sets |
| Energy conservation and efficiency in generation, distribution and end-use of electricity. | ▪ Devise and implement national energy efficiency and conservation programme.<br>▪ Establishment of standards and incentive regime.<br>▪ Establish natural gas as fuel for energy generation. | ▪ Efficient fossil fuel generation plant;<br>▪ Energy efficient domestic appliances;<br>▪ Energy efficient air conditioning equipment;<br>▪ Human resource development;<br>▪ Information technologies. |

**Source: Dominica INC Phase II Project Report 2005**

Mention has already been made in Chapter 4 of Dominica's renewable energy programme to reduce dependence of fossil fuel generated electricity. This includes the development of a Renewable Energy Policy, a Sustainable Energy Plan, and geothermal and renewable energy projects currently being pursued with the support of the Ministry of Energy, Public Works and Ports.

Dominica is one of thirteen Caribbean countries participating in The Caribbean Renewable Energy Development Programme (CREDP) which is an initiative of the Energy Ministers of CARICOM region established to change the market environment for Renewable Energy in the Region. The aim of the CREDP is "to reduce barriers to the increased use of renewable energy thus reducing the dependence on fossil fuels while contributing to the reduction of greenhouse gas emissions". http://www.caricom.org/jsp/projects/credp.jsp?menu=projects

The objectives of the project are to:

- Reduce greenhouse gas emissions by removing barriers to renewable energy development
- Establish the foundation for a sustainable renewable energy industry
- Create a framework under which regional and national renewable energy projects are mutually supportive

### 5.2.1.2 Road Transportation

Growth in transportation, and associated greenhouse gas emissions, reflects many factors including increased urbanization, rising living standards, and technological developments. In Dominica economies of scale and rugged topography impose constraints on many conceptual responses to reducing emissions from the transport sector.

**Table 5.2 – Technology Needs for Road Transportation Sector**

| Response | Mitigation Measures | Technology Needs |
|---|---|---|
| Public transportation to reduce growth of energy use in transportation sector. | ▪ Publicly owned bus service;<br>▪ Public awareness;<br>▪ Car-pooling;<br>▪ Mitigation policy and regulatory regime;<br>▪ Human resource development. | ▪ Energy efficient buses;<br>▪ Technical assistance. |
| Infrastructure | ▪ Improving road surfaces and routes to reduce energy use. | ▪ Road building equipment;<br>▪ Technical expertise;<br>▪ Information technologies; |
| Vehicle Efficiency Improvements | ▪ Establishment and enforcement of standards for vehicle energy efficiency.<br>▪ Public awareness.<br>▪ Human resource development. | ▪ Information technologies;<br>▪ Vehicle testing equipment;<br>▪ Efficiency improvement equipment;<br>▪ Emissions testing equipment;<br>▪ Regulations and standards establishing emission limits.<br>▪ Monitoring of standards and regulations |

**Source: Dominica INC Phase II Project Report**

**Photo 5.1 Recently rehabilitated Bath Estate- St Aroma link road**

With regards to road infrastructure, since 2000, Government of Dominica has completed a number of road rehabilitation projects throughout the island. These include the Soufriere Scotts Head Road Rehabilitation project, The Roseau Valley Road Improvement and Maintenance Project, the Airport Road Project Lot One, the Blenheim Viellecase Road Project, the Loubiere Grand bay Road Rehabilitation Project. In addition two major road projects are currently being undertaken. These are the West Coast Road Project, the Airport Road Project Lot Two, and the Rosalie Petite Soufriere Project. The latter when completed will cut travel from both communities from 20 to 4.16 kilometers. These projects have contributed significantly to the improvement of road surfaces and routes thereby reducing energy use in the transportation sector

### 5.2.2 Adaptation Technologies

The INC Phase II Assessment was also conducted for the most important sectors vulnerable to the impacts of climate change. The assessment was based on the critical sectors identified in the INC, the Climate Change Issues paper and other climate change related documents. Detailed adaptation technology needs were assessed for Coastal zones, Disaster management and Response, Water Resource management, Human Settlements, Agriculture and the Health sectors. Since the preparation of the INC and the INC Phase II Assessment, a number of relevant adaptation technologies have been introduced in the various sectors.

#### 5.2.2.1 Agricultural Sector

In the Agricultural sector the increasing scarcity and irregularity of rainfall has led to the implementation of large irrigation projects. The climate response, adaptation measures and technology needs identified for the Agricultural Sector is presented in Table 5.3.

Under the ongoing SPACC Project, funds will be made available to farmers to construct on-farm water storage facilities and small-scale irrigation. The significant increase in the number of farmers who are presently using “Greenhouse” technology has led to the formation of the Greenhouse Farmers Association and publication of greenhouse production manuals. Financial institutions are now more receptive to providing loans for greenhouse technology. More significantly the Ministry of Agriculture has been able to mobilize technical assistance specifically targeted at increasing productivity of greenhouses. More drought resistance and greenhouse suitable plants varieties have also been introduced.

**Table 5.3 – Agriculture Sector Technology Needs**

| Response | Adaptation Measure | Technology Needs |
|---|---|---|
| Improved farming practices to conserve soil moisture and nutrients, reduce runoff, and control soil erosion. | ▪ Increased storage of water;<br>▪ Improved drainage systems;<br>▪ Public awareness;<br>▪ Water conservation tools and methods;<br>▪ Crop rotation;<br>▪ Contour cropping;<br>▪ Agro forestry;<br>▪ Multi-cropping. | ▪ Greenhouse technologies;<br>▪ Micro-dams and ponds;<br>▪ Water storage tanks;<br>▪ Information technologies;<br>▪ Low cost pumps;<br>▪ Laboratory equipment;<br>▪ Low cost efficiency irrigation materials;<br>▪ Genetic material. |
| **Response** | **Adaptation Measure** | **Technology Needs** |
| New and modified Crops | ▪ Genetic research;<br>▪ Genetic engineering<br>▪ Use of new crops and animal types;<br>▪ Public awareness of genetic modification and its implications;<br>▪ Germplasm management;<br>▪ Use of traditional knowledge;<br>▪ Improve distribution networks | ▪ Genetic material;<br>▪ Human resource development;<br>▪ Information technologies;<br>▪ Laboratory and storage equipment. |
| Environmental Management to reduce adverse environmental effects. | ▪ Topographical engineering to enhance water use;<br>▪ River bank protection;<br>▪ Watershed protection;<br>▪ Reforestation;<br>▪ Establishment and maintenance of protected areas;<br>▪ Strengthened legislative and regulatory frameworks;<br>▪ Public awareness;<br>▪ Biodiversity monitoring and protection. | ▪ Information technologies;<br>▪ Heavy duty equipment;<br>▪ River level monitoring equipment;<br>▪ Human resource development;<br>▪ GIS equipment;<br>▪ Meteorological monitoring equipment. |

**Source: Dominica Initial National Communication Phase II Project Report 2005**

Under the ongoing Sustainable Land Management Programme, a workshop on the development of Community Resource Maps & Climate Change Vulnerability Atlases for the Creation of National Resource Management Plans was conducted. A number of community personnel, agricultural extension officers and farmers were introduced to GIS technology. Workshop participants received theoretical training sessions in the use of the field tested Handbook and the various GPS/GIS equipment and software.

**Photo 5.2 Workshop participants training in interfacing GPS field data with GIS software**

Participants also received practical training for field data gathering using the relevant equipment and materials, and interfacing the GPS field info with GIS software (in-house computer based applications). The training will help develop the capacity of farmers and extension officers to produce the Resource Maps, Vulnerability Atlases and the Resource Management Plans for the Dublanc/Syndicate areas adjacent to the Morne Diablotin National Park. It is hoped that eventually the process will lead to development of island wide Resource Management Plans for Dominica.

### 5.2.2.2 Human Settlements

Topographical conditions have resulted in most settlements being in coastal areas at risk to coastal flooding and sea-level rise. This includes critical roads and other public infrastructure. Human settlements planning in Dominica faces severe problems in terms of personnel and technical resources. This essentially restricts development control to inspection and monitoring of buildings and related tasks. Climate change responses, adaptation measures and technology needs for the human settlements sector are presented in Table 5.4.

**Table 5.4– Human Settlements Technology Needs**

| Response | Adaptation Measure | Technology Needs |
|---|---|---|
| Health Impacts | ▪ Public awareness;<br>▪ Regulatory;<br>▪ Monitoring;<br>▪ Environmental health management;<br>▪ Medical interventions;<br>▪ Climate change related health infrastructure. | ▪ Information technologies (hardware and software);<br>▪ Air cooling systems;<br>▪ Disaster resistant construction;<br>▪ Vector control methods. |
| **Response** | **Adaptation Measure** | **Technology Needs** |
| Infrastructural and Environmental Effects | ▪ Public awareness;<br>▪ Strengthened solid waste | ▪ GIS tools;<br>▪ Human resource |

| Response | Adaptation Measure | Technology Needs |
|---|---|---|
| | management capability;<br>▪ Liquid waste;<br>▪ Urban and community forestry;<br>▪ Physical planning, building codes and development control;<br>▪ Strengthened physical structures. | development;<br>▪ Meteorological and oceanographic monitoring equipment;<br>▪ Solid waste management equipment;<br>▪ Water and sewage systems. |
| Economic and Financial Consequences | ▪ Insurance mechanisms;<br>▪ Improved development control;<br>▪ Public awareness;<br>▪ Hazard and risk assessment;<br>▪ Economic incentives for retrofitting and structural improvements etc;<br>▪ Economic diversification. | ▪ Public awareness;<br>▪ Human resource development;<br>▪ GIS tools;<br>▪ Economic modeling and forecasting incorporating climate change. |

**Source: Dominica INC Phase II Project Report 2005**

All construction in Dominica requires prior approval of the plans by the Housing and Planning Department. This ensures that houses are built to the established safety standards and housing codes. Recent experiences suffered by homeowners has also largely contributed to an heightened awareness of the needs for safety measures in construction industry in Dominica

**5.2.2.2.1Government Loan Housing Scheme and the Housing Revolution**

The GOCD has secured financing for the provision of low interest loans to public sector workers. In addition under its “Housing Revolution”, the Government has provided assistance to marginalized persons/families for construction of low income but safe houses that are able to withstand the seasonal hurricanes. The houses are equipped with modern facilities that allow for adaptation to climate change.

**5.2.2.2.2 Solid Waste management Equipment**

**Photo 5.3 Biomedical Waste Gasification Unit**

The Solid Waste Management Act of 2002 established the Dominica Solid Waste Management Corporation (DSWMC) with overall responsibility for the collection, transportation and disposal of solid waste in Dominica. In 2009, the DSWMC opened a new central waste processing facility at Fond Cole, thus resulting in the closure of two main landfills and many rural community waste disposal sites on the island.

**Photo 5.4 Special Biomedical Waste collecting Vehicle**


The same year a new system of Curbside Waste Collection was introduced replacing the Skip System. To date curbside collection accounts for 90% of all waste generated on the island. Also as part of improving it's waste management capability, the DSWMC acquired a new Gasification Unit. This has greatly improved the disposal of biomedical waste at a central location. The Unit is presently installed at the Princess Margaret Hospital. The DSWMC also acquired a new vehicle specially designed for the collection and transportation of the biological waste generated at different institutions around Dominica for processing at the facility.

Previously derelict vehicles were being used to make artificial reefs to enhance coastal fisheries. When this practice was ended, for many years after, derelict vehicles and white goods were being collected and "temporarily" stored at various sites around the island pending final disposal. This apart from the eyesore that it created in a country which prides itself for its ecotourism practice provided perfect breeding grounds for rodents and vectors. In 2009, the DSWMC with assistance from the Bolivarian Republic of Venezuela installed a compactor which allows for the processing of the derelict vehicles and white goods. Consequently the temporary storage sites have been emptied and white good are no longer "stored" around the island.

#### 5.2.2.3 Water Resource Management

Climate change can be expected to impact the volume and distribution of rainfall in Dominica. Water resource management will be required in the context of other non-climate related stresses such as population growth. This will require that adaptive actions be taken from demand management and supply development and management (Table 5.5). Demand management involves the use of measures for influencing water users' behavior to improve efficiency of water use. Supply development and management programmes aim at development of new or existing sources.

Other concerns for water managers include ensuring the quality of water supplies. Sea level rise and accompanying higher tides will also adversely affect estuarine freshwater conditions with implications for domestic and municipal uses, as well as affecting marine and river ecosystems.

Adaptive responses to water resource management will require actions in terms of supply development and management, demand management, and water quality. Strengthening of human resource capability and awareness must also be considered as cross-sectoral priorities if sustainability of responses is to be achieved. The relevant technology needs are summarized in

The Dominica Water and Sewerage Company Limited **(DOWASCO)** is a registered company wholly owned by the Government of the Commonwealth of Dominica. **DOWASCO** was established by an act of Parliament - Water and Sewerage Act#17, in December 1989 and incorporated in the same year. The Water and Sewerage Act makes provision for a national policy for water and the granting of an exclusive licence to DOWASCO for the development and control of water supply and sewerage facilities in Dominica. . The company is also responsible for the operations of the sewerage system in the city of Roseau. All new construction located outside of the Roseau Sewage Project service area requires approval by the Planning Division before construction can begin. Plans must include the designs for sewage disposal systems.

**Table 5.5 Water Sector Technology Needs**

| Response | Adaptation Measure | Technology Needs |
|---|---|---|
| Supply development and enhancement. | ▪ Improved forestry management to protect water supply;<br>▪ Increased storage capacity for drier conditions;<br>▪ Improved efficiency in distribution and supply of water. | ▪ Meteorological and hydrological measurement tools;<br>▪ Hydrological studies;<br>▪ GIS tools;<br>▪ Construction of dams and ponds; Desalination of saline water; Water reuse. |
| Demand management measures and actions | ▪ Economic and legal framework (e.g. pricing and allocation of property rights, restrictions/prohibitions on use of certain methods) to encourage conservation and efficient use. | ▪ Water saving household technologies (low flush toilets, low water use washing machines etc);<br>▪ Drip irrigation;<br>▪ Public awareness and information tools;<br>▪ Technical training and exchange. |
| Water Quality Protection | ▪ Protection of watersheds;<br>▪ Monitoring of water quality;<br>▪ Monitoring of underground fuel tanks for seepage into water system;<br>▪ Appropriate disposal of waste fluids and chemicals;<br>▪ Public awareness. | ▪ Biological and chemical water treatment technologies;<br>▪ Testing equipment;<br>▪ Technical training;<br>▪ Construction of sluices against sea-level rise. |

**Source: Dominica INC Phase II Project Report**

DOWASCO has completed three major projects which have contributed to building resilience to climate change. In 2006 the Watton Waven, Trafalgar, and Copthall Water project was completed.. In 2007, the Giraudel, Eggleston and Castle Comfort Water Supply Project was commissioned. The project was completed in 2009. With the completion of these two later projects **DOWASCO** estimates that 90% of the population of Dominica has access to drinking water from its water systems.

In addition DOWASCO has initiated projects aimed at alleviating water supply problems caused by climate change. These include work commissioned in 2010 on improvement of the water supply system in the Campbell community. Works include the upgrading the present intake as well the construction of a 30,000 imperial gallon water storage tank, a pump house and a sump. In April 2011 DOWASCO also commissioned the Delices Water Supply system which included upgrading the existing system to construction of a 30,000 imperial gallon storage tank, installation of two new electric pumps to complement the existing ram pump. Work on a 500,000 imperial gallon water storage tank at Morne Bruce began in April 2011 and is expected to be completed in April 2012. The project when completed will o augment the storage capacity and provide increase supplies to the capital City of Roseau and surrounding areas. Additionally work is expected to begin on a major West Coast Water Supply Project which will significantly improve water quality and access to consumers on the west coast of the island.

Given Dominica's topography as it pertains to potential for run-off during the rainy season, sewage and waste water that is not properly disposed off can have serious consequences for water quality and human health. The risk is even greater due to the fact that many of the water supply intakes are located in low lying watershed areas. In 2005, the Roseau Water and Sewage Project was completed. This project built a central sewage collection, processing and disposal facility for servicing all residents of Roseau and surrounding areas. Additionally all construction, including those located outside of the Roseau catchment area and not serviced by the Roseau Sewage Project, require authorization by the Planning Division before construction can begin. Building plans submitted for approval to Planning Division must include among other aspects, the designs for safe sewage and waste water disposal systems.

### 5.2.2.4 Coastal Zone

With potential impacts from sea-level rise, warming seas, more intense storm activity and other non climate change threats such as pollution, the coastal zone remains one of the most dynamic and at risk areas to the adverse impacts of climate change. As already indicated earlier, in Dominica, historical events coupled with topographical conditions have resulted in most settlements being in coastal areas at risk to coastal flooding and sea-level rise. This includes critical roads and other public infrastructure. . Hence the concentration of population and economic activity in coastal areas further heightens vulnerability.

The coastal zone adaptation technologies in **Table 5.6** below are based on the IPCC methodological distinction of retreat, accommodate, and protect as the three (3) principal responses to climate change impacts in the coastal zone.

**Table 5.6 – Coastal Zone Technology Needs**

| Response | Adaptation Measure | Technology Needs |
|---|---|---|
| Retreat | ▪ Phased development;<br>▪ Withdrawal of government subsidy and services;<br>▪ Public awareness;<br>▪ Restricting development. | ▪ GIS Mapping;<br>▪ Information technologies;<br>▪ Human resource development;<br>▪ Ecosystem monitoring;<br>▪ Meteorological and oceanographic monitoring. |
| Accommodate | ▪ Protection of ecosystems;<br>▪ Land use codes and standards;<br>▪ Hazard insurance;<br>▪ Public awareness | ▪ GIS mapping;<br>▪ Information technologies;<br>▪ Human resource development;<br>▪ Beach nourishment;<br>▪ Sea defenses;<br>▪ Meteorological and oceanographic monitoring. |
| Protect | ▪ Land use and coastal area use planning;<br>▪ Enforcement of building standards;<br>▪ Hazard insurance;<br>▪ Public awareness;<br>▪ Coastal area management. | ▪ Engineering technologies;<br>▪ Dikes, levees, and sea-walls;<br>▪ Groynes;<br>▪ Detached breakwaters;<br>▪ Beach nourishment;<br>▪ Littoral drift replenishment;<br>▪ Meteorological and oceanographic monitoring technologies;<br>▪ Human resource development |

**Source: Dominica INC Phase II Project Report**

**Photo 5.5 Pointe Mitchel Sea Wall under construction**


Given Dominica's limited land space and land ownership system, retreat from the coastal areas has not been widely considered as a feasible response option. In recent years, the main response to climate change impact in the coastal areas has been that of accommodation and protection namely the in the form of the construction of massive sea walls and sea defenses. This response presents a serious challenge for a developing island state like Dominica, which must allocate significant amounts of scarce available resources to this activity in order to protect existing coastal infrastructure from the annual storms and hurricane damage.

### 5.2.2.5 Disaster Response

Projections for stronger and possibly more frequent storms and hurricanes, as well as changes in temperature and rainfall patterns, mean that disaster management and response will be an increasingly significant element of the national response to climate change. Disaster management and response activities can be envisaged at three (3) distinct but inter-related levels: community action, emergency response, and longer term hazard management/risk reduction measures – **Table 5.7**.

**Table 5.7– Disaster Management and Response Technology Needs**

| Response | Adaptation Measure | Technology Needs |
|---|---|---|
| Community level action | ▪ Public awareness;<br>▪ Community enhancement and risk reduction projects. | ▪ Information technologies (computers, internet, GIS);<br>▪ Environmental engineering (e.g. contour terracing, artificial reefs);<br>▪ Human resource development. |
| Emergency preparedness | ▪ Communications and logistics management;<br>▪ Emergency shelter;<br>▪ Search and rescue capabilities;<br>▪ Public awareness. | ▪ Communications equipment;<br>▪ Information technology;<br>▪ Emergency shelter;<br>▪ Human resource development. |
| Hazard management | ▪ Land use planning;<br>▪ Zoning;<br>▪ Hazard resistant construction practices;<br>▪ Strengthened legislative and institutional framework. | ▪ GIS mapping;<br>▪ Meteorological monitoring equipment;<br>▪ Information technologies;<br>▪ Environmental engineering – contour terracing, riverbed protection, habitat protection, sea defenses. |

**Source: Dominica INC Phase II Project Report**

### 5.2.2.6 Health

The health sector is likely to be adversely affected by climate change via a number of pathways including increased heat related health complaints, more injuries and other problems arising from extreme weather events, and nutritional and long term chronic problems associated with alterations in weather and climatic parameters –Table 5.8.

This will require that actions are taken to respond to adverse impacts associated with local environmental conditions and which involve adaptation at the level of environmental management. These would include vector borne and other diseases and complaints relating to environmental conditions. Action will also be needed in terms of health management and response to increased disaster events as a result of climate change.

**Table 5.8. Health Sector Technology Needs**

| Response | Adaptation Measure | Technology Needs |
|---|---|---|
| Improved Environmental Management | ▪ Public awareness;<br>▪ Improved water supply;<br>▪ Improved solid and liquid waste management;<br>▪ Environmental monitoring and surveillance;<br>▪ Strengthened data collection and exchange;<br>▪ Increased vector control;<br>▪ Strengthened regulatory framework;<br>▪ Human resource development;<br>▪ Flood defense systems;<br>▪ Development control and physical planning;<br>▪ Housing design;<br>▪ Vaccine development;<br>▪ Strengthened regional cooperation and information exchange. | ▪ Information technologies;<br>▪ Technical training;<br>▪ Vector control equipment and supplies;<br>▪ Primary health care including vaccines and medicines;<br>▪ Epidemic forecasting tools;<br>▪ Laboratory equipment;<br>▪ GIS tools. |
| Disaster Response | ▪ Strengthened building codes and practices;<br>▪ Land use planning;<br>▪ Community disaster management capabilities;<br>▪ Human resource development;<br>▪ Strengthened emergency response capability;<br>▪ Strengthened regulatory framework. | ▪ Communications equipment;<br>▪ Water purification;<br>▪ Information technologies;<br>▪ GIS;<br>▪ Marine, aerial and terrestrial emergency response vehicles;<br>▪ Human resource development;<br>▪ Disaster resistant emergency shelters. |
| Management of Chronic Health Concerns. | ▪ Strengthened data collection;<br>▪ Human resource development;<br>▪ Development of management regimes;<br>▪ Research programmes;<br>▪ Public awareness;<br>▪ Strengthened chronic care capabilities. | ▪ Information technology.<br>▪ Air conditioning;<br>▪ Human resource development;<br>▪ Laboratory facilities;<br>▪ Appropriate chronic care equipment and facilities;<br>▪ Meteorological monitoring equipment. |

**Source: Dominica INC Phase II Project Report**

#### 5.2.2.6 Institutional Capabilities

Critical to achievement of virtually all of the adaptation and mitigation options will be the presence of a strengthened capability for coordinating and advancing measures relating to climate change.

*Of particular importance at this stage is the issue of information dissemination. This arises from the need to sensitize decision makers to climate change concerns at various levels utilizing different types of media. The intention is to get persons in key sectors to incorporate concerns for climate change into the planning and implementation of activities. Similarly, but at a different level, it is necessary to strengthen technological capability to enhance greater public awareness of climate change.*

Important initiatives have already begun in this regard by the ECU utilizing resources under the UNDP/GEF Enabling Activities project. Workshops and seminars have exposed an increasing amount of key sectoral and technical agencies to issues relating to climate change. Efforts have also been made to sensitize sections of the general public about climate change issues and concerns. The focus of efforts in the future should be to extend the capability to provide and facilitate various types of information relating to climate change

## 5.3 RESEARCH AND SYSTEMATIC OBSERVATION

According to the UNFCCC Draft decision / CP.8, Non-Annex I Parties are encouraged to provide information on climate change research and systematic observation, including their participation in and contribution to activities and programmes, as appropriate, of national, regional and global research networks and observing systems.

Non-Annex I Parties are also encouraged to provide information on research relating to programmes containing measures to mitigate climate change; programmes containing measures to facilitate adequate adaptation to climate change; and the development of emission factors and activity data.

As outlined in Article 5 of the Convention, Dominica like all parties to the Convention is committed to :
(a) Support and further develop, as appropriate, international and intergovernmental programmes and networks or organizations aimed at defining, conducting, assessing and financing research, data collection and systematic observation, taking into account the need to minimize duplication of effort;
(b) Support international and intergovernmental efforts to strengthen systematic

observation and national scientific and technical research capacities and capabilities, particularly in developing countries, and to promote access to, and the exchange of, data and analyses thereof obtained from areas beyond national jurisdiction; and
(c) Take into account the particular concerns and needs of developing countries and cooperate in improving their endogenous capacities and capabilities to participate in the efforts referred to in subparagraphs (a) and (b) above

### 5.3.1 Methodology

The requirements in the Reporting Guidelines are based on the needs for meteorological, atmospheric, oceanographic and terrestrial observations of the climate system as identified by the Global Climate Observing System (GCOS). The GCOS has identified a minimum set of Essential Climate Variables that is deemed essential and has elaborated a set of climate monitoring principles that countries should adhere to in developing observational networks. The Essential Climate Variables are contained in the Second Report on the Adequacy of the Global Observing Systems for Climate in support of the UNFCCC submitted by GCOS and are reproduced in **Table 5.9** while the climate monitoring principles are included in **Appendix 3**.

**Table 5.9 – Essential Climate Variables**

| Domain | Essential Climate Variables |
|---|---|
| **Atmospheric** (over land, sea and ice) | **Surface**: Air temperature, Precipitation, Air pressure, Surface radiation budget, Wind speed and direction, Water vapour.<br>**Upper-air**: Earth radiation budget (including solar irradiance), Upper-air temperature (including MSU radiances), Wind speed and direction, Water vapour, Cloud properties<br>**Composition**: Carbon dioxide, Methane, Ozone, Other long-lived GHGs, Aerosol properties |
| **Oceanic** | **Surface**: Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Current, Ocean colour (for biological activity), Carbon dioxide partial pressure<br>**Sub-surface**: Temperature, Salinity, Current, Nutrients, Carbon, Ocean tracers, Phytoplankton |
| **Terrestrial** | River discharge, Water use, Ground water, Lake levels, Snow cover, Glaciers and ice caps, permafrost and seasonally-frozen ground, Albedo, Land cover (including vegetation type) Fraction of absorbed photosynthetically active radiation (FAPAR), Leaf area index (LAI), Biomass, Fire disturbance |

As reported in the INC Phase II Report, the methodological approach consisted of an assessment of the extent to which Dominica has operationalised systems necessary to generate the Essential Climate Variables (where relevant) and the capacity needs for addressing any deficiencies that were identified.

### 5.3.2 Current Data Collection

#### 5.3.2.1 Atmospheric Variables

It should be noted at the outset that systematic observation activities in Dominica have been undertaken independent of any programming for climate change. They are more closely linked to the general commitments of the country in the field of aviation-related meteorology. Despite the above, special mention must be made of the DOMEX (Dominica Experiment) Project, which is being conducted by the Department of geology and geophysics of the Yale University. The Orographic and Precipitation in the Tropics Project aims:

- To understand the physics of mountain triggered convection and precipitation in the tropics using Dominica as a natural laboratory
- To develop data sets that can be used to test and improve numerical models of convection and precipitation in the tropics
- To better understand and predict the weather and climate of the Lesser Antilles including Guadeloupe, Dominica and Martinique.

The project will utilize a wide range of instruments including Aircraft, Satellites, Rain and weather gauges, Aerosol LIDAR, Radar, Disdrometer, Webcams, Balloon soundings and Surface Stations

### 5.3.2.1.1 Surface Variables

The meteorological offices at the Canefield and Melville Hall Airports are monitoring all of the Surface climate variables with synoptic meteorological stations, which include the following equipment, viz:10 meter tower, NEMA 4-Enclosure, Data logger with telemetry, Rainfall sensor, Wind speed & direction sensor and Barometer pressure sensor

**Photo 5.6 Climate Data Collection Equipment at the Canefield Airport**

The World Bank has supplied automatic weather stations, two of which were installed at each airport in January 2003. These stations measure the following physical parameters, viz: rainfall, pressure, air temperature, humidity, dew point, vapour, and the intensity of the rain over a given period

The stations record this information every five (5) minutes and the data is stored on tape. Backup to zip disks are done at the end of the year. Both of these stations are automated, so that the information will be collected 365 days a year, irrespective of office hours/holidays.

Data on visibility is recorded manually, and no data is collected on radiation intensity, sunshine intensity and the ultra-violet (UV) index.

**Photo 5.7 Temperature Observation at the Canefield Airport**

The data collected by the new automatic stations is sent simultaneously to the airports and the Office of Disaster Management (ODM). Neither airport operates 24 hours a day, and the ODM does not have a back up generator. This means that the receipt of the data is not always being monitored and there is potential for breaks in the data transmission should a technical problem occur while the airport is closed, or when there is a power failure affecting the ODM.

Dominica has an additional ten (10) new wireless-automatic weather stations, similar to the ones described above, which will be installed around the country in locations selected by the ODM. The data will be sent directly to the National Hurricane Centre in Miami. The data from the airports go directly to Washington, D.C.

Rainfall data are also collected by other agencies at points other than the airports. These agencies are:

- DOMLEC - collects rainfall data using three (3) manual rain gauges. They collect the data daily in some cases and thrice weekly in others in the following locations - Fresh Water Lake, Laudat Power Station and Trafalgar Power Station.

- The Forestry, Wildlife and Parks Division collects rainfall data manually each day at six (6) stations and records the data on a weekly sheet, which is sent to their office. The data is compiled on a monthly and yearly basis in six (6) locations. The data is recorded manually and sent to the Division of Agriculture on a monthly basis.

- The DOMEX Project which began in 1997 and is expected to run until 2011 , has installed 10 rain gauges, satellite linked weather stations, webcams, disdrometer and an Aerosol LIDAR as part of a research on “Orographic Precipitation in the Tropics” being conducted by the department of Geology and Geographics of the Yale University. http://domex2011.com

- The Division of Agriculture collects rainfall data at fourteen (14) locations throughout Dominica. This is done manually at this time, but the Division has recently taken possession of six (6) new portable Davis Vantage Pro 6160 wireless weather stations which should be in operation by December 2004. These stations are portable and the Department of Agriculture plans to use them to help the farmers determine the best time to plant crops/best type of crop to plant and best location for a given crop. The stations measure the following, viz:

- Rain fall data
- Temperature
- Amount of light
- UV
- Wind Speed & Direction

#### 5.3.2.1.2 Upper-Air Variables

During the intensive 5 week phase of the DOMEX Project 20 –four hour missions were flown over Dominica using a fully instrumented research aircraft., to investigate the details of upstream trade wind airflow, the airflow distortion around mountains, the generation of precipitation over Dominica and the changed airflow in the lee. Beside this Project which ended in May of 2011, , none of these variables are being monitored in Dominica.

#### 5.3.2.1.3Composition

An Aerosol LIDAR installed for use in the DOMEX Project was used to measure atmospheric Aerosol components. Besides this specific project which ended in May 2011, other variables are not being monitored in Dominica.

### 5.3.3 Oceanic Variables

These essential climate variables are not currently being monitored in Dominica. A sea level monitoring station was installed at the Coast Guard Base as part of the CPACC project. It was destroyed during Hurricane Lenny in 1999 and has not been replaced. The location of the data collected in unknown.

A tidal station at the Fisheries Development Division was also destroyed by Hurricane Lenny and has not been replaced. All the data accumulated during it operational period has been lost.

The Fisheries Development Division is involved in ongoing measurements of the shallow submarine hydrothermal vents in the Soufriere/Scotts Head Marine Reserve (SSMR). This data is being collected as a part of a PhD thesis for a group of students from IECB University of Vienna who are having the data forwarded to an overseas company for retrieval and downloading of information. The Division would like to be a major stakeholder and integral player in climate change issues, in particular sea level rise issues, and has just appointed an officer who will be responsible for climate change matters as related to fisheries. It is in the process of assessing its needs in this respect and has identified an automatic tidal station as high on its list of priorities.

### 5.3.4 Terrestrial Variables

#### 5.3.4.1 River Discharge-Water Use and Ground Water Level

The freshwater resources in Dominica come from ten (10) major watersheds and their accompanying river basins and there is a need for the river discharge-water level, flow rate, water quality, and the like to be measured in each of the major watersheds.

River discharge is measured in Dominica by DOWASCO in one (1) river. Other than that, no other measurements are being taken or recorded.

DOWASCO tests the water quality on a daily basis at its in-house laboratory for Bacteriological analysis, CL2 residual, Total Coliform, Faecal coliform and E-Coli. The physical parameters are: Temperature, pH, Conductivity, Turbidity. The chemical parameters are: Aluminum, , Copper, Ammonia, Manganese, Iron, Chloride, Sulphate, Sulphide, Nitrite, Nitrate, Orthophosphate, Total hardness, Total solids and Total dissolved solids .They occasionally measure the river flow using a flow velocity meter, but do not measure the level of the lakes, or test the water quality of the lakes.

DOMLEC measures the level of the freshwater lake on a periodic basis (March-June-dry season) and the water heights in the areas around the hydroelectric headworks.

#### 5.3.4.2 Land Cover

Land Cover is monitored by the field staff of the Lands and Surveys Division and the Forestry, Wild Life and Parks Division. There is limited monitoring of land cover via aerial photographs. The last one was done in 1992.

The Physical Planning Department has a Geographic Information System (GIS) mapping system that was donated by the Canadian Government in 1994. However due to the lack of funds from government, the GIS programme has been inactive. The European Union will be providing funding for Land Use Planning and Environmental Management to strengthening the Physical Planning Department, the formulation of a land use policy, administration and development control activities, and putting in place appropriate legislation. However the funds do not cover long-term training for human resources, in the context where the department has identified an urgent need for one person to be trained in GIS.

#### 5.3.4.3 Fire Disturbances

The Dominica Fire and Ambulance Services is responsible for monitoring and responding to wild land fires. The brush fire season in Dominica usua1ly coincides with the “dry” season, with the greatest amount of activity occurring in the months of March through May. The majority of the wild land fires occurring in Dominica can be classed as ‘brush” fires, with few true forest fires per se.

The available data shows that there has been an increase in the number of fires responded to in recent years **– Table 5.10**.

**Table 5.10 - Wild Land Fires**

| YEAR | 1981/85 | 1986/1990 | 1991/1995 | 1996/2000 | 2001/2003 |
|---|---|---|---|---|---|
| **Av. # Fires** | 103 | 106 | 141 | 140 | 159 |

*Source: Dominica and Fire Ambulance Services*

An analysis of the years when the most fires and least fires were responded to, highlighted two factors as the common denominators – the amount and distribution of rainfall, coupled with vegetation type, are a1ways intimately connected to the risk and eventual occurrence of brush / forest fires.

Ninety-eight per cent (98%) of all brush fires responded to by the Dominica Fire Department are those involving plant species prone to fires during the dry months. Additionally, the years when less rainfall was recorded are those when the most fires *are* responded to.

In 1999, the Forestry, Wild Life and Parks Division performed a reconnaissance survey in the southern part of Dominica (from Loubriere in the south to Salisbury in the North) to assess the effects of the bush fires on lowland vegetation at an elevation ranging from sea level to about 800 ft above sea level. The public threat from the bush fires was so low due to the remote location of the fires that no other action was taken.

### 5.3.5 Summary

The data being collected in Dominica is inadequate to support monitoring of climate change trends in Dominica. There is no data collection and monitoring of critical variables like sea levels and emissions of greenhouse gases, including carbon dioxide and methane. Most of the data collected relate to atmospheric surface variables and the collection is not comprehensive. Most of the data collection is limited to the airports, with precipitation being the only variable that is collected in other parts of the island. However, the distribution of the collection points have not been rationalized, with the result that even this data does not provide a comprehensive picture of precipitation in Dominica.

### 5.3.6 . Deficiencies of Systematic Observation Capabilities

#### 5.3.6.1 Equipment

Dominica has a mixed bag of equipment. Each department has purchased or has been given different types of equipment, none of which is compatible with the others' systems.

The ODM and the Meteorological Office have a total of thirteen (13) new automatic weather stations, which can collect and store the data digitally and operate twenty four (24) hours a day, seven (7) days a week. However, only four (4) automatic stations are currently in operation (two (2) at each airport). The remaining nine (9) units will be installed when the human and financial resources are available for additional cable and personnel. *These additional stations represent an opportunity to rationalize data collection across the island to provide a comprehensive picture for the variables being monitored.*

#### 5.3.6.2 Data Storage

Data storage by the various stakeholders is done both manually and digitally viz:

- The Forestry Department stores the rainfall, wind speed and direction data manually and is in the process of converting the monthly records to a digital format.
- The Meteorology Office stores the wind speed and direction, air temperature, due point, pressure, and vapour and rainfall data digitally.
- DOMLEC stores the rainfall data both digitally and manually.
- DOWASCO stores the rainfall data both digitally and manually.
- The Department of Agriculture stores the rainfall, wind speed and direction data manually.
- The Fisheries Division stored the data tide range both digitally and manually.
- The Office of Disaster Management stores the rainfall, wind speed & direction, air temperature, due point, pressure, vapour, and UV data digitally.
- Data obtained under the DOMEX Project including a list of publications can be obtained at the project website: http://domex2011.com

#### 5.3.6.3 . Human Resources Capabilities

The Meteorological Offices and the ODM lack the full complement of personnel necessary to collect data 365 day per year.

#### 5.3.6.4 Institutional Capacity

Dominica lacks a significant institutional capacity to carry out its responsibilities and obligations. At present, each of the stakeholders is “doing their own thing”. There is no central clearinghouse for the data and no central purchasing office for equipment. Several government departments are monitoring for rainfall-wind speed and direction in basically the same area, whilst a large section of Dominica has no records or history of rainfall data. If there was better sharing of information and coordination there would not be any duplication of effort and the existing human resources could possibly cover the entire country. Both time and money would be saved and the coverage could be extended to weekends and holidays.

Currently all the stakeholders in Dominica are facing the same problems, viz:

- Lack of funds;

- Lack of trained personnel; and

- Broken equipment/no equipment.

The most pressing need in Dominica is for all the stakeholders to sit down and discuss their equipment and manpower needs, and decide on an institutional protocol for collection, storage, dissemination and submission of climate-related data to the appropriate users.

Consideration has to be given to the role of the Environmental Coordinating Unit in this process, as the principal institutional responsibilities for climate change related issues in Dominica rests with that Unit . It serves as the main national implementing agency for most of the major international environmental conventions working with partner ministries and organizations to promote the awareness and adoption of the various provisions and approaches embodied in international environmental agreements, including the UNFCCC. However the ECU does NOT have the legal authority (legislative mandate) giving it jurisdiction for developing, maintaining and disseminating climate change data in the Commonwealth of Dominica.

Consideration also has to be given to the role and function of the meteorological services. There is an ongoing demand for meteorological information for a variety of uses – aviation, disaster management, agriculture, water supply, hydroelectric power, and climate change monitoring – that cannot be supplied by the current aviation-focused service.

There is also a need to develop and/or strengthen the working relationship with the private sector - especially DOMLEC and DOWASCO - in the gathering and sharing of climate change related information.

## 5.4 EDUCATION, TRAINING AND PUBLIC AWARENESS

Non-Annex I Parties are invited to provide information on activities relating to climate change education, training and public awareness. Article 6 : Education, Training and Public Awareness of the Convention specifically outlines the responsibilities that signatory governments must realize in order to fulfill their commitment in regards to informing on and promoting knowledge of climate change. Implementation of a public awareness programme will facilitate greater participation in climate change reduction and will be in compliance with the Commonwealth of Dominica's obligations as a signatory to the Convention.

An effective public awareness campaign on climate change in Dominica should have the following objectives:

- Inform and educate to increase knowledge on the anthropogenic causes of climate change
- Inform and educate to increase knowledge on the effects of climate change

- Inform and educate to increase knowledge on the individual and collective responsibilities required for mitigation of climate change through the reduction of the GHGs
- Inform and educate to increase knowledge on the individual and collective responsibilities required for adaptation to climate change

### 5.4.1 Tools for Mass Awareness

Much has been written about public awareness and education on climate change. The first and foremost step in regard to education, training and public awareness is to develop a process nationally and regionally to prepare teaching materials that impart education, training and create public awareness. This has to be done under a multi-tier approach.

The International Panel on Climate Change (IPCC) and other United Nations organizations have over the years brought out considerable scientific and response strategy materials on the science of climate change, its effects and adaptation. Such materials are however only for a very limited number of knowledgeable professionals who are benefited from this type of literature and research materials.

Chatterjee (2003) describes the six important tools which are necessary in order to achieve an effective public awareness programme. Due to their relevance , these are recommended for use in in order to fully engage the Dominican population;

#### *5.4.1.1 Tool I: For Civil Society*

Preparation of materials on climate change for the use and consumption of the common man, civil society, community (particularly for students at different levels of school education).

***For Dominica*:**

It will be necessary to make full use of mass media such as newspapers, periodicals, and radio and television products to disseminate knowledge of climate change to stakeholders in all walks of life; advocating not just sustainable life style which includes electricity-saving, water-saving, garbage classification, reduction, recycling and reuse, but also the consumption and use of locally produced food and goods.

A primer on climate change in Dominica will be written that clearly identifies the short and long term results of climate change. This and a synopsis written in vernacular of the average Dominican of the Initial National Communication of 2001, Policy on Adaption of Climate Change, Phase 2 Climate Change Report and Climate Change Convention should be provided to each of the country’s newspapers, radio host, and television news reporters. This document should be broken into chapters that are no longer than 5 pages per chapter. This will facilitate their accessibility.

Weekly tip and/or fact sheets on sustainable life styles produced by the Environmental Coordinating Unit should be issued to the media houses with the expectation they will publish the tips each week either through weekly columns in their papers or through plugs on the radio at regularly scheduled days and times.

Lastly, a video documentary should be produced for broadcast on the local television channel and in schools and at seminars that are held in the name of climate change. Much footage already exists. It would be the matter of obtaining and editing the existing footage. Some new footage would be needed as well as interviews. This documentary if done well could do much in the way informing the Dominican public and making the international local.

#### *5.4.1.2 Tool II: For School Curriculum*

There is a need to bring out small books on "What is Climate Change"; "How it affects our life - our economic prosperity and our health and other welfare"; and "How all of us together can save the environment for our benefit and for our future generations". These materials have to be in simple language that people understand as well as to introduce such an education as a part of school curriculum in primary, middle and at higher levels.

*For Dominica*:

Incorporating climate change publicity and education into the framework of basic education is an important component of Dominica's overall quality education;

The lessons plans should be packaged and disseminated through the Ministry of Education. The dissemination of the curriculum should be conducted through a contest for the class which conducts the most effective climate change related project. For example, a class might decide to plant trees on a river bank to prevent erosion after completing the curriculum.

#### *5.4.1.3 Tool III: Through a Participatory Process*

To bring out small books and literature through a participatory process with the community that would provide linkages to their day to day life, their life style and how traditional knowledge of the common people can be integrated to some simple responses to climate change. Such books and literature must be written in the language and vocabulary they would easily understand with illustrations they are familiar with. This is a huge task but must be done with an urgency to impress upon the people how their actions today may not only help their present generation, but also the future generations, for a better and cleaner environment.

*For Dominica:*

Engage rural villages in multi-week workshops using popular theater techniques where participants are given the literature and educated as to climate change. During workshop time participants work to create skits that reflect the effects of climate change in their lives and the ways that villagers contribute to its detrimental effects or the ways they work to prevent climate change in their environment. The workshops would culminate in a showcase of all participating villages that would be videoed and edited for local television.

#### *5.4.1.4 Tool IV: For Policy Makers*

The next tier of activities should be to involve middle level and higher level of policy makers, decision makers, planners at the national and regional level to educate and train such categories of people on climate change. The idea is to enable them to integrate climate change concerns in all national and regional activities so that all our development activities are sustainable and would finally address to the main agenda of the developing countries - Poverty eradication and better quality of life for all.

*For Dominica*

Fully utilizing the promotional function of the government will be necessary. All levels of government should regard raising public awareness as an important work to address climate change and carry it out with care. For this purpose, Dominica will take various measures to promote climate change awareness with all level of government officials and decision-makers of enterprises and institutions.

The same summary of the documents to be presented to local media houses in Tool I will be distributed to all ministers and permanent secretaries. Their documents should also include a disk with each of the full documents on it in order for them to reference the documents on a whole. They should also be provided a copy of the documentary on climate change in Dominica.

The Environmental Coordinating Unit will formulate an idea paper for each ministerial department that itemizes functions in which the Environmental Coordinating Unit foresees that particular department committing to in order to achieve a reduction in their contribution to global warming.

The Environmental Coordinating Unit will also present each ministerial department with the recommendations on creating and adopting policy which considers the effects of climate change. For example, the housing department would receive the Climate Change Policy Adaption that relates specifically to the housing sector. The recommendations would contain the specific policies that need to be revisited and any areas where new policy must be written.

Government wide seminars would also be conducted. See Tool V.

#### *5.4.1.5 Tool V: By Organizing Workshops and Seminars*

District level, national level and regional level workshops and seminars should also be organized at regular intervals for faster dissemination and exchange of information among various groups and categories of people, communities, civil societies etc. Such a process will accelerate the process of education and training for officials, professionals and schoolteachers to update and exchange their knowledge and experiences.

*For Dominica*

Holding various thematic training seminars targeting different audiences and organizing different workshops on both popular and professional climate change science will be advantageous. On a ministerial level, the Environmental Coordinating Unit will liaise with each ministry to execute a half-day seminar to educate the stakeholders on the climate change initiatives the ministry will be undertaking and adjustments that may need to be made.

Specifically, within the Ministry of Education, several half-day seminars will occur in each of the districts to educate district education officers, principles and key teachers on the dissemination of climate change lesson plans and the coordination of the project contest for classrooms.

In communities where policy change will drastically alter their landscape or quality of life, seminars will be facilitated by representatives of the Environmental Coordinating Unit to fully explain the situation and address concerns and questions. Public Sector stakeholders will be connected to the campaign through workshops designed to inform them of the campaign that is taking place and the shifts in policy that will affect them both directly and indirectly.

It is important to note that no mention of the use of a web site has been made. This is not an over site. Rather it is a reflection of the realities of Dominica. With a total population of only 70,000 and less than half of that population having regular internet access, the designing and maintenance of web site is not seen as a viable option for disseminating information to the average Dominican.

#### *5.4.1.6 Tool VI: Taking the help of Communication Media*

Education, training and public awareness must also take advantage of all communication media like local newspapers, simple fact sheets, television, radio, village dramas, street plays etc.

According to Chattejees(2003) measuring the success of the ETPA Programme in each country must be done systematically by means of several indicators for the society at different levels like the Government level, Business sector level, Community level, Local level (e.g. school level) and at the Individual level. Some of the indicators for measuring the success of an education, training and public awareness programme include the following:

- Measuring improvement of general public awareness on climate change as a percentage of the total population;
- Measuring the increase in awareness on climate change among civil society, policy makers, regulators, industries;
- Climate change introduced in the lower, middle and high school curriculum;
- Proportion of land area covered by forests and land area protected for biological diversity;
- Per capita Carbon dioxide emissions;
- GDP per unit of energy use;

- Proportion of population with sustainable access to an improved water source and safe water

**5.4.2 Responsibilities Institution**

This model of Education, Training and Public Awareness on Climate Change will certainly yield the desired results if it is implemented and monitored appropriately by the Environmental Coordinating Unit and given the appropriate level of support at the Government level; primary, high schools level; and community level. Furthermore, all walks of life of the society will be fully employed to disseminate Dominica's efforts and policies for response to climate change and to promote public awareness of climate change.

Public Education and Awareness is addressed in the commonwealth of Dominica's' Policy on Adaptation to Climate Change. **Table 5.11** provides a summary of the approved P and A for the Dominica's priority sectors identified as most vulnerable to climate change.

**Table5.11Summary of Approved Public Awareness Activities for Vulnerable Sectors**

| **Sector** | **Strategy and Actions** | **Rational** | **Priority** | **Time frame** | **Resource Needs** | **Remarks** | **Institutions** |
|---|---|---|---|---|---|---|---|
| **Coastal Zone** | Development and implementation of a coordinated public education and awareness campaign on coastal resources | To sensitize society at all levels on the impacts of climate change on coastal resources | Very High | Short-term | Financial Human Equipment | Opportunities exist locally for mass dissemina- tion of public awareness material. Deficiency in production of relevant material for broadcasting | Media houses, GIS, ECU, Fisheries Div., Forestry Div. Physical Plan-ning, Disaster Management Unit, DAIC, Min. of Educa- tion, Min. of Agriculture, and Community Development, DHTA |
| **Human Settlement** | Development and implementation of integrated, sustained and coordinated public education and awareness program regarding human settlement | To sensitize the general public as to the impacts of climate change | Very High | Short-term | Financial Human Equipment | Opportunities exist locally, for mass dissemina- tion of public awareness material. Deficiency in production of relevant material for broadcasting | Assoc. of Architects, Physical Planning, Media houses, GIS, ECU, Fisheries Div., Forestry Div. |
| **Water Resources** | Development and implementation of integrated and coordinated public education awareness program with emphasis on water conservation | To sensitize society at all levels on the impacts of climate change | Very High | Short-term | Financial Human Equipment | Opportunities exist locally for mass dissemina- tion of public awareness material. Deficiency in production of relevant material for broadcasting | Media houses, GIS, ECU, Fisheries Div., Forestry Div. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Agriculture** | Development and implementation of a coordinated public education and awareness campaign on agriculture | To sensitize society and farmers in particular on the impacts of climate change on agriculture | Very High | Short-term | Financial Human | Opportunities exist locally for mass dissemina- tion of public awareness material. Deficiency in production of relevant material for broadcasting | Media houses, GIS, ECU, Fisheries Div., Forestry Div. Physical Plan-ning, Disaster Management Unit, DAIC, Min. of Educa-tion, Min. of Agriculture, and Community Development, DHTA, NGOs |
| **Forestry and other terrestral Resources** | Implementation of acoordinated public education and awareness campaign on forestry and other terrestrial resources | To sensitize society at all levels on the impacts of climate change on Forestry, and its impacts on sinks | Very High | Short-term | Financial Human Equipment | Opportunities exist locally for mass dissemina- tion of public awareness material. Deficiency in production of relevant material for broadcasting | Media houses, GIS, ECU, Fisheries Div., Forestry Div. |
| **Fisheries** | Development and implementation of a coordinated public education and awareness campaign on marine resources | To sensitize society at all levels on and fishers in particular on the impacts of climate change | Very High | Short-term | Financial Human | Opportunities exist locally for mass dissemina- tion of public awareness material. Deficiency in production of relevant material for broadcasting | Media houses, GIS, ECU, Fisheries Div., Forestry Div. Physical Plan-ning, Disaster Management Unit, DAIC, Min. of Educa-tion, Min. of Agriculture, Community Development, Hotel Assoc. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Tourism** | Development and implementation of a coordinated public education and awareness campaign on tourism | To sensitize society at all levels of the impacts of climate change | Very High | Short-term | Financial Human Equipment | Opportunities exist locally for mass dissemina- tion of public awareness material. Deficiency in production of relevant material for broadcasting | Media houses, GIS, ECU, Fisheries Div., Forestry Div. Physical Plan-ning, Disaster Management Unit, DAIC, Min. of Educa- tion, Min. of Agriculture, Community Development, Hotel Assoc. |
| **Human Health** | Development and implementation of a coordinated public education and aware-ness campaign on health matters | To sensitize society at all levels on the impacts of climate change on human health | Very High | Short-term | Financial Human Equipment | Opportunities exist locally for mass dissemina- tion of public awareness material. Deficiency in production of relevant material for broadcasting | Media houses, GIS, ECU, Fisheries Div., Forestry Div. Physical Plan-ning, Disaster Management Unit, DAIC, Min. of Educa- tion, Min. of Agriculture, and Community Development, DHTA |
| **Financial Sector** | Development and implementation of integrated and coordinated public education and awareness program | To sensitize the general public, and the financial sector in particular, to the impacts of climate change | Very High | Short-term | Financial Human Equipment | Opportunities exist locally for mass dissemina- tion of public awareness material. Deficiency in production of relevant material for broadcasting | Media houses, GIS, ECU, Fisheries Div., Forestry Div. Physical Plan-ning, Disaster Management Unit, DAIC, Min. of Educa- tion, Min. of Agriculture, and Community Development, DHTA |

Source: Commonwealth of Dominica's' Policy on Adaptation to Climate Change

## 5.5. CAPACITY-BUILDING

Non-Annex I Parties are encouraged to provide, in accordance with decision 2/CP.7, information on how capacity-building activities, as contained in the framework annexed to that decision, are being implemented at national and, where appropriate, at sub regional and/or regional levels. This could include, inter alia, options and priorities for capacity-building, participation in and promotion of South-South cooperation, the involvement of stakeholders in capacity-building, coordination and sustainability of capacity-building activities, and the dissemination and sharing of information on capacity building activities. Activities conducted and currently being implemented includes the following:

### 5.5.1 Climate Change Adaptation Policy

In 2002 following the preparation, approval and submission of the Initial National Communication to the COP, the Government of Dominica as part of its commitment to the obligation of the Convention developed and adopted a National Climate Change Adaptation Policy which was adopted by the Cabinet in 2002. The aim of the National Climate Change Adaptation Policy is to foster and guide a national plan of action, formulated in a coordinated and holistic manner, to address short, medium and long term effects of Climate Change, ensuring to the greatest extent possible that the quality of life of the people of Dominica and opportunities for sustainable development are not compromised.

The objectives of this policy are to:

1. Foster the development of processes, plans, and strategies to:
    - Avoid, minimize, adapt, or mitigate to the negative impacts of climate change on Dominica’s natural environment including ecosystems, ecological processes, biotic resources, lands and water;
    - Avoid, minimize or respond to the negative impacts of climate change on economic activities;
    - Reduce or avoid damage to human settlements and infrastructure resulting from climate change;
    - Avoid or minimize the negative impacts of Climate Change on human health;
    - Improve knowledge and understanding of Climate Change issues;
    - Conduct systematic research and observation on Climate Change issues.
    - Explore and access opportunities being developed through negotiations on climate change issues and related matters to meet the development objectives of the country.
2. Foster the development and enforcement mechanisms for appropriate and innovative legislative and regulatory instruments, which will promote effective implementation.
3. Foster the development of appropriate institutional systems and management mechanisms to ensure effective planning for and responses to Climate Change.
4. Foster the development of appropriate economic incentives to encourage public and private sector adaptation measures.
5. Establish and institutionalize a National Climate Change Committee.

This National Climate Change Adaptation Policy include provisions “to foster the development of processes, plans and strategies to avoid, minimize, adapt or mitigate to the negative impacts of climate change on Dominica’s natural environment … on economic activities …to human settlements and infrastructure …on human health …”. It also contains a listing of Policy Directives for a range of socio-economic sectors including Coastal and Marine Resources, Agriculture, Human Settlements, Forestry and Terrestrial Resources, Water Resources, Health, Tourism, and the Financial Sector.

The policy is intended to guide the work of all Governmental, Statutory, Non-governmental and Civil entities which are involved in or which may seek to become involved in addressing Climate Change issues and their impacts in Dominica. Responsibility for its implementation has been assigned to the Ministry of Agriculture and the Environment through the ECU.

The Policy also includes a provision for a public review to determine its effectiveness, which should be conducted on its fifth anniversary.

### 5.5.2 Initial National Communication Phase II Enabling Activity Project

Another important project conducted in recognition of its commitments as a signatory to the convention is the Phase II Enabling Activity. This is a capacity building project intended to build upon the activities completed in the context of Dominica’s INC. The overall goal is to allow Dominica to extend current knowledge to facilitate the emergence of national networks and promote the integration of climate change concerns in the developing national dialogue. The project was implemented in 2002 and was designed to generate the following outputs:

- Identification and submission of technology needs;
- Capacity building to assess technology needs, modalities to acquire them and absorb them, design, evaluate and host projects;
- Capacity building for participation in Systematic Observation networks; and
- Preparation of programs to address climate change improvement of emission factors.

**Summary of Capacity Needs**

In implementing the Project it was realized that that Dominica has significant capacity deficiencies in each of the thematic areas reviewed – Technology Needs, Systematic Observation Networks and Improvement in GHG Emission factors. It has also shown that the current economic constraints limit the extent to which the Government can aggressively respond to these capacity deficiencies. What is therefore needed is for Dominica to begin to address those issues that are feasible within its present constraints, while seeking the assistance of the international community in addressing the other more complex issues.

It must be noted however that, notwithstanding the provisions of the UNFCCC, financing for the implementation of technology needs and systematic observation projects remain virtually non-existent. This suggests the need for enabling type activities that can catalyze private sector, community and other resources towards collaborative implementation with public and private sector stakeholders in implementing climate change adaptation and mitigation related policies and measures.

In this context, it is significant to note that there are two (2) cross-cutting issues that have emerged from the thematic analyses, and which are deemed fundamental to the success of any climate change programming in Dominica. These are:

- The need for an Institutional Framework, wherein the responsibilities are clearly identified and within which the lead institution(s) have the mandate to perform.

- Public and stakeholder education and awareness, to extend beyond general awareness raising activities, into the realm of targeted sectoral activities, aimed at sensitizing specific sectors of the threats from climate change to their operations and soliciting their participation in responding to the problem of climate change.

These issues should receive priority attention in any program of capacity development as their implementation can provide a "jump-start" to other activities.

At the thematic level, priority actions include the following:

- *Technology Needs* – Increase in use of renewable energy to retain Dominica's status as a net GHG sink.

- *Systematic Observation* – Rationalisation of meteorology services to satisfy needs for meteorological information and upgrading of basic data collection.

- *Greenhouse Gas Emissions* – Improving capabilities to accurately monitor GHG emissions.

### 5.5.3 National Capacity Self Assessment (NCSA)

The Government of Dominica secured assistance from the GEF and UNEP to undertake a NCSA for Global Environmental Management". This process commenced in Dominica in January 2004 and was completed in July 2005. It focused on three thematic areas, Land Degradation, Biodiversity and Climate Change.

The NCSA process provided Dominica with the opportunity to conduct a thorough assessment of the capacity needs and constraints facing national efforts to improve environmental conservation and sustainable development programmes, and to meet global environmental management obligations as set forth in the Rio Conventions and related regional and international instruments.

The NCSA process analyzed the institutional capacity framework that was initiated under the UNFCCC and the strategies put in place to conserve biodiversity in Dominica as outlined in Dominica's NBSAP, and facilitate the identification of management strategies relevant to the environmental and sustainable development. More specifically, the project was intended to:

a) determine capacity needs with a view to implementing the overall national environmental objectives of the Ministry of Agriculture and the Environment at the individual, institutional and systemic levels;

b) assess the capacity of the ECU to coordinate issues of sustainable development and to give support and guidance relevant to needs of the respective ministries, agencies and parties;

c) review and test national mechanisms for stakeholder participation;

d) identify conflicts and strengthen synergies among multi-lateral environmental agreements (UNCCD, UNCBD, UNFCCC), and among the stakeholders and ministries implementing activities under these agreements;

e) assess the institutional capacity of the various Divisions within the Ministry of Agriculture and the Environment and other Ministries to respond to the sustainable development objectives as required in the UNCBD, UNCCD and UNFCCC communications;

f) develop a framework to facilitate accessing and preparation of future requests for external funding and assistance.

The NCSA process in Dominica has determined that the human and institutional resources required to optimize environmental management are currently not in place. To compound this problem, at present there is no holistic institutional system, with adequate structures and mechanisms, in place for environmental management in Dominica. Instead, there is fragmentation and duplication, without any clear delineation of roles and responsibilities. Currently, there is little real and meaningful consultation between the various bodies involved in environmental management. Meaningful consultation means that each entity not only knows what the others are doing, but also that the impact of actions in each area is assessed and evaluated before any actions are taken. Therefore, the effective establishment of an effective environmental management framework that will, amongst other national priorities, provide for the implementation of the Rio Conventions will require -

- the establishment and strengthening of linkages and networking between the institutions involved in environmental management;
- the strengthening of institutions and organizations that have key mandates and responsibilities for environmental management, most notably the ECU, the National Parks Unit, and the Physical Planning Unit;
- the establishment of a coastal zone managmement institutional capacity; and
- the engagement of stakeholders for meaningful collaboration and consultation on environmental management.

#### 5.5.3.1 NCSA Strategy and Action Plan

At the completion of the public review process, a final national workshop was convened to evaluate comments arising from the public review of this Report in order to promote discussion and obtain consensus on a Strategy and Action Plan to implement recommendations based on the outputs from the various stages of the NCSA process. The assessment of these issues was undertaken with the view of identifying inadequate existing legislation and policy, overlaps in legislation and institutional mandates, and ways of harmonizing laws and regulations to provide a more efficient legal and policy framework. This initial report was presented to a broad stakeholder group at a national workshop with policy makers in the key ministries and organizations. The results of this work, and its review at the workshop, formed the basis for the development of this NCSA Strategy and Action Plan, which has been submitted to the Government of the Commonwealth of Dominica for approval.

Dominica's Final NCSA Strategy and Action Plan contains a summary of these assessments that addresses, amongst other matters:

- the lack of formal institutional mechanisms for coordinated action or information sharing among government resource management agencies (either bilateral or multi-institutional);
- unclear and often overlapping institutional mandates (e.g. mangroves are the responsibility of both forestry and fisheries divisions);
- policies of the international agencies currently providing financial assistance to the country are sometimes in contradiction of environmental goals or government priorities, and often conflict with one another;
- monitoring and enforcement of environmental laws and regulations is inadequate, because of lack of resources, incomplete laws and regulations, and lack of cooperation and support of the police and judiciary;
- and finally, environmental laws are not binding on government activities (e.g. government projects do not have to perform environmental impact assessments), which limits the capacity to manage resources sustainably or to generate public support for conservation.

### 5.5.4 Dominica’s Climate Change RAF Concepts Paper

Dominica’s plans to address climate change are also articulated in its CC Concept Paper which was developed and submitted to the GEF for consideration under its RAF allocations. In the GEF 4 Programme a new RAF modality for financing Biodiversity Conservation and Climate Change Projects was initiated.
Projects financing: The RAF provides few countries with individual allocations while others, being part of group allocation, would still have a minimum amount of resources available under the biodiversity and climate change focal areas. In addition, resources would be available under the non-RAF focal areas of adaptation to climate change, international waters and persistent organic pollutants. Dominica’s climate change related activities proposed to the GEf are summarized in Table 5.12

**Table 5.12 Proposed Climate Change Activities for Climate Change RAF**

| Threats | Proposed Solutions | Outcomes |
|---|---|---|
| • Increasing GHG emissions due to growing energy demands supplied mainly by fossil fuel generation | • Promote the development and expansion of renewable energy resources (solar, photovoltaic, wind, geothermal, hydro)<br>• Promotion of public transportation initiatives | • Decrease in GHG emissions<br>• Reduction in pollution<br>• Enhanced economic development through the reduction of importation of fossil fuel |
| • Splintered and independent public sector meteorological data collection agencies | • Rationalization and consolidation of the meteorological services | • Maximization of the use of resources available for the collection, analysis and use of meteorological information |
| | | |
| • Lack of resources for community participation in sustainable energy generation initiatives | • Provide appropriate technological transfer and financing to encourage community participation | • A greener, healthier country with a robust economy through the effort of grassroots sustainable environmental management by utilizing alternative energy resources |
| • Limited knowledge of Dominica's renewable energy resources and potential | • Feasibility study on the potential, sources and economic viability of alternative energy | • Financing plan for GHG mitigation integrated thermal energy replacement and renewable energy development programmes |
| • Inaccurate and infrequent GHG inventories | • Conduct more frequent and accurate GHG Inventories | • More accurate data available for the compilation of GHG inventories in the targeted sectors – Land Use, Land Use Change and Forestry, Road Transport, Electricity Generation, Bitumen and Solid Waste |
| • Negative social practices resulting increasing vulnerability to climate change is increasing | • Increase information dissemination for climate change mitigation | • Increased awareness of climate change among senior technical and managerial level policy makers in public and private sectors |
| • Limited technical capabilities | • Conduct training in proper communication skills in regards to climate change related issues | • Increased capacity knowledge of selected target groups (e.g. farmers, schools, media, disaster response personnel, building contractors) |
| • Inadequate access to information technologies | • Improve access to appropriate technology through technological transfer | • Increased availability of information on climate change relevant technology through establishment of virtual and on-the-ground climate change information centers |
| • Inadequate instrumentation for measuring climate | • Improved systematic observation capabilities | • More reliable meteorological information for a variety of uses – aviation, disaster management, |

| Threats | Proposed Solutions | Outcomes |
|---|---|---|
| parameters | | agriculture, water supply, hydroelectric power and climate change monitoring |
| • Lack of trained personnel/ Lack of human capacity | • Development of human resources capabilities through training programmes<br>• Training in data collection and analysis for personnel in targeted sectors | • If there is better sharing of information and coordination there would not be any duplication of effort and the existing human resources could possibly cover the entire country. Both time and money would be saved.<br>• An improved capacity for database development and maintenance |
| • Indiscriminate burning of forests and grasslands during the dry season | • Implementation of a rehabilitation /reforestation initiative to increase acreages of forest trees | • Reduction of the seasonal emission of GHG and resulting rehabilitation of forest sink areas |
| • Unregulated importation of cheaper diesel fuel and its higher carbon content and vehicular emissions | • Introduction of vehicular emissions testing programme prior to the issuance of licensing certificates<br>• Regulate imports of cleaner type of fuel and the installation of converters to ensure efficient combustion | • The implementation process of vehicular testing for emission factors prior to the issuance of license. This would be based on a standardized methodology |
| • Indiscriminate waste disposal | • Implementation of a waste management system based on waste separation by types<br>• Promotion of commercial waste composting initiatives | • Better managed longer lasting dumps/landfills<br>• Reduction and controlled GHG emissions through better waste management initiatives. This would indirectly address health concerns |

### 5.5.5 Sustainable Development Plan

Dominica's Sustainable Development Plan relies heavily on projects to develop geothermal energy and other renewable energy resources (e.g., wind, PV) and alternate energy sources. These projects provide the basis for the proposed GHG mitigation measures and as such could take advantage of the UNFCCC's Kyoto Protocol. The Kyoto Protocol introduced the Clean Development Mechanism (CDM) as a trading regime such that developed (Annex 1) countries with commitments to meet GHG emission targets can implement project activities to reduce GHG emissions in developing (non-Annex 1) countries while also contributing to sustainable development. The project would earn certified emission reduction (CER) credits, each equivalent to one tonne of $CO_2$ which can be traded and sold and used by industrialized countries to meet a part of their emission reduction targets under the Kyoto Protocol.

Countries or private entities in developed countries also take part in a voluntary carbon trading market by implementing projects in developing countries and seek verifiable emissions reductions (VERs) that are outside of the Kyoto compliance regime. These VERs are also purchased in the expectation that they can be used to comply with future obligations under the successor to the Kyoto protocol.

Since no specific mention was made of carbon trading or CDM in the Sustainable Development Plan or the National Energy Policy the issue is raised here. This would allow geothermal and other renewable projects to take advantage of the CDM by registering projects with the CDM Executive Board. In order to be considered for registration, a project must first be approved by the DNA but currently Dominica does not have a DNA nor any institutions or legislation that would promote the development of carbon trading eligible projects, review and approve carbon trading projects and generally provide governance for carbon trading.

### 5.5.6 Sustainable Land Management Programme (SLM)

The Government of Dominica has secured assistance from the UNDP GEF to undertake the Capacity Building and Mainstreaming of Sustainable Land Management Project in the Commonwealth of Dominica t. The long term goal of the project is: *"ensure that agricultural, coastal, forestry and other terrestrial land and resource uses in Dominica are sustainable, thereby allowing for the maintenance of productive systems that assure ecosystem productivity and ecological functions while contributing directly to the environmental, economic and social wellbeing of the people of Dominica"*.

The overall objective of this project is *"to develop capacities for sustainable land management in appropriate government, civil society institutions and user groups, and mainstream sustainable land management considerations into government planning and strategy development"*.

The project is being conducted as part of a wider regional e UNDP/GEF LDC and SIDS targeted portfolio approach for capacity development and mainstreaming of SLM in the Caribbean. The expected outcomes of this project are consistent with those of the global portfolio project, specifically:

*Outcome 1:* SLM mainstreamed into national development policies, plans and regulatory frameworks

*Outcome 2:* individual and institutional capacities for SLM will be enhanced through
(1) stakeholder training on SLM principles through workshops, seminars and technical exchange visits,
(2) awareness raising activities around relevant national, regional, and international environmental events and (3) enhancement of national institutional structures and functions to better address SLM

*Outcome 3***:** systemic capacity building and mainstreaming of SLM principles through
(1) timely completion of high quality naps
(2) integration of SLM principles and nap
priorities into national development strategies to achieve the millennium development goals and
(3) a medium-term investment plan for SLM will be developed.

*Outcome 4:* enhanced technical support SLM planning and project execution through:
(1) dissemination and utilization of knowledge products (tools, guidelines and manuals for capacity development and mainstreaming on selected topics in SLM),
(2) Facilitation of access to global and regional knowledge networks and communities of practice, linked to existing networks, such as capnet, cpf, etc.

Joint activities are conducted with the SPACC project which is presently being implemented in Dominica.

**Photo 5.8 SLM Workshop participants conducting field activity**

### 5.5.7 Participation In Regional And International Climate Change Related Programmes

Dominica has participated in a number of regional and international programmes all geared towards its commitments as a signatory to the convention. Participation in regional programmes is important as the individual islands states by themselves do not have the required financial, institutional or human resources to confront climate change. As a result of this challenge twelve Caribbean Community countries—Antigua and Barbuda, the Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, Saint Lucia, St. Kitts and Nevis, St. Vincent and the Grenadines, and Trinidad and Tobago—have come together to build capacity in the Caribbean region for the adaptation to climate change impacts, particularly sea level rise. Regional climate change related projects implemented as a result of this collaboration include the following:

#### 5.5.7.1 Caribbean Planning For Adaptation To Climate Change (CPACC) Project http://www.caricom.org/jsp/projects/macc%20project/cpacc.jsp

In 1994, Barbados hosted the Global Conference on the Sustainable Development of Small Island Developing States. The resulting Barbados Programme of Action (BPoA) focused on sustainable development through adaptation to climate change impacts. In response to the BPoA, Caribbean governments approached the Organisation of American States (OAS) to request support for the development of regional projects aimed at building capacity to adapt to climate change.

The result was a proposal for the CPACC Project, which was submitted for funding to the Global Environment Facility (GEF). CPACC was approved and granted USD $5.6 million. The goal of the CPACC project was to build capacity in the Caribbean region for the adaptation to climate change impacts, particularly sea level rise. This was accomplished through the completion of vulnerability assessments, adaptation planning, and capacity building activities. Participating countries in CPACC included the majority of CARICOM members. These are: Antigua and Barbuda, the Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, Saint Lucia, St. Kitts and Nevis, St. Vincent, and Trinidad and Tobago.

Before completion of CPACC, the Caribbean region successfully negotiated a CAD $3.5 million grant from the Canadian Climate Change Development Fund of the Canadian International Development Agency (CIDA). This grant supported CPACC's successor, the ACCC Project.

#### 5.5.7.2 Adaptation To Climate Change In The Caribbean (ACCC) Project http://www.caricom.org/jsp/projects/macc%20project/accc.jsp

The ACCC Project succeeded the CPACC project. ACCC, which lasted from 2001 to 2004, was overseen by the World Bank, with support provided by CARICOM.

This project was designed to sustain activities initiated under CPACC and to address issues of adaptation and capacity building not undertaken by CPACC, thus further built capacity for climate change adaptation in the Caribbean region. ACCC also facilitated the transformation of the Regional Project Implementation Unit (RPIU) originally established through CPACC into a legal regional entity for climate change (the Centre). It did so by providing the resources to develop a comprehensive business plan for the Centre and a strategy to ensure its financial sustainability (as noted below).

ACCC had nine components. They were:

1. Project design and business plan development for a regional climate change centre;
2. Public education and outreach;
3. Integration of climate change into a physical planning process using a risk management approach to adaptation to climate change;
4. Strengthening of regional technical capacity, in partnership with the Caribbean Institute for Meteorology and Hydrology (CIMH), the University of the West Indies (Scenario Projection and Establishment of Climate Change Master's Programme), and the Caribbean Environmental Health Institute, in order to enhance association between Caribbean and South Pacific small island States;
5. Integration of adaptation planning in environmental assessments for national and regional development projects;
6. Implementation strategies for adaptation in the water sector;

7. Formulation of adaptation strategies to protect human health;
8. Adaptation strategies for agriculture and food; and
9. Fostering of collaboration/cooperation with non-CARICOM countries.

### 5.5.7.3 Mainstreaming Adaptation To Climate (MACC) Project http://www.caricom.org/jsp/projects/macc%20project/macc.jsp?menu=projects

The MACC Project (2004 to 2007).. MACC was implemented by the World Bank, with funding of USD $5 million from GEF. The executing agency is the CARICOM Secretariat located in Georgetown, Guyana. In-kind participants included the Government of Canada and the Government of the United States of America through the National Oceanic and Atmospheric Administration (NOAA).

The project's main objective was to mainstream climate change adaptation strategies into the sustainable development agendas of the Small Island and low-lying states of CARICOM. MACC will adopt a learning-by-doing approach to capacity building, consolidating the achievements of CPACC and ACCC. The participating countries were : Antigua and Barbuda, the Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, Saint Lucia, St. Kitts and Nevis, St. Vincent, and Trinidad and Tobago.

MACC had five major components:

1. Building capacity to identify climate change risks – Among other things, this will include strengthening networks to monitor impacts on regional climate, downscaling global climate models, and developing impact scenarios;
2. Building capacity to reduce vulnerability to climate change;
3. Building capacity to effectively access and utilize resources to minimize the costs of climate change;
4. Public education and outreach; and
5. Project management.

As MACC sought to build capacity in a cost-effective way, the expected outcomes of this project include a full set of deliverables that will be monitored and evaluated. This will contribute to the long-term sustainability of project activities and objectives, since participant countries will be able to benefit from the project even when it is completed.

### 5.5.7.4 Caribbean Community Climate Change Centre (CCCCC) http://www.caribbeanclimate.bz/

The CCCCC is an outcome of the implementation of Component 5 –Project Management, of the MACC project.

**Mission:**
The mission of the CCCCC is to support the people of the Caribbean as they address the

impact of climate variability and change on all aspects of economic development through the provision of timely forecasts and analyses of potentially hazardous impacts of both natural and man-induced climatic changes on the environment, and the development of special programmes which create opportunities for sustainable development.

The CCCCC coordinates the Caribbean region's response to climate change. Officially opened in August 2005, the Centre is the key node for information on climate change issues and on the region's response to managing and adapting to climate change in the Caribbean.

It is the official repository and clearing house for regional climate change data, providing climate change-related policy advice and guidelines to the Caribbean Community (CARICOM) Member States through the CARICOM Secretariat. In this role, the Centre is recognized by the UNFCCC, the UNEP, and other international agencies as the focal point for climate change issues in the Caribbean. It has also been recognised by the United Nations Institute for Training and Research (UNITAR) as a Centre of Excellence, one of an elite few. This reputation is a major honour for the Centre, and it should be a great source of pride for the people of the Caribbean as well.

#### 5.5.7.5 Special Program on Adaptation to Climate Change (SPACC)

On October 3, 2006, a Grant Agreement was signed between the World Bank, acting as the implementing agency for the GEF, and the CCCCC, acting as the executing agency, for the implementation of the SPACC: Implementation of Adaptation Measures in Coastal Zones (SPACC) Project. The four-year project became effective on 1 February 2007 and will be completed by 31 January 2011.

The main objective of the project is to support efforts by Dominica, Saint Lucia and St. Vincent and the Grenadines to implement specific (integrated) pilot adaptation measures addressing the impacts of climate change on the natural resource base of the region, focused on biodiversity and land degradation along coastal and near-coastal areas.

Listed activities for implementation in Dominica include the following:

**Morne Diablotin National Park and its Neighboring Communities**

(i) **Developing a park management plan** consistent with the land use plan of adjoining buffers areas that will protect biodiversity of global importance, incorporating climate change considerations (such as modifications in rainfall patterns temperature increases and changes in ecosystems composition), and corresponding enforcement strategy adopted by the community and to be implemented with the community;

(ii) **Measures to address water supply deficits** inter alia: rain harvesting, demand management, provision o f water storage, expansion o f existing system, water efficient household appliances;

(iii) **Flood risk analysis** that includes the identification of flood prone areas where no dwelling development should take place (land zoning); key flood mitigation actions; strengthening institutional and community ability to enforce adopted land zoning.

Specific adaptation measures under consideration include, inter alia:
**(a) agreements** on land use in buffer areas compatible with the protection o f the National Park, and mechanisms for implementing new agro-forestry practices where required, including enforcement strategies;
**(b) land use changes** that increase watershed retention times, as a mean to reduce flood hazards downstream;
**(c) improve water availability** through demand management; rain harvesting, water retention structures, and conservation of water producing areas;
**(d) strengthening Park monitoring** efforts combined with community awareness and involvement programs.

**Morne Trois Pitons National Park Integrated Ecosystem Management**
The project would address biodiversity and land degradation issues and vulnerabilities to climate change in a globally significant World Heritage Site, by:
**(a) updating** and complementing the management plan for the Morne Trois Pitons National Park;
**(b) establishment** of pilot adaptation measures to enhance the resilience of aquatic systems and watershed areas and improvement to water resource management so as to enhance the capabilities for sustainable development of adjoining communities thereby reducing stress on the Morne Trois Pitons National Park.

These will be pursued by:
(i) **A participatory revision** of the protected area management plan to address climate change vulnerabilities;
(ii) **Development of a participatory land use plan** for the buffer area and surrounding watershed basins. These plans will among other things address:
(a) water management measures.
(b) land degradation measures to reduce erosion, foster biodiversity, and reduce the impact on neighboring marine ecosystem;
(c) neighboring coastal marine ecosystem management options agreeable to the community, environmentally sustainable, and resilient to the
impacts of global warming.

### 5.5.7.6 Participation in International Activities

To demonstrate its commitment to the obligations to climate change, from the ratification of the Convention, Dominica has actively participated in the COP international activities. It is present at working group, international workshops on the various climate change themes such as adaptation, mitigation, deforestation and aforestation. More importantly Dominica has participated in all the COP meetings and related scientific panel discussions.

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