

National Report
Integrating Management of Watersheds and Coastal Areas
GRENADA

**Department of Economic Affairs
Ministry of Finance
Financial Complex
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1.0 INTRODUCTION

Grenada, the most southern of the Windward Islands is located between Trinidad on the south and St. Vincent on the north. The tri-island state is of volcanic origin and consists of Grenada, Carriacou and Petite Martinique, which together have an area of 133 sq miles and a population of approximately 95,000. The mainland Grenada is 21 miles long and 12 miles wide and spatially $11^{\circ} 58'$ north latitude and $61^{\circ} 20'$ west longitude (Appendix 1).

Geomorphologically, the island is characterized by a mountainous terrain, which rise steeply from the West Coast and descend more gently to the East Coast. Carriacou is characterized by a north to south west mountain range.

On the island of Grenada and Carriacou, approximately 77% and over 54% respectively of the land area has slopes exceeding 20° . Approximately 3% of the land area is at sea level and these include the main towns and many of the key socio-economic facilities (UNFCCC, 2000).

The small size of the island and its geography is of particular importance to the intimacy, which exists between the watersheds and coastal areas. In fact, considering the broad definition of the coastal area, the entire island can be regarded as a coastal entity. The drainage pattern of the island, poor land use practices, dependence on freshwater, coastal resources and the marine environment make integrated management of coastal areas and watersheds of critical importance to survival. These are cross-sectoral in nature wherein the activity of one sector adversely affects the development of the other and poses a threat to economic sustainability and environmental quality.

Integration is an essential aspect of the management system, which ensures linkages between the process of planning and implementation in attaining sustainable development goals. This will allow relevant management issues arising from the physical, social and economic linkages to be adequately addressed; ensure programs and projects are internally consistent with goals and objectives avoiding duplication and facilitating complementarity; provide consistency in national and local government policies and management actions. The integrated management will allow for policy and management strategies to respond to the challenges of changes in the watershed and coastal areas and be consistent with national economic and sustainable development goals. Hence, for Grenada, the Integrated Coastal Area and Watershed Management Project can be considered both timely and appropriate.

1.1 Background

This paper provides an analysis of the current watershed, water resources and coastal zone management issues in Grenada pursuant to Grenada's obligations on the Global Environment Facility approved Project entitled "Integrating Management of Watersheds and Coastal Areas in Small Island Watersheds and Coastal Areas in Small Island Developing States in the Caribbean".

Each of the thirteen small island states in the wider Caribbean region, participating in the Project, is charged to prepare a national report on Integrating Watershed and Coastal Area Management. Based on the thirteen national reports a draft regional synthesis including the identification of common problems and recommended solution will be prepared. The later document will constitute the basis of a regional project.

1.2 Project Objectives and Scope:

The major objective of the Project is to improve watershed and coastal zone management practices in support of sustainable development. The primary focus areas are coastal area management and bio-diversity, tourism, protection of water supplies, land-based sources of pollution and climate change.

The Project will also address some major environmental problems of Small Island Developing States including the following:

- ◆ Coastal water quality;
- ◆ Contamination of ground water Coastal and freshwater from Land-based activities;
- ◆ Solid and liquid waste disposal and pollution control;
- ◆ Over-extraction of groundwater and depletion of available water resources, exacerbated by seasonal demands (tourism);
- ◆ The adverse effects on the productivity and bio-diversity of coastal ecosystems due to dam construction, and canalisation of water courses and the consequent problems of sedimentation;
- ◆ The adverse impact of tourism on water supplies and aquatic resources, including the generation of solid and liquid wastes, loss and degradation of the natural ecosystems and high water consumption;
- ◆ Manpower limitations in terms of adequately trained experts to address the problems;
- ◆ Limited legislation and institutional capacity in environmental management.

1.3 Methodology

The methodology employed to prepare the National Report included the following:

- ◆ Review of existing literature;
- ◆ Personal interviews;
- ◆ Stakeholder consultations;
- ◆ Questionnaire survey.

1.4 Limitations of the Report

The major limitations of the Report are the following:

- ◆ Inadequate data;
- ◆ Time constraints.

1.5 Plan of the Report

The Report follows the guidelines as stated in “Outline for National Reports” (Appendix 2).

1.0 CURRENT WATERSHED/WATER RESOURCES MANAGEMENT ISSUES

2.1 Definition of Watershed

The Ministry of Agriculture defines a watershed area as a hydrologically defined area bounded by topographical features and drained in a central location to a common destination. The area stores, filters and releases water to the catchment area.

For purposes of the regional Project, the term watershed refers to the ecosystems within a contiguous watershed divide from hinterland to coastline and drained by one major river system.

A watershed is sometimes referred to as a catchment or drainage basin and constitutes an independent hydrological unit. Each watershed can also be divided into smaller units or sub watersheds based on the tributaries of the main river system (Briefing note of Regional Project).

2.2 Freshwater Habitats and Ecosystems

According to the Land Use Division (LUD 2000) of the Ministry of Agriculture, the Island of Grenada is divided into 71 watersheds (Figure 1) the details of which are given in Appendix 3. Of these watersheds attributes of the 12 largest are shown in Table 1.

Table 1: Largest Watersheds in Grenada (LUD, 2000)

River	Basin Number	Area (Acres)
Great River	29	11,167
Beausejour	31	3,793
St. Patrick's	63	2,944
St. John's	11	3,022
Bailles Bacolet	14	2,861
St. Marks	50	2,528
Antoine	69	2,699
Pearls	71	3,066
Chemin	9	1,953
Duquesne	58	2,182
Charlotte	44	2,019
Gouyave	43	1,830

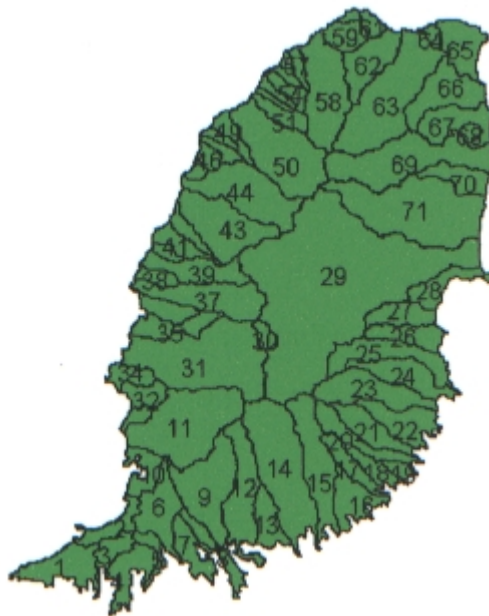


Figure 1: Watersheds of Grenada (LUD, 2000)

In the case of Carriacou and Petite Martinique there are 20 watersheds (Figure 2); attributes of the major ones are shown in Table 2.

Table 2. Largest Watersheds in Carriacou

Watershed	Basin Number	Area (Acres)
Limlair - Dover	5	1029.5
Craigston	2	835.3
Mt. Pleasant	8	687.2
Hillsborough	7	564.6
Grand Bay	12	632.5
Harvey Vale	15	584.3

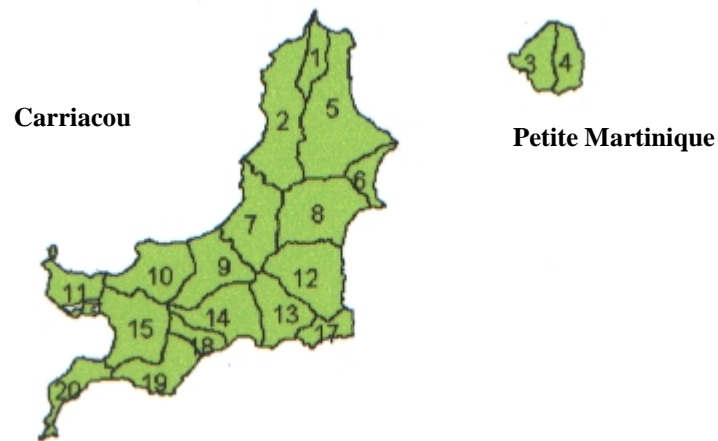


Figure 2: Watersheds of Carriacou and Petite Martinique (LUD, 2000)

Figure 3 contains the system of upland forested protected areas in the state, while the entire system of National Park and protected areas are seen in Appendix 4. Such upland watershed protected area includes the forest reserve and forested crown lands. The forest reserve is controlled by the Forestry Division and the forested crown lands by the Lands and Surveys Division, of the Ministry of Agriculture. Hence, the forested crown lands can be given out to farming or some other form of development.

The watershed included in the protected area system for the Island was determined by clipping the protected area coverage with that for the watershed. Table 3 shows the watersheds wholly or partially included in the protected areas for the State.

The Forestry Department, has a mandate to manage upland watersheds under its 10-year strategic plan (2000-2010). This Department is hoping to implement integrated watershed management, however, the Department has direct management control over Forest Reserve areas and Government-owned lands such as Annandale Estate and Grand Etang. With respect to lands outside the forest reserves, the Department has restricted management responsibilities. A significant portion of lands comprising the watersheds is privately owned. The watersheds on privately owned lands are not being managed properly. There is no specific soil or water conservation legislation or any legislation for environmental management on private lands or non-forest state lands.

Table 3: Watersheds Included In the Upland Protected Areas (LUD, 2000)

Basin Number	% Within Protected Area	Name of Area
Grenada		
65	41	Levera
71	18	Mt. Hope/Clabony Watershed
50	0*	Mt. St. Catherine
29	38	Grand Etang
37	31	Concord Watershed
31	18	Annandale Watershed
9	10	Chemin River Watershed
67	14	Lake Antoine
Carriacou		
2	55	High North (A)
7	21	Forest Reserve

* Legislation is pending to create a forest reserve in the Mt. St. Catherine watershed, which will change this figure to 68 percent.

2.3 Major Threats to Watershed Management

Anthropogenic impacts causing degradation in the upland watershed which are included in the protected area system for the island are minimal and therefore such areas are considered not threatened. However, the activities in the private owned lands, which are part of the watershed and are above the point of abstraction are of significant concern.

The major threats to management of these systems include the following:

- ◆ Encroachment by farmers;
- ◆ Use of agro-chemicals (fertilizers, pesticides, weedicides);
- ◆ Siltation of rivers and dams;
- ◆ Inadequate land use practices;
- ◆ Pollution;
- ◆ Land tenure rights;

- ◆ Unplanned developments;
- ◆ Lack of control of forest clearance.

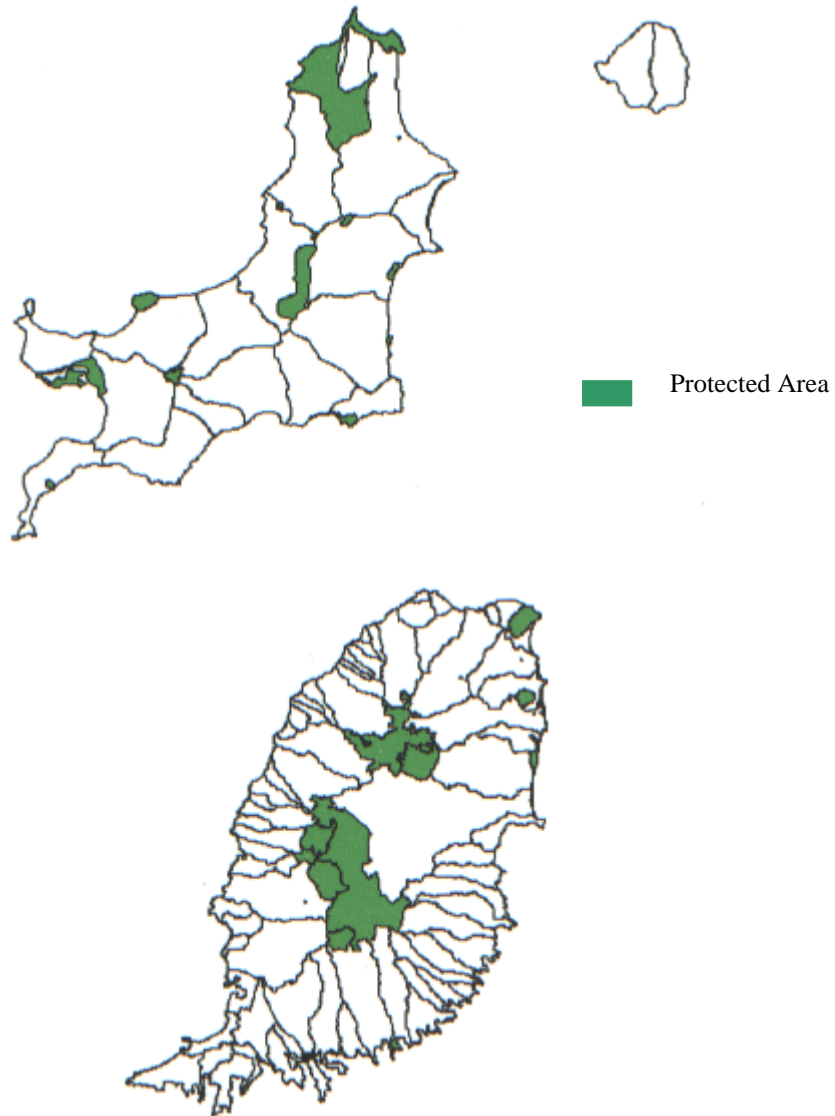


Figure 3: Watershed Included In Protected Areas For Grenada and Carriacou (LUD, 2000)

2.4 Fresh Water Ecosystems

The freshwater ecosystems of the tri-island state (Figure 4) include the following:

- ◆ Three main volcanic lakes (Grand Etang, Levera, Antoine);
- ◆ One man made lake (Palmiste);
- ◆ Several surface water streams including an intricate river network;
- ◆ Small number of springs.

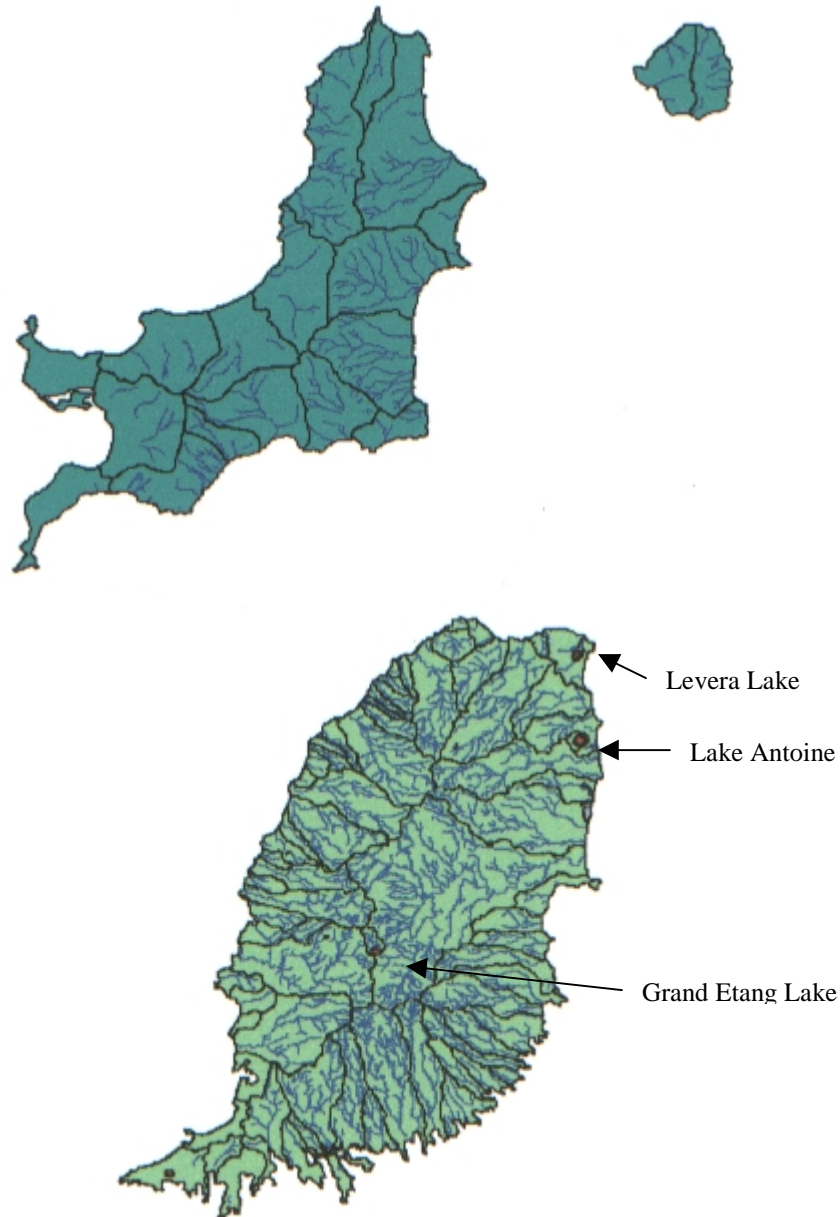


Figure 4: Freshwater Ecosystems (LUD, 2000)

Information on the geological and ecological attributes is generally lacking. Figure 5 displays the Lake Antoine ecosystem.



Figure 5: Lake Antoine

Lake Antoine is 20 feet above sea level and reaches a maximum of 100 feet deep. The lake was formed 12,000 to 15,000 years ago during the final stage of volcanic activity on the Island. Species associated with this lake include *inter alia*: Tilapia and other freshwater fish, Red-legged Tortoise, Fulvus tree-duck, and the Everglade kite.

2.5 Major Threats to Freshwater Ecosystems Management

Threats to the management of these ecosystems relate to lack of information, education and public awareness and include the following:

- ◆ Pollution from agricultural chemicals and waste. Agricultural practices in the watershed areas of these water bodies have the potential of introducing chemical residues into these ecosystems;
- ◆ Heavy sediment load of streams as a result of erosion caused by the removal of vegetation;
- ◆ Farming too close to the banks or farming on slopes that are too steep is a major concern;
- ◆ The washing of gears and equipment laden with agricultural chemicals has resulted in frequent fish kills in the streams;
- ◆ Direct and indirect discharge of sewage, grey water, solid waste, lubricants and other effluents from manufacturing plants;
- ◆ Over pumping of lakes during dry season;
- ◆ Over growth in the lakes due to low water levels in the dry season;
- ◆ Inappropriate fishing techniques such as the use of chemicals in rivers;
- ◆ Accelerated erosion and land slides;
- ◆ Absence of a water-balance to determine the amount of abstraction.

2.6 Supply and Demand

The demand for water is categorized as domestic and non-domestic. The domestic demand includes:

- ◆ Public consumption;
- ◆ Animal/livestock;
- ◆ Domestic farming.

The non-domestic is inclusive of:

- ◆ Commercial (excluding hotels);
- ◆ Industrial;
- ◆ Public (excluding schools);
- ◆ Hotels;
- ◆ Schools.

With respect to the domestic demand 64 % of the island population was connected to the National Water and Sewerage Authority (NAWASA) public water supply system in 1991. At the present rate of connection the percentage of household connected will reach 86 % in 2005 (OTH, 1995).

There are 23 surface water and 6 ground water supply facilities in the entire country, which produce 12 million gallons per day (mgd) in the rainy season and a maximum of 7 mgd in the dry season. The water demand in the rainy season is 10 mgd and for the dry season is 12 mgd. The per capita domestic water consumption is 130 liters and giving a total demand for the island in 1991 of $2,948,772 \text{ m}^3 \text{ yr}^{-1}$. If the domestic connection rate is maintained the total demand is projected to be $3,205,825 \text{ m}^3 \text{ yr}^{-1}$ in 2005 (OTH, 1995) (1 gallon is equal to 4.5 liters; 220 gallons is equal to 1 meter cube).

In 1991 the non-domestic consumption figure was about 1.5 million cubic meters of water (85 % in St. George parish alone) and is projected to be 2.1 million in 2005. Commercial activities predominated with 44 %, industrial sector 22 %, hotels 21 %, schools 10 % and public 3 % of the total (OTH, 1995).

2.7 Tariffs Structures

Under the provisions of NAWASA's Act of 1990, water and sewerage tariffs were established to achieve full cost recovery. Water and sewerage charges are incorporated into a single monthly customer bill for the metered and a single quarterly bill for the unmetered consumers. There is one rate structure applicable to the whole country. Information on the tariffs and tariff structure is extracted from Stanley, 1998, revised and verified using NAWASA's 1999 leaflet "New Water and Sewerage Tariff Structure".

Fixed monthly charges are billed to the unmetered consumers. They are based on the market value of the property. The charge represents a percentage of the property market value, which decreases with increases in property value.

Unmetered residential (domestic) consumers are charged at a rate gradually decreasing from 0.25 % for the first \$100, 000 of the property value to 0.025 % of the property value above \$600,000.

Unmetered commercial/industrial consumers and government pay a percentage of the property value ranging from 0.35 % for the first \$500,000 to 0.25 % above a value of \$1,000,000. The minimum charge for all fixed rate consumers is \$96.00 per year.

In the case of metered consumers, the monthly charge consists of a fixed part and a proportional part. For domestic consumers the fixed charge is \$ 8 per connection, while the commercial/industrial consumers fixed charge is 40 % of unmetered rates for these premises. The proportional charge is based on the actual water consumption. Domestic proportional rates are broken into three categories:

- ◆ For monthly consumption under 2,200 gallons, a rate of \$ 6 is charged for each 1,000 gallons consumed;

- ◆ For consumption between 2,200 and 5,500 gallons per month, a rate of \$ 10 is charged for each 1000 gallons consumed;
- ◆ For consumption above 5,500 gallons per month, a rate of \$ 15 is charged for each 1,000 gallons consumed.

Commercial/industrial consumers are charged \$15.81 for each 1000 gallons. Sewerage rates are one-third of the water bill for domestic consumers, and two-thirds for other consumers. Water supplied to unmetered consumers from catchments in Carriacou is charged the rate of \$ 5 per consumer per month.

In addition, water is charged to ships and private trucks/tankers (which buy water for resale) at a rate of \$ 25 and \$ 15 per 1000 gallons respectively.

NAWASA has also implemented a standardized schedule of charges for water and sewer connections and reconnections. Connection service charge varies from \$ 80 to \$ 1875 per connection. Fees of \$ 75 and \$ 150 are charged to domestic and commercial/ industrial consumers respectively for reconnection of the water service.

Although, stated in the Act that NAWASA may make regulations prescribing rates and charges for the performance of any of its function under this Act, such regulation are subject to Cabinet approval. Before any changes in tariff are implemented, a written request must be prepared by NAWASA and submitted to the Minister responsible for Public Utilities. The Minister prepares a submission and presents it to Cabinet. After a decision made by Cabinet, the Ministry advises the NAWASA of the decision, which in return regulates the rate increase by issuing Statutory Rules and Orders.

2.8 Water Sources

Surface water is the main source of available potable water in Grenada. However, wells/ boreholes (main source in Carriacou) and springs constitute other sources and produces about 10 percent of the water consumed. Three public desalination facilities were constructed, one in each of the three islands of the state. To date non of these facilities have been commissioned. In addition, there are five private desalination plants, which are located in the tourism and manufacturing sectors.

Barging of water is not a significant practice in Grenada. Evidence of barging occurs from the neighbouring islands to Petite Martinique.

2.9 Rain-fed and Irrigated Agriculture

Irrigated agriculture can be considered to be minimal and most of the agriculture is rain-fed. Weaver (1989) estimates that the current agricultural water demand is 15% of the total demand. Of the three main export crops, cocoa and nutmeg do not require irrigation and are rain fed. At present, only forty acres of agricultural

lands are irrigated in addition to the subsistence vegetable production, which are grown in the back yard of private homes.

There are plans, by the Ministry of Agriculture, to put 450 acres under irrigation. The Report on the Banana Rehabilitation Programme indicated that 80 percent of banana cultivation would have to be irrigated for the sub-sector to be viable. At present 10 – 15% of banana plantation and about 70% of commercial vegetable production are irrigated. However, under the Government's Agricultural Diversification Project, expansion of vegetable production may require extensive irrigation in the dry season. In addition, plans for irrigation, to increase food production, include an FAO Project, which is already approved.

The main source of irrigation is surface water pumped from rivers and there are no measures in place with respect to drainage linked to irrigation schemes.

The environmental impacts of irrigation are negligible since irrigation is not widely used.

2.10 Conservation and Re-use

Water loss in the distribution system is a major factor contributing to wastage of this vital resource. It is estimated that between 45 to 50% losses occurs in the distribution system and another 16% through wastage (Peters, 1999). A leak detection and repairs program initiated by NAWASA is intended to reduce the leakage to about 25 percent.

The island wide metering program was instituted as a means of implementing water conservation measures. Some residents, mindful of the metered water rates, collect rainwater for non-potable uses.

The recycling and reuse of water is not extensive and to date is practiced by one hotel (La Source) to irrigate lawn and plants during the dry season. Limited reuse of household kitchen water is also practiced (Calaloo drains etc.).

The National Water Policy includes universal metering, public information and awareness as essential components of the conservation programme.

There is an extensive use of the cistern system for the collection and storage of water in Carriacou and Petite Martinique.

2.11 Economic Value of Water

Water is essential for life and livelihood and is an essential commodity for the productive sector of the economy. Water production and conservation is high among Government's priorities. Water is regarded as a public property, a limited natural resource, which has significant economic value. Priority in the use of

water is given to human consumption and the watering of animals. The management of water resources is the responsibility of Quasi-Government institution NAWASA. The following criteria guides the implementation of Grenada's water resource policy:

- ◆ Systematic management of water resources with equal regard to quantity and quality;
- ◆ The integration of water resources management with environmental management ;
- ◆ The coordination of water resources planning with that of the user sectors;
- ◆ The coordination of water resources management with that of land use (National water Policy, 1999).

It is generally agreed that the economic value of water is not well appreciated by the end users.

2.12 Ground Water vis-à-vis Surface Water

Extent of Exploitation

The water, which constitutes the public supply, is sourced proportionally 90 % surface and 10 % wells/boreholes and springs. Surface water is used extensively in Grenada with major rivers and the Grand Etang Lake (during the dry season), mainly exploited. Groundwater is significant in Carriacou and Petite Martinique. Boreholes are the main exploited source on these islands.

The demand for surface water is about 55% of total production and this excludes line losses due to leakage. The estimated distribution losses are between 45 –50% of production. It therefore follows that demand is greater than supply when losses are considered. Ground water capacity constitutes about 15% of demand. The exploitation rate for ground water is approximately 50 percent (NAWASA, 2000).

Ground water sources are used to augment surface water sources during the dry season. This is important to meet the demand since surface water yields drop by 25% during the dry season (NAWASA, 2000).

Ground water is significant in Carriacou and in the south and south east of Grenada.

2.13 Policies and Legislation for Conservation

The policies for conservation includes the following:

- ◆ Universal metering programme;

- ◆ Leak detection programme;
- ◆ Public awareness programme;.
- ◆ Requirements of minimum storage for Public Buildings;
- ◆ Tax related incentives for conservation;

The metering programme in Grenada commenced in 1997. To date three parishes are fully metered namely St. Andrew, St. David and St. George. The metering programme resulted in about 40 percent water conservation in the parishes. Load shedding in the metered areas has been discontinued.

One negative impact of the metering programme is the increase use of the rivers in the rural areas to supplement the public supply.

The leak detection programme has been given an added boost with the finalization of a Leak Detection Project with the French Government (The Vendomme Water Project).

The incentives for conservation are built in the public tariff structure. The new tariff structure is credited for encouraging conservation especially among domestic users. A comprehensive system of fiscal incentives for water conservation needs to be developed.

NAWASA has responsibility for all freshwater throughout Grenada and the protection of these sources are embedded in the Act governing this institution (NAWASA Act No. 250, 1990). Under this Act

Part II Section 5 (4): The Authority shall have full powers and Authority over all waters whether surface or underground in the state of Grenada....

Part VIII Section 38: Waterworks areas shall be retained as forest reserves for the protection, conservation and maintenance of which the Chief Forestry Officer shall be responsible in accordance with legislation governing his functions.

The Draft 1999 National Water and Sewerage Authority Act (Part six) addresses watershed, water catchment areas, protected areas and co-ordination between the various departments responsible for the management of these areas. According to this draft Act, watershed means “all lands that lies above the discharge point into the sea of a river, stream or tributary”.

In addition, scattered pieces of legislation exist in Forestry Act, Physical Planning Unit/ Land Development Control Authority (PPU/LDCA) Act, which cover some aspects of watershed protection. The National Forestry Policy and 10 year implementation strategy also cover areas such as watershed and wildlife management, biodiversity and tree planting.

The forest policy strategic plan calls for the establishment of units with specified responsibilities and include *inter alia*:

- ◆ Forest conservation Unit: forest protection, monitoring of activities with forest and research;
- ◆ Upland Watershed Management Unit: identify and prioritise critical upland watershed areas in need of rehabilitation, establish and develop effective working partnership with landowners and users in priority areas in order to improve watershed management;
- ◆ Tree establishment and management unit: develop and manage information systems relating to relevant public and private sector activities in forestry, develop the capacity to provide and assist all interested in planting and managing trees;
- ◆ Environmental Education Unit.

2.14 Salt Water Intrusion

Salt-water intrusion is of great concern in Grenada. Most dugged wells are within 100 meters of the coastline. Recent technical reports indicated vulnerability of 4 ground water wells in the south of the main island and several in Carriacou. Two wells have been abandoned within the last 10 years. Most of the shallow wells of Carriacou also showed increase concentration of chlorides within the same period.

2.15 Measures to Prevent Contamination

The measures in place to prevent contamination are very limited. In the case of wells for public consumption the storage efficiency, safe yield of aquifer and pumping regime were established to prevent overexploitation.

There is a routine monitoring programme for saltwater intrusion, however, the practice of using observation boreholes has been discontinued.

2.16 Data on Sea Level Rise and Land Subsidence

Data on sea level rise and land subsidence are extremely limited. Currently the Government is involved with the Caribbean Planning for Adaptation to Climate Change Programme and the Initial Communications from the United Nations Framework Convention on Climate Change. It is expected that these projects will provide the required data on sea level rise.

Studies on coastal erosion in Grenada were conducted by DIWI Consult GmbH for the Ministry of Works in 1993. The 1994 report outlined areas of Grenada and Carriacou that are vulnerable to erosion and inundation as a result of sea level rise (SLR) (Appendix 5). In addition, Peters (1999) did an assessment of potential

beach erosion to SLR and reviewed previous work done by Chambers 1984 (Appendix 6). The LUD (1999) produced a ‘Grenada Screening Assessment Report’ in which a matrix was developed rating the different biophysical impacts of SLR (Table 4).

Table 4: Screening Assessment Matrix (LUD, 1999)

Biophysical Impact	Human Settlements	Water Resources	Tourism	Recreation	Infrastructure	Fishing	Ports	Historic Cultural
Erosion	1	2	1	2	2	1	2	3
Inundation	1	2	1	1	1	1	1	1
Salinisation	2	2	3	n	n	n	3	3

1 = Major Impact; 2 = Significant Impact; 3 = Minor Impact; n = No Impact

2.17 Land Use

The absence of a land use policy is compounding the problem of land use conflict in relation to watersheds. Lands of important watersheds and catchment areas are privately owned and are put to uses, which are undesirable for the protection of these watersheds. Such uses include farming and rearing of animals resulting in a potential for increase organic and inorganic nutrient loading and pesticide residues in the catchment areas. The type and areas of farming such as growing of bananas and vegetables on steep slopes has the potential for increase in soil erosion and sediment loading of the water bodies.

A serious conflict arises out of farming that occurs above the point of water extraction by the public water utility. The farming activities contribute to pollution of the water supply.

Conflicts in use and protection of critical watersheds were a priority issue discussed during the synthesis of the National Forestry Policy. The present problems experienced resulted because previously watersheds were not managed. Based on the expressed concerns of the Forestry Department, stakeholders and the general public that contributed to the forestry policy, the uplands Watershed Unit was established. There is however a need for serious research and data collection in watersheds since significant gaps exist in the limited available data.

Evidence of physical development in the upland watershed areas are not significant.

Presently, the Institute of Hydrology in England is offering technical assistance in developing a model for catchment areas, which will include estimation of the amount of water released and protective measures. Legislative and policy issues and research needs will also be considered.

2.18 GIS Capabilities

GIS capabilities exist within the Land Use Division (LUD), Ministry of Agriculture and the Physical Planning Unit, Ministry of Finance. According to the LUD, GIS was initiated in 1994 under an FAO project to determine the land and economic suitability for agriculture using PC Arc/Info 3.2 software package. This information technology tool was used to determine areas suitable for the growing of 42 selected rain-fed agricultural crops.

On completion of this project, the facilities were used to automate coverages of protected seascapes and national parks. The analogue versions of the protected areas were generated from a 1988 OAS project.

Presently, the GIS is been used to facilitate decision making in the Land Use Division. There are plans to further develop the GIS capabilities in this unit.

In the PPU, GIS was implemented under UNDP/UNCHS 1991 “Physical Planning and Related Environmental Management Project”. The GIS capability is presently used as a scientific tool to enhance decision making within the PPU. The GIS capabilities within this unit also require development.

2.19 Flood Data

There are no measures in place with respect to disaster preparedness for floods and droughts. This could be due to the limited resources available at the National Emergency Relief Organisation (NERO) and the relatively short existence of a formal institution coordinating disaster activities. However, preparedness for floods fall under the measures that are applicable to the preservation of life and property in flood prone areas during the occurrence of hurricanes.

In recent times there were significant damages due to natural hazards but data on the extent and associated costs are not available.

2.20 Climate Change and Natural Disasters

There are no measures in place with respect to disaster preparedness. The Government of Grenada is currently negotiating a disaster preparedness project with the World Bank.

The Initial Communications Project under the UNFCCC, which has been recently concluded and endorsed by Government, revealed the following potential impact of climate change:

Potential Effects of Climate Change

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

- ◆ Firstly, there is uncertainty about the interaction of all the global processes - natural and man-made - and the socioeconomic dynamics.
- ◆ Secondly, the data sets necessary for rigorous analysis, through simulations of the natural processes are incomplete and therefore restricts how the extent to which the results from initial analyses may be interpreted.

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

Impact on Water Resources

Water Availability

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

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

Water Quality

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

Impact on Agriculture and Fisheries

Agriculture

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

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

Crop production

Agricultural crop production would be influenced by changes in soil moisture for bananas, cocoa and nutmeg. Higher temperatures would increase evapotranspiration, while CO₂ enrichment could boost productivity in C3 plants. This includes tree-crops (nutmegs and cocoa), cassava, maize, yams, bananas, coconut, sweet potatoes, pigeon peas, and beans (Wittwer 1992). Greenhouse-grown type vegetables can produce large fruit size, and larger fruit numbers and can show yield increases of 10 to 70% (Wittwer 1992).

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

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

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

Livestock

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

Fisheries

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

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

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

2.21 Impacts of Extreme Weather Occurrences

The impacts of extreme weather occurrences on watersheds includes the following:

- ◆ Destruction of vegetation;
- ◆ Increase erosion;
- ◆ Increase siltation of rivers and dams;
- ◆ Reduction in water-holding capacity.

Extreme weather occurrences were associated with hurricanes Janet 1955, Flora 1963, Arthur 1990 and Lenny 1999 (NERO, 2000).

Considering the vulnerability of Grenada to natural hazards a number of plans and manuals were formulated, in most cases coordinated by NERO, over the years to minimize the effect of such eventualities: These include:

- ◆ Risk Hazard Analysis and Mapping
- ◆ National Disaster Mitigation Plan
- ◆ Disaster Management Plan
- ◆ CPACC Project on Vulnerability of Groundwater Aquifers to SLR (incomplete)

- ◆ Water Management Contingency Plan (NAWASA)
- ◆ A Manual of Standard Operating Procedures in the Event of any Disaster

The Disaster Management Plan is still under review and additional measures to reduce the impact of natural disasters are incorporated in the newly revised Grenada Building Code and Guidelines.

2.22 Pollution

The geomorphology of the island is such that land based sources of pollution ultimately affects the marine environment through leaching, washout and fallout. Agricultural activities in the form of chemicals used and waste generated are the main sources of non-point pollution of the upland watersheds.

The previous and existing solid waste disposal facilities are located within the coastal zone. The previous disposal facilities were located at Levera, Woburn, Telescope, Lagoon Road and Grenville (Appendix 7). These facilities were not properly environmentally engineered when established, and at present poses a potential threat to the marine environment from leachate.

2.23 Impacts of Deforestation and Sedimentation

The impacts of deforestation and sedimentation are significant on the watersheds. The impacts include the following:

- ◆ Reduced dry season yields;
- ◆ Exacerbated soil erosion;
- ◆ Increased surface run-off and reduced water retention;
- ◆ Clogged dams.

2.24 Tourism

The major tourism related concerns to watershed management includes the following:

- ◆ Management of tourism facilities located in upland watershed areas;
- ◆ The carrying capacity for eco-tourism in watershed areas;
- ◆ Establishment of environmental standards for tourism development;
- ◆ Establishment of environmental assessment guidelines for tourism projects and activities;
- ◆ Establishment of institutional capacity for tourism development;
- ◆ Amendment to existing legislations;
- ◆ Increase water demand in tourist peak season which corresponds with to the dry season period;

- ♦ Mitigation measures to be included in project design and subsequently adhered to.

There is a potential for impacts on watersheds from tourism due to the diversification of the tourism product to eco/nature tourism and the absence of established carrying capacity. Increased human activities in the upland watershed areas will introduce contaminants and increase sedimentation of dams.

2.25 Health

Improper management of watersheds can have serious health consequences such as increase water-borne diseases. Chemical contaminants, such as inorganic nutrients and pesticide residues, may be introduced by farming and rearing of animals, while microbial contaminants such as fecal coliforms and fecal streptococcus, may result from human related activities within the watersheds.

Statistics on the incidence and type of water borne diseases in Grenada for the year 1999 are shown in Table 5.

Table 5: Water Borne Diseases for 1999 (Epi Unit, 2000)

Infection	Suspected
Shigellosis	6
Diarrhea	452
Gastro Enteritis <5	1371
>5	1200

2.26 Water Quality

The water that is transmitted in the distribution system is treated by either slow sand or rapid sand filtration and chlorinated to produce a chlorine residue level of 0.3 mg/L.

Water quality monitoring is done by NAWASA and the Environmental Health Department of the Ministry of Health and the Environment. Results indicate, that in most cases the water quality is within acceptable bacteriological limits. However, there are a few sources of water that are unchlorinated and bacteriological analyses often reveal the fecal coliforms of about 100 coliform forming units(cfu)/100 ml and total coliforms of about 1000 cfu/100 ml. Despite this, a relationship between the source of the water and the occurrence of water borne illnesses were never established.

In addition, the capacity of NAWASA Laboratory is limited to routine analyses required for portable water. Bacterial analyses are limited to six samples twice per week. The Laboratory does not have the necessary equipment to carry out advanced analysis of water quality.

Realising that the source of the water is the most critical element in the production of good quality water, it was necessary to develop the capability to assess the source of the water and evaluate potential risks.

2.27 Data, Information Management and Research

In general there is a dearth of available information on watershed management.

Data on rainfall are collected by the Meteorology Office at the Point Salines International Airport and by the Land Use Division of the Ministry of Agriculture. There is an extensive rainfall measuring system at selected stations throughout the Island. Several sites were not properly maintained and have been condemned after several years of use. There is a dire need to rationalize the rainfall measuring system throughout the country.

The stream gauge system to measure river flows instituted by NAWASA are not presently operational.

The water quality programme in place is generally for analysis of a basic range of water drinking quality parameters.

2.28 Equipment Stock

The equipment stock include the following:

- ◆ Rain gauges (approx. 60)
- ◆ Stream gauges (minimal use)
- ◆ Laboratories (NAWASA, Ministry of Agriculture – Produce Chemist Lab)

Grenada presently utilizes the services of Caribbean Environmental Health Institute, Caribbean Institute of Meteorology and Hydrology and the Caribbean Water Basin Initiative (provides assistance in research). Private external laboratories are utilized on a periodic basis for advance water quality testing.

There is a very limited capacity for collating and processing water resources data. As a consequence, data / information reliability and quality control are inadequate.

2.29 Agencies Involved

Agencies involved in the management of watersheds include the following:

- ◆ Ministry of Health
 - Environmental Health Department

- ◆ Ministry of Agriculture
 - Land Use Division
 - Department of Forestry and National Parks
 - Department of Fisheries
 - Agricultural Extension Division
- ◆ Ministry of Tourism
 - Meteorological Office
- ◆ Ministry of Finance
 - Physical Planning Unit
 - Land Development Control Authority
 - Bureau of Standards
 - National Science and Technology Council
- ◆ Ministry of Works
 - Roads Division
 - NAWASA
- ◆ Ministry of National Security
- ◆ NGO Community (ART, GRENCODA, FOE).

Additional needs include extensive research/studies and capacity development for the management of watersheds and include the following:

- ◆ Identification of and prioritization of important watershed areas;
- ◆ Determination of land ownership within all important watershed areas;
- ◆ Rehabilitation, identification and classification of activities within the watersheds;
- ◆ Determination of potential environmental and health impacts;
- ◆ Estimation of water balance equations;
- ◆ Legislative review;
- ◆ Policy formulation;
- ◆ Database development;
- ◆ Procurement of monitoring equipment;
- ◆ Modeling capacity;
- ◆ Human resources development and training;
- ◆ Economic valuation of water and market-based approaches for watershed services;
- ◆ Institutional strengthening;
- ◆ Database development .

Sustainable Development Council

Through the Capacity 21 Project, the Government of Grenada and the United Nations Development Programme through CARICAD coordinated the establishment of Sustainable Development Councils in six small islands developing states in the region. The Grenada Sustainable Development Council was launched in February 1996 and operated out of the Ministry of

Finance. The Director General/Permanent Secretary of the Ministry of Finance served as the Cabinet appointed Chairman of the Council.

Role/functions

It was generally agreed that there continues to be a role for the Council within the Grenadian context to ensure that the country continues on a path to sustainable development.

The role of the Council was defined as follows to analyse, evaluate and formulate sector and intersectoral strategies for the promotion of sustainable development and to appropriately advise policy makers in the Public and Private Sectors and the community at large.

Objectives

The objectives of the Council includes the following:

- ◆ To ensure inter-agency coordination of policies and programmes, geared to the attainment of sustainable development, so as to minimize duplication of effort, and to promote the greatest complementarity;
- ◆ To facilitate national level co-ordination mechanisms for the adoption of a holistic approach to development, offering opportunities for the widest possible participation by all groups in the discussion of issues of national interest;
- ◆ To advise Government on measures required to integrate environmental and economic considerations in decision-making processes and on local, regional and global issues of sustainable development;
- ◆ To promote greater understanding and public awareness of the cultural, socio economic policy approaches to attaining sustainable development in Grenada;
- ◆ To provide a forum for monitoring progress and recommendations made.

Membership

The membership of the Council is broad based and cross sectoral and includes representatives from all national stakeholders groups – the government, the private sector, the non-governmental organisations and community based organisations communities, academia and the public in general.

Mandate

The Grenada Sustainable Development Council received its mandate from the Government of Grenada through an Act of Cabinet. At the national level, the

Council fulfilled its mandate to serve as a primary mechanism for coordination and information exchange in the elaboration and implementation of sustainable development plans, for stimulating public awareness on sustainable development issues and for formulating and advising government on sustainable development policy.

Major Focus Areas

The major topics dealt with were as follows:

- ◆ Agricultural and Tourism Development;
- ◆ The Building Code;
- ◆ The Draft Engineering Documentation;
- ◆ The Biodiversity Project and Biosafety Protocol;
- ◆ The Climate Change Project;
- ◆ The Convention on Desertification;
- ◆ The National Physical Development Plan;
- ◆ Disaster preparedness;
- ◆ Telecommunications Reform;
- ◆ The Eastern Caribbean Environmental Charter and Environmental Management;
- ◆ Solid waste management.

Medium Term Work Programme

The primary medium term objectives of the Council includes the following:

- ◆ Stimulating public awareness on sustainable development issues;
- ◆ Institutionalization;
- ◆ Fostering collaboration and cooperation;
- ◆ Building capacity.

2.30 On-going Research

There is no on-going research with respect to water resources management in Grenada.

2.31 Stakeholder Participation/ Awareness and Education

During the formulation of the National Forestry Policy (NFP) extensive public consultations were held throughout the island. Issues on watersheds were raised and discussed during each public forum and among the large group of stakeholders, which were pooled to participate in the drafting of this policy.

The National Biodiversity Strategy and Action Plan included a component for public awareness and issues of watershed management especially as it relates to farming practices in watershed areas were highlighted.

A community type water resource management program was initiated by ART in the rural village of Apres Tout. The community was mobilised by ART and with technical assistance from NAWASA and measures were taken to protect the water source improving the water supply to this village.

The public awareness programme serves to highlight the impact of activities in watershed areas. To a large extent the public awareness programme was targeted to areas outside of the protected watershed zone where most of the negative impacts are occurring.

There are no studies or data existing on the impact of public awareness and education on the management of watersheds.

There are limited community type programmes existing for water resources management. The Water of Life Project conducted by ART is one such Project.

There is very limited public involvement in the decision-making processes as it relates to watershed management.

The public however is very concerned about the issues of degradation of the environment. During public consultations on the attendant issues there is extensive public involvement in the process and very positive reactions to proposed mitigation measures.

There is a need for a sustained public awareness/public information campaign on the issues.

The recognition of gender importance in watershed management has not been addressed.

2.32 Institutional Framework

Many agencies share the responsible for water/watershed management. The structure of these organizations and relevant regulations are shown in Table 6.

Table 6: Agencies Responsible for Watershed Management (Legislated)

Agencies	Structure	Legislation
NAWASA	Statutory; Multi-sectoral Board of Directors with Chairman. General Manager responsible to board.	NAWASA ACT (1990) and Amendments (1991 and 1993) Draft NAWASA ACT (1999)
Land Development Control Authority	Statutory; Multi-sectoral membership with chairman.	LDCA Act (1968) and Amendments (1983); Land Development Regulations (SRO No. 13, 1988)
Land Use Division	Chief Land Use Officer with supporting staff responsible to CTO and PS Ministry of Agriculture.	Crown Lands Ordinance (Cap. 78, 1896); Crown Land Rule (SRO No. 36, 1934); Crown Lands (Amend.) Rules (SRO Nos. 3, 19, 39, 1965)
Department of Forestry and National Parks	Headed by the Chief Forestry Officer responsible to the CTO and PS, Ministry Of Agriculture.	Forest, Soil and Water Conservation Ordinance (Cap. 129, 1949) Amendments (1984); Crown Lands Forest Produce Rules (1956); Protected Forest Rules (SRO No. 87, 1952) National parks and Protected Areas Act Cap. 206 (1990)
Environmental Health Department	Headed by the Chief Environmental Health Officer responsible to the Chief medical Officer and PS.	Public Health Ordinance (Cap. 237, 1925 Amendments and Regulations (SRO No. 218, 1957)
Grenada Bureau of Standards	Statutory Body	Standards Act No. 6 (1989)
National Science and Technology Council	Consisting of a Technical Committee with a chairman.	Science and Technology Council Act Cap 298 (1982)

Policies existing, which are related to environmental management and by extension have linkages to watershed management are:

- ◆ Medium-Term Economic Strategy (2000-2002): promote sustainable economic and social development; environmental protection programs to foster physical and institutional sustainability of development; emphasise policies and actions designed to safeguard the environment;
- ◆ Tourism Policy and Master Plan for Tourism Sector (1997): consistency of tourism development with environmental protection and conservation of the natural resource base; tourism development is in accordance with established carrying capacity;
- ◆ Agricultural Policy and Programs of the Ministry of Agriculture (1997-2010) was submitted for approval by the Government;
- ◆ Grenada Biological Diversity Strategy and Action Plan (2000): established eight principal concepts for the conservation of biodiversity and includes *inter alia*: Strengthening management of key ecosystems;

promoting sustainable use of biological resources; incorporating ecosystem valuation into National Accounting; strengthening existing legislation for biodiversity protection;

- ◆ National Forest Policy and 10-year Strategic Plan;
- ◆ OECS Solid and Ship Generated Waste Management Programme.
- ◆ National Initial Communications Project under the United Nations Framework Convention on Climate Change (UNFCCC);
- ◆ Caribbean Planning for Adaptation to Climate Change (CPACC);
- ◆ National Physical Development Plan;
- ◆ Building Code and Guidelines;
- ◆ Activities under the Convention to Combat Desertification and CITIES.

The formulation of policies involves the formation of intersectoral committees with key stakeholders. A series of national consultations were conducted to ensure the full extent of public participation in synthesizing the policies.

The establishment of policies is important to national development in relation to water resources development. Once policy directions are established it provides guidelines, which are utilized for prioritizing of projects. This ensures that projects are rated allowing for those pertinent to critical aspects are addressed firstly.

2.33 Sector Investments

The sector investments include the following:

- ◆ Development of Master plans and other studies;
- ◆ Establishment of universal metering programme;
- ◆ Implementation of water mains replacement programme;
- ◆ Public information programmes;
- ◆ Capacity development and training Programmes;
- ◆ Creation of Mt. St. Catherine Forest Reserves

Financing for improving the efficiency of water sector performance is basically in the form of loans, grants from regional and internal organisations and internal funding from government and quasi government organisations.

2.34 Human Resources for Water Resources Management

The existing in-country resources for water resources management include several persons with post-graduate training in water resources management in related areas. Expressed immediate priorities are for human resources in the following areas:

- ◆ Ground water management;

- ◆ Hydrology;
- ◆ Hydrogeology;
- ◆ Graduate training in watershed management.

There is however a dire need for a human resource audit in relations to watershed management and related environmental management in general.

The Government of Grenada is desirous of creating an environmental management unit as a Quasi-Government administration for the day-to-day administration of environmental management.

3.0 CURRENT COASTAL AREA MANAGEMENT ISSUES

This section will focus on current coastal management issues and will attempt to fill the existing gaps not covered in the previous section as it relates specifically to coastal zone management.

3.1 Definition of the Coastal Area

The regional project defines the Coastal Area as a geographic entity of land and water affected by the biological and physical processes of both the terrestrial and the marine environments. The area of land affected by its proximity to the sea and that is unavoidable within a small island system setting. For the purpose of the climate change project, which is ongoing in Grenada, the landward limit of the area of influence of the marine environment is taken as that area which falls within the 150 feet contour and the coastline.

3.2 Coastal Habitats and Ecosystems

According to the Draft Sectoral Report (2000): The Environment, prepared by the PPU, Grenada's shoreline is 121 km long, with rocky geomorphology and diverse ecosystems, including mangrove swamps, coral reefs, sea grass beds, beaches and lagoons (Figure 6). At present only two of these areas were declared to be protected areas by the Fisheries Division, which are the coral reef of Molinere and the sea grass beds of Woburn. In fact, an official from the Ministry of Agriculture referred to them as 'paper' protected areas since there are no management infrastructure or regulations in place for their protection.

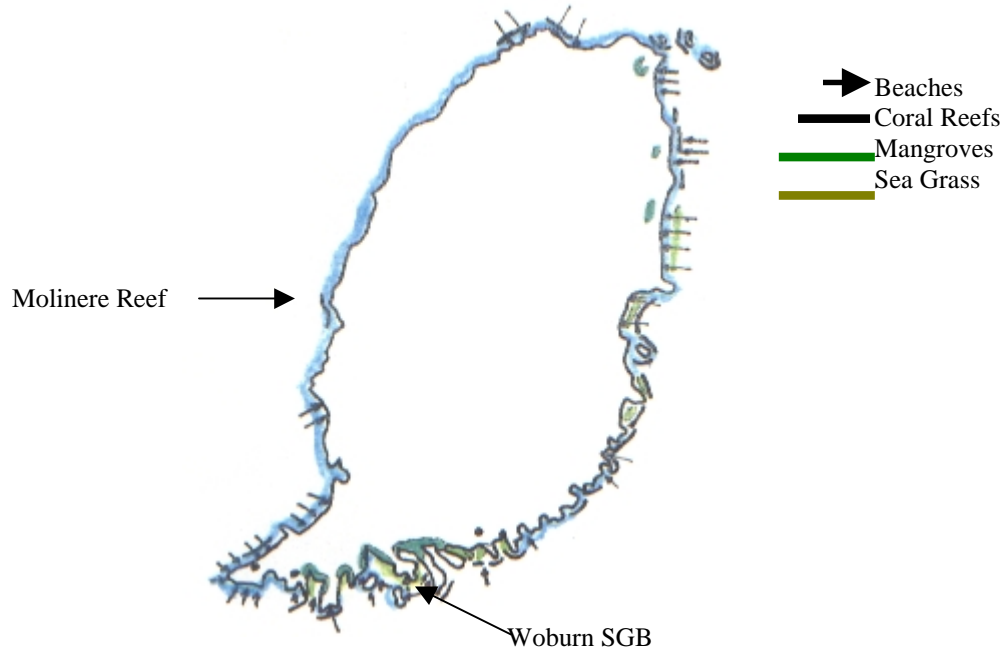


Figure 6: Grenada Marine and Coastal Ecosystems (Adopted from PPU, 2000)

A recent study entitled, *Near Shore Marine Resources of Carriacou, Petite Martinique and Outlying Islands* was conducted (Price, 1998) as part of the Integrated Physical Development and Environmental Management Plan (GOG, UNDP, UNCHS, CDB, 1998). The study revealed that Carriacou and Petite Martinique together with their outer islands have over 60 km of Coastline, 100 hectares of mangroves and many hundreds acres of sea grass beds and coral reefs (Figure 7).

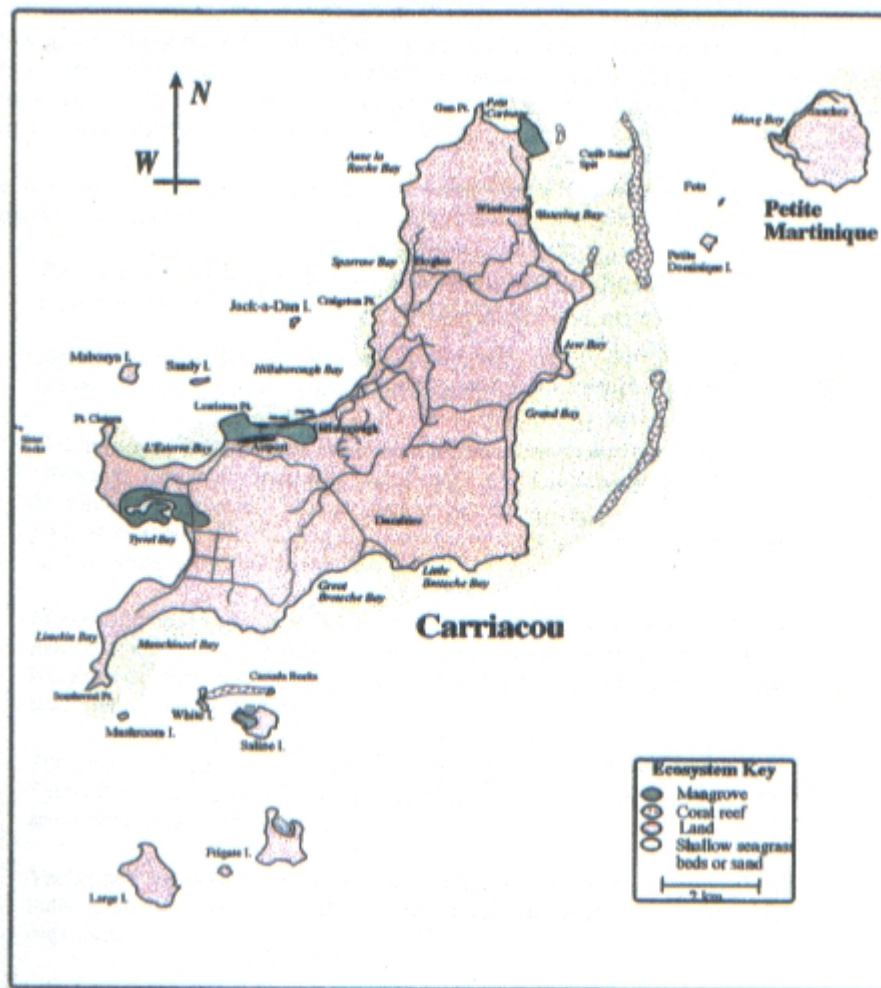


Figure 7: Marine Ecosystems of Carriacou, Petite Martinique and Outlying Islands (Price, 1998)

Included in the Integrated Physical Development and Environmental Management Plan for Carriacou and Petite Martinique, is a system of proposed Marine Protected Areas (MPA). These areas were determined based on analysis of the marine environment, an assessment of the ecological values of resources and the suggestion that the establishment of MPAs is the first step to be taken in the development of an ecotourism based economy (Dixon, *et al.*, 1993).

3.3 Significant Coastal Ecosystems

Mangrove swamps, coral reefs, sea grass beds, beaches and river outlets are the main coastal ecosystems and provide invaluable ecological, biological, geological functions. These ecosystems are of valuable socio-economic importance. Their vulnerability to global environmental changes and phenomena such as sea level rise (SLR); rise in seawater temperature; increase frequency and potency of natural hazards is of immense importance.

Mangrove Swamps

There are 470 and 98 acres of mangrove in Grenada and Carriacou respectively (Eschweiler, 1982), which consist mainly of the typical populations of red, black, white and button types. However, Barriteau (1998) in his study on coastal wetlands, which was presented during the Forestry Policy consultations, concluded that mangrove forest is constantly under threat and present estimates may be less. Significant areas of mangrove in Grenada include: Levera Pond, Conference Bay, La Sagesse, and the Bays and Islands from Woburn to Westerhall Bay. Important mangrove systems in Carriacou include: Petite Carenage Bay, Saline Island, Tyrrel Bay, and Lauriston Point (Env. Profile, 1991).

According to Barriteau (1998), data and information on the loss of mangroves is lacking. However, through interviews and community meeting with users of the resource, it was qualitatively established that a large portion has been lost to conversion, over-harvesting and pollution.

Based on interviews conducted the average Grenadian sees mangrove wetlands as “a smelly, useless, mosquito infested swamp”. The problem is compounded by politicians who insist that they should be converted into “something more immediately useful” which will have short-term economic benefits and allow them to gain political mileage (Barriteau, 1998).

Mason (2000) identified major threats to mangroves include:

- ◆ Tourism oriented development such as hotels and marinas proposed for coastal wetland areas particularly in the St. Davids parish and Levera pond;
- ◆ Possibility of conversion to landfills;
- ◆ Major infrastructural development such as the expansion of Lauriston Airport at Carriacou;
- ◆ Public ignorance of the ecological, environmental and socio-economic importance of the perception of these ecosystems due to lack of awareness;
- ◆ Sand mining.

Coral Reefs

Coral reefs occur mainly along the south (mainly fringing reefs), north and east (mainly barrier reefs) of the coast of Grenada and Carriacou. The 'best reef' of Grenada is identified as the Molinere reef, while Saline Island and White Island, outlying Carriacou, are said to have the 'best reefs in the Country' (GOG, OAS, 1988). The biological compositions of these reefs are mainly Elkhorn, finger, and brain coral.

Hunte (1987) who conducted quantitative marine biological surveys of the Grand Anse reef and other adjacent areas indicated that community structures are characteristic of reefs under stress from high nutrient levels. In addition, the reefs outside the bay and north of the deep basin were exposed to sediment stress. However, the six fathoms offshore reefs were found to be in a healthy condition despite the elevated nutrient levels measured in the water. However, it is hoped that the construction of the south coast sewer system in 1994 will reduce the influx of organic nutrients into the Grand Anse marine environment.

DuBois (1984) found that Molinere reef and other West Coast beaches appear to be under stress from high sedimentation rate.

In Grenada the major threats to coral reefs include the following:

- ◆ Run-offs;
- ◆ Dredging;
- ◆ Pesticide and chemical use;
- ◆ Coral harvesting;
- ◆ Anchor damage by boats;
- ◆ Sewage pollution;
- ◆ Sand mining;
- ◆ Coastal developments;
- ◆ Diseases;
- ◆ Sedimentation;
- ◆ Pollution;
- ◆ Coral Bleaching;
- ◆ Sea temperature rise;
- ◆ Loss of macro algal grazers;
- ◆ Coastal development;
- ◆ Physical damage.

Sea Grass Beds

Sea grass beds consisting of turtle and manatee grass are found along the east central and south parts of Grenada's coast and on the west coast of Carriacou (Env. Profile, 1991). Smith (1987) shows sea grass beds in Grenville Bay, Great

Bacolet Bay, the southern bays from Mount Hartman to westerhall and windward Bay in Carriacou.

The sea grass bed of True Blue Bay, an important grazing site for the white sea egg, is stressed as a result of heavy sediment load in the water and little information exist on the status of other sites in Grenada. According to GOG/UNDP et al., (2000) in Carriacou and Petite Martinique sea grass beds are damaged to varying degrees by anchors and chains in Tyrrel Bay, Windward, Sanchez, and White, Saline and Sandy Islands. In Tyrrel Bay and near the main port of Hillsborough, nutrients and pollution from land based sources and yachts are causing detrimental algal growth in the sea grass beds.

Beaches

Beaches are widespread along the coastline of Grenada and its dependencies. Typically they are located in small pockets within bays and are have active profile widths varying from 14m to 45m (Peters, 2000). The longest and most known is Grand Anse which is 2.7 km long.

Major threats to beaches include:

- ◆ Sand mining;
- ◆ Developments;
- ◆ Recreational activities;
- ◆ Tourism activities;
- ◆ Hunting of nesting turtles.

3.4 Major Threats to Management of Coastal Ecosystems

The following is a summary of the major threats to the management of the coastal habitats and ecosystems:

- ◆ Vulnerability to Sea Level Rise and Global Warming including sea temperature rise;
- ◆ Influx of nutrients from land-based activities;
- ◆ Stress from sediment loading;
- ◆ Coastal developments;
- ◆ Ecological imbalance such as the selective removal of key grazer species;
- ◆ Marine activities such as the anchoring and washing of boats and discharge of sewerage by yachts;
- ◆ Lack of awareness and education;
- ◆ Lack of Political will;
- ◆ Lack of appropriate legislation for coastal zone management;
- ◆ Watersport activities;

- ◆ Sand mining;
- ◆ Lack of integrated management responsibility.

3.5 Living and Non-living Marine Resource Exploitation

Almost all sand used in the construction industry comes from beaches and the occurrence of sand mining resulted in recorded beach erosion on most beaches prior to 1992, which was determined by profiling. In fact, Chambers (1986) indicated that extensive sand mining, which has caused serious erosion, was observed at Beausejour, Palmiste, Conference and Telescope Bays (Appendix 6).

Presently, sand mining is only authorized at three sites in Grenada. The sites in Grenada are Pearls, Telescope and Galby. At present only the Pearls site is used for official sand mining activities. Responsibility for the mining of sand was given to the Gravel and Concrete Corporation a statutory body. The high cost of obtaining sand, mainly due to the haulage, has led to smaller scale illegal sand mining at almost all beaches throughout the state.

The exploitation of mangroves is on a small scale mainly for production of charcoal and building materials. The practice of harvesting of corals for the production of jewelry although significant in the past is now the decline. Over harvesting of specific species of reef fish and shellfish remains the main issue related to exploitation of coastal resources. Spare fishing constitute the main form of livelihood to many and on a daily basis harvesting is done in areas which are demarcated as MPAs, due the higher catch per unit effort. This was noticed in the Woburn and Molinere areas and the proposed MPAs of Carriacou; in fact approximately 10,000 kgs of the reef fish are exported from Carriacou to Martinique on a weekly basis.

According to the Fisheries Division, the pelagic fishery is commercial and the fishing effort increased steadily over the years in terms of number of fishing vessels and the equipment used. The main species caught and targeted is the Yellow-fin Tuna contributing a leading average of 16 % of the landings. Other significant contributors to the landings are *inter alia*: Dolphin, Black-fin Tuna and flying fish all of which are important to the fishery at the national level.

The removal of the mangroves is reducing the natural physical and biological functionality of this ecosystem. The harvesting of corals is physically damaging the structure of the reefs and the functions they provide. Preference in the harvesting of more valuable species of reef fish and shellfish, such as snapper and lobsters, has the potential of skewing the species abundance to those that are less important, offsetting the population dynamics of a normal functioning reef and damaging the stock structure. The sein fishery, which is common along the southwest and western coast, is damaging to the physical structures of the fringing and patch reefs in their path. In addition, they do not discriminate in type and to a

lesser extent size of fish caught since regulations for the ‘match’ size of the nets are absent resulting in wastage, which can affect the stock replenishment rate.

An evaluation of the pelagic fishery is challenging, since regional common stocks exist for most species, warranting a regional approach to management. The absence of adequate data on the stock structure and fishing effort together with socio-political and economic implications make the management of the fishery a challenge and in most cases the stock is damaged before management measures are implemented.

3.6 Aquaculture

Aquaculture is not significant in the coastal area however, suitable sites on the eastern part of the island were identified for such project. Presently, there is an existing demonstration center at Paradise, St Andrew’s which will be used as a pilot project.

3.7 Climate Change and Natural Disasters

The impact of extreme weather occurrences on coastal ecosystems include:

- ◆ Damage to coastal ecosystems;
- ◆ Beach erosion;
- ◆ Coastal erosion and inundation;
- ◆ Increased siltation and sediment loading;
- ◆ Damage to infrastructure

There are no specific measures in place with respect to disaster preparedness and climate change on coastal ecosystems.

The development practices, which constitute to threat to life and property include:

- ◆ Inappropriate construction designs;
- ◆ Building too close to the shore line;
- ◆ Sand mining

The Initial Communications Project under the UNFCCC, previously referenced, identified the following potential impact of climate change:

Impact on the Coastal Zone

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

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

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

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

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

Beach Erosion

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

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

Sandy Islands and Reefs

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

Tourism

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

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

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

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

Human Health

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

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

Preliminary analysis of the three most common diseases, influenza, viral conjunctivitis and gastro enteritis shows correlation between annual and July precipitation and these diseases. Significant positive correlations are observed for the incidence of viral conjunctivitis and influenza and August precipitation - $R=0.70$ and $R=0.62$ respectively.

3.8 Transboundary Threats

The transboundary threats include the following:

- ◆ Oil spills and Pollution of coastal areas;
- ◆ Fish kills and Algal intrusion;
- ◆ Toxic waste trans-shipment;
- ◆ Freshwater influx.

3.9 Tourism

The major tourism concerns to coastal area management includes the following:

- ◆ Hotel construction and other developments;
- ◆ Carrying capacity excesses;
- ◆ Lack of coastal zone management;
- ◆ Lack of regulation of coastal zone activities;
- ◆ Violation of laws;
- ◆ Pollution/contamination;
- ◆ Loss of habitats.

3.10 Health

The Ministry of Health is the body responsible for performing the regulatory function as regards coastal water quality. Water quality monitoring is limited in spatial extent. Specific sampling sites were established, such as in the vicinity of the Green Bridge sewage outfall and the inner harbor, and bacteriological analyses are done on a periodic basis to determine the level of sewage related microbes in the water. It is believed that the plume from the St. George's sewage is affecting the coastal area. Ear and enteric infections among sea bathers have been blamed on coastal water quality although no statistical links were established.

Numerous complaints are received by the Environmental Health Department concerning the presence of raw sewer in the water of bays. It is assumed that yachts and other small vessels are the main culprits but investigations were never confirmed. However, the possibility of land based activities as a contributor to such contaminants was never ruled out due to the drainage pattern and frequency of flush out especially after heavy rains.

The link between food poisoning from the consumption of fish and shellfish has long been established, but data to verify the outbreaks as a consequence are not available. However, once there are evidence of sewage contamination of the marine environment the potential for food poisoning by microbes and helminthes exist.

4.0 INTEGRATED WATERSHED AND COASTAL AREA MANAGEMENT

Table 7 provides the result of a questionnaire survey on the impacts in coastal areas of watershed activities. The forms were developed during the inception workshop (April, 1999) and distributed along with the report outline.

The rankings were arrived at by detailing the most frequent responses on each item from the survey documents. Additionally, the table was subjected to intense review during the consultations. Three new areas were added to the list of impacts in coastal areas namely: refuse disposal, sewage and grey water.

In the case of coastal zone activities impacting on watersheds, the conclusions from the consultations were that the impacts were minimal throughout (Table 8).

This section also includes matrices with respect to sections 3 and 4 of the report outline.

5.0 RECOMMENDED INPUTS TO REGIONAL ACTION PROGRAMMES

Given the small size of the islands, along with the limited access to resources and limited capacity, it is important to place the project on a regional context so as to improve cost effectiveness and efficiency.

The actions most effectively executed at the regional level include the following:

- ◆ Networking and information exchange;
- ◆ Regional consultations;
- ◆ Capacity building, institutional strengthening and technology transfer;
- ◆ Public awareness and information programmes;
- ◆ Education, training and human resources development;
- ◆ Model legislation;
- ◆ Transboundary issues;
- ◆ Multi-lateral environmental agreements.

Institutional (Government, Non-governmental and Private Sector)

	Problems Identified	Intended Goals	Barriers/ Constraints	Actions
Institutional framework (development and/or enhancement)	Multiplicity of institutions, laws and regulations; Lack of land use policy	Rationalized system for environmental management; Reduction in land use conflicts	Turfism; Land tenure rights	Environmental audit and legislative review; Development of policy; Public awareness
Capacity building	Inadequate infrastructure; Lack of adequate human resources	Infrastructure and human resources development	Lack of resources	Investment in physical capacity, education and training
Stakeholder participation and awareness	Centralized decision making system	Civil society and generally public participation in decision making process	Lack of capacity within civil society; Mistrust of motives of civil society by government	Development of institutions involving government and civil society

Institutional (Government, Non-governmental and Private Sector)

	Problems Identified	Intended Goals	Barriers/ Constraints	Actions
Research and Development	Lack of planning capability	Development of research capacity	Insufficiency of funds and human capital	Institutionalization of research capacity, education and training
Information and decision support systems	Lack of baseline information	Development of management information system	Insufficiency of funds and human capital	Procure adequate equipment; Engage technical assistance for education and training
Social and cultural issues	Lack of appreciation of the importance of environmental issues; Lack of political will; Lack of concern for environmental issues	Ensure that social and cultural activities are consistent with environmental conservation and preservation	Resistance to change	Public information and awareness campaign; Enforcement of laws

Legal and Policy

	Problems Identified	Intended Goals	Barriers/ Constraints	Actions
Development and/or enhancement	Inadequacy of laws and regulations; Lack of standards	Comprehensive legal and regulatory framework; Development of appropriate standards	Outdated and irrelevant legal framework; Inadequacy of baseline information	Legal review; Environmental audit; Standards development
Harmonization	Lack of clear jurisdiction Lack of coordination	Efficient and effective delivery system	Turfism; Inadequate information flow	Consultations; Education and training
Enforcement, monitoring and compliance	Enforcement monitoring and compliance mechanism-	System of self policing to be instituted	No system of reporting and accountability	Public awareness campaign
Multi-lateral environmental agreements	Multiplicity of agreements; Agreements not tailored to national circumstance	Rationalization of	Lack of capacity	Ratification of agreements; Implication of objectives

Financial

	Problems Identified	Intended Goals	Barriers/ Constraints	Actions
Investments/funding (national and international funding institutions)	Insufficient financial resources for: Maintenance/rehabilitation Studies Human resources Education and public awareness Infrastructure development	Develop the capacity to fully address issues	Insufficient funds available; Absence of integrated action plan	Meeting of donors; Funding to be sourced for facilitating obligations under various ratified conventions
Economic instruments	Inadequate incentive mechanism for conservation; Lack of integration of watershed and coastal management issues in national planning	Develop and implement economic instruments for conservation; Integrated development planning	Low priority for environmental issues; Status quo been defended	Studies to be done; Public awareness

Legal and Policy

	Problems Identified	Intended Goals	Barriers/ Constraints	Actions
Development and/or enhancement	Inadequacy of laws and regulations; Lack of standards	Comprehensive legal and regulatory framework; Development of appropriate standards	Outdated and irrelevant legal framework; Inadequacy of baseline information	Legal review; Environmental audit; Standards development
Harmonization	Lack of clear jurisdiction Lack of coordination	Efficient and effective delivery systems	Turfism; Inadequate information flow	Consultations; Education and training
Enforcement, monitoring and compliance	Weak enforcement, monitoring and compliance mechanisms	System of self policing to be instituted	No system of reporting and accountability	Public awareness campaign
Multi-lateral environmental agreements	Multiplicity of agreements; Agreements not tailored to national circumstance	Rationalised system of multilateral agreements.	Lack of capacity	Ratification of agreements; Implication of objectives

Institutional (Government, Non-governmental and Private Sector)

	Problems Identified	Intended Goals	Barriers/ Constraints	Actions
Institutional framework (development and/or enhancement)	Multiplicity of institutions, laws and regulations; Lack of land use policy	Rationalized system for environmental management; Reduction in land use conflicts	Turfism; Land tenure rights	Environmental audit and legislative review; Development of policy; Public awareness
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Research and Development	Lack of planning capability	Development of research capacity	Insufficiency of funds and human capital	Institutionalization of research capacity, education and training
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APPENDIX 1
MAP OF GRENADA



APPENDIX 2

OUTLINE FOR NATIONAL REPORTS

APPENDIX 3
WATERSHEDS OF GRENADA

Table 2(2). Watershed numbers and areas in Grenada according to Dept. of Agriculture.

NO.	TITLE	AREA (AC.)	NO.	TITLE	AREA (AC.)
1.	True Blue	1045	37.	Black Bay	1525
2.	Grand Anse	487	38.	Marigot	263
3.	Grand Anse Valley	452	39.	Trand Roy	1065
4.	Mt. Hartman	1191	40.	Dothan	191
5.	Clark's Court Bay	258	41.	Palmiste	401
6.	Richmond Hill	1157	42.	Mt. Nesbit	306
7.	Woburn	1094	43.	Dougladston	1830
8.	Confer	162	44.	Gouyave	2019
9.	Chemin	1953	45.	Millet Bay	134
10.	St. George's	502	46.	Maran	205
11.	St. John's	3022	47.	Gros Point	406
12.	St. Louis	1607	48.	North Gros Point	143
13.	Petit Baccave	802	49.	Nettle Point	234
14.	La Chaussee	2861	50.	Victoria	2528
15.	La Sagesse	1689	51.	Waltham	459
16.	Petit Trou	788	52.	Silver	105
17.	Requin	473	53.	Great Ravine	177
18.	Belle Vue	421	54.	Great Crayfish	339
19.	Bishop	186	55.	Little Crayfish	162
20.	La Tante	812	56.	Crayfish	67
21.	Crochu	827	57.	Duquense Point	162
22.	Mama Cannes	1122	58.	Union	2182
23.	Grand Bacolet	1433	59.	La Sausos	478
24.	Munich	931	60.	David Point	110
25.	Marquis	1362	61.	Mt. Rodney	277
26.	Deblando	717	62.	Sauteurs	1133
27.	La Digue	654	63.	St. Patrick's	2933
28.	Harford	728	64.	Levera	119
29.	Great River	11167	65.	Levera Pond	849
30.	Grand Etang	282	66.	River Sallee	1352
31.	Beausejour	3793	67.	Mt. Ross	893
32.	Grand Mal	396	68.	Lake Antoine	115
33.	Fontenoy	167	69.	Tivoli	2699
34.	Mt. Moritz	411	70.	Conference	645
35.	Perseverance	745	71.	Pearls	3066
36.	Woodford	454			

Source: Land Use Division, Government of Grenada..

APPENDIX 4

SYSTEM OF NATIONAL PARKS AND PROTECTED AREAS FOR GRENADA CARRIACOU AND PETITE MARTINIQUE

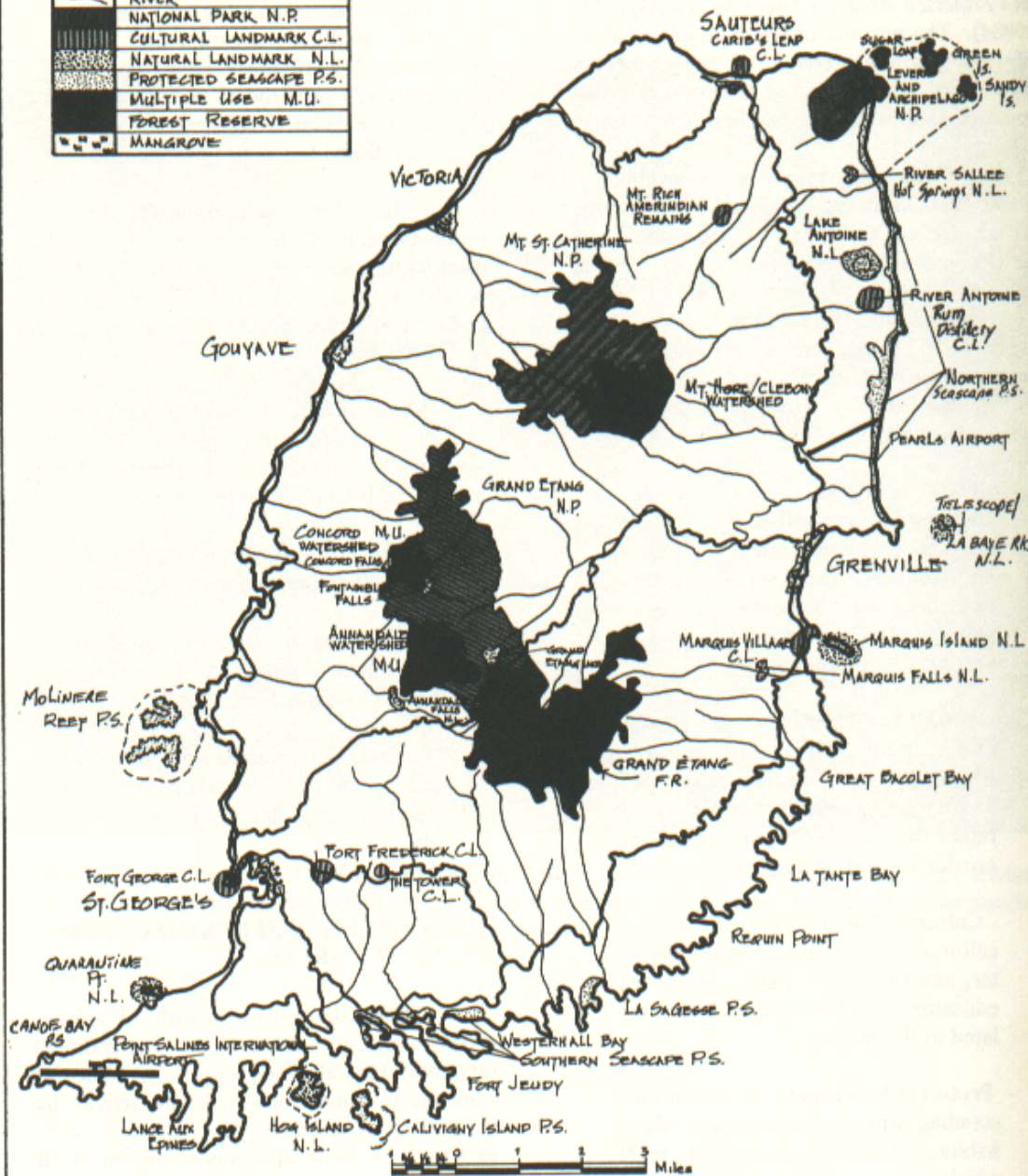
(Source: Environmental Profile, 1991)

GRENADA

National Parks and Protected Areas

LEGEND

	MAIN ROAD
	RIVER
	NATIONAL PARK N.P.
	CULTURAL LANDMARK C.L.
	NATURAL LANDMARK N.L.
	PROTECTED SEASCAPE P.S.
	MULTIPLE USE M.U.
	FOREST RESERVE
	MANGROVE

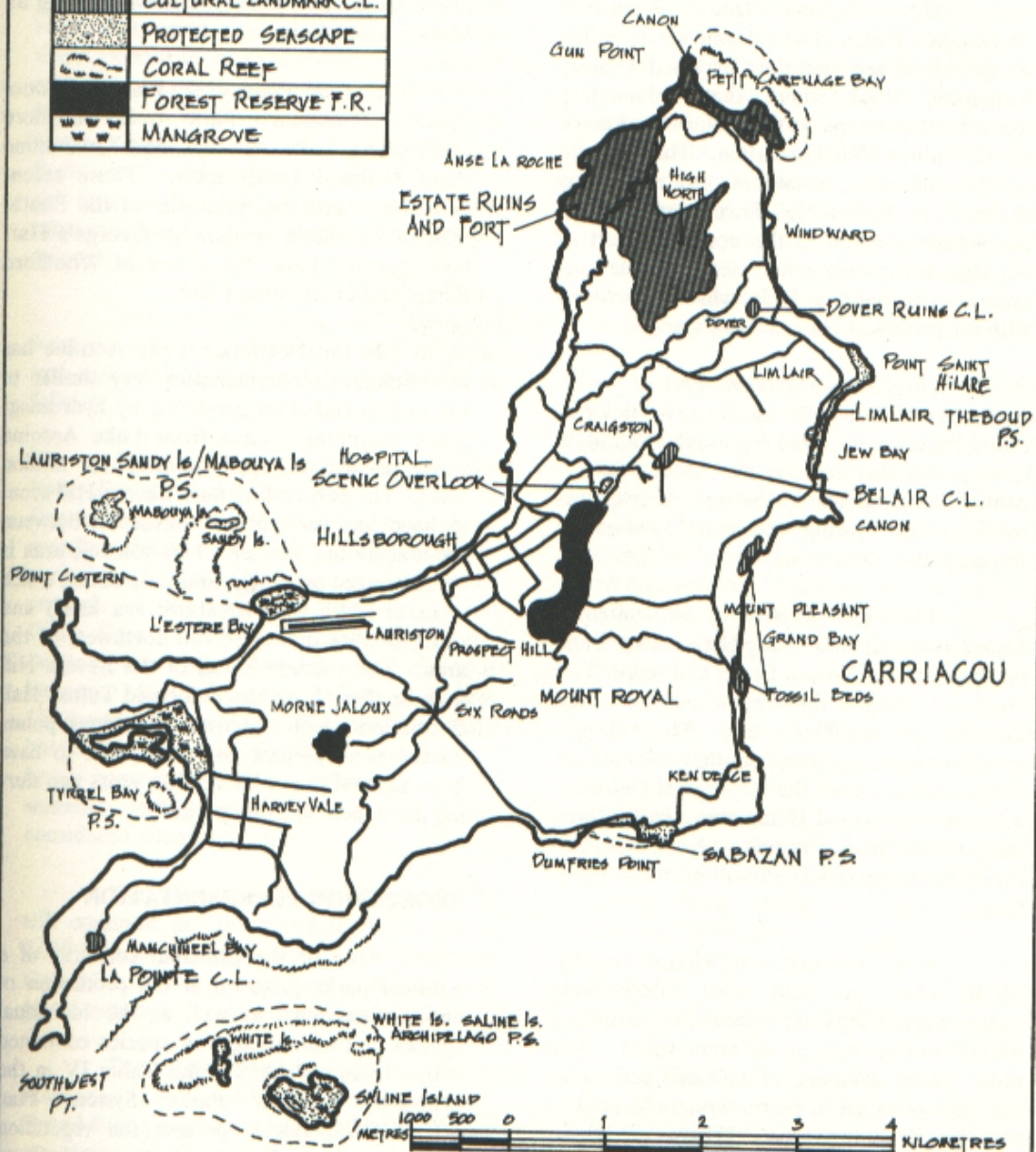


CARRIACOU

National Parks and Protected Areas

LEGEND

	MAIN ROAD
	NATIONAL PARK N.P.
	CULTURAL LANDMARK C.L.
	PROTECTED SEASCAPE
	CORAL REEF
	FOREST RESERVE F.R.
	MANGROVE



APPENDIX 5:

VULNERABLE AREAS TO EROSION AND INUNDATION (DIWI Consultant GmbH, Volume 2, 1994)

GRENADA

TABLE 1. CRITICAL AREAS OF CAREENAGE OR COASTLINE

AREA	Type of Coastline	Length of Afflicted Area (m)
Grand Anse	Beach	2,300
Felage	Headland	250
Melville Street	Coastal Road	1,200
Grand Mal Bay	Coastal Road	1,000
Beausejour Bay	Coastal Road	200
Dothan Bay	Coastal Road	400
Palmiste Point	Headland	200
Palmiste Bay	Coastal Road	200
Mabouya	Headland	250
Gouyave Bay	Coastal Road	200
Gouyave Bay	Coastal Road	400
Milet Bay	Headland	550
North of Gros Point	Headland	400
South of Point des Orties	Coastal Road	550
Bonair, South of Victoria	Headland	400
St. Mark's Bay to Victoria Town	Coastal Road	200
St. Mark's Bay to Victoria Town	Coastal Road	350
St. Mark's Bay	Coastal Road	250
St. Mark's Bay	Coastal Road	1,100
Waltham Estate	Coastal Road	500
Crayfish Bay	Coastal Road	600
Duquesne Point	Headland	600
Grenville Bay	Coastal Road	500
Grenville Bay	Coastal Road	1,000
Soubise Point/Battle Hill	Headland	400

CARRIACOU

Area	Type of Coastline	Length of Afflicted Area (m)
Harvey Vale	Beach	350
Harvey Vale	Mangrove	150
Lauriston	Coastal Road	1,125
West of Hillsborough	Coastal Road	500
Hillsborough Town	Beach	
Windward	Coastal Road	400
Jew Bay	Coastal Road	200

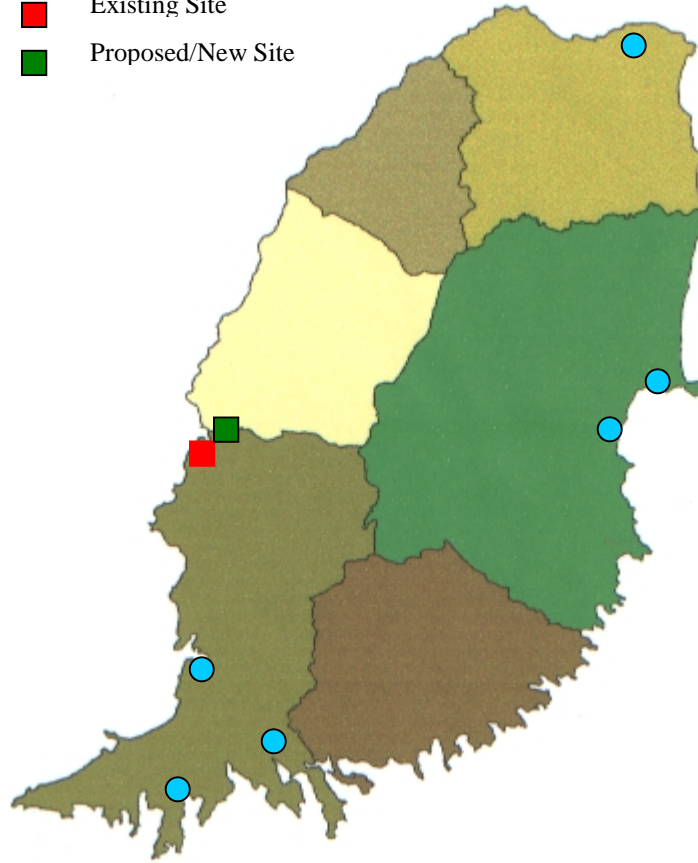
APPENDIX 6

AREAS OF SERIOUS COASTAL EROSION (Environmental Profile, 1991)

APPENDIX 7

PREVIOUS AND EXISTING SOILD WASTE DISPOSAL SITES (Adapted from Environmental profile, 1991)

- Previous Site
- Existing Site
- Proposed/New Site



APPENDIX 8

LIST OF PARTICIPANTS