The Government of Barbados

State of the Environment Report 2000

GEO Barbados

Barbados State of the Environment Report 2000
GEO Barbados

Published by the United Nations Environment Programme for the Ministry of Physical Development and Environment, Barbados

Prepared by: Ms. Vernese Inniss

Edited by: Mr. Derrick Oderson, Environmental Officer, Ministry of Physical Development and Environment, Barbados
and
Ms. Amrikha Singh, Research Officer, Ministry of Physical Development and Environment, Barbados

Designed by: G.D. Gerardo del Castillo Ramirez (timbomx@montevideo.com.uy)
Cover designed by: G.D. Iván Jiménez Thomas Gallegos
Cover photographs provided by Mr. Steve Devonish, Project Manager, Environmental Special Projects Unit, Ministry of Physical Develpment and Environment

For further information and details of how to obtain copies of this publication, please contact:

Dr. Leonard Nurse
Permanent Secretary
Ministry of Physical Development and Environment (Environment)
4th Floor, Frank Walcott Building
St. Michael
Barbados
Telephone: (246) 431-7663
Fax: (246) 437-8859
Email: meenr@sunbeach.net

Printed on Multiart paper free of wood, chlorin and acid, with Colortec vegetable oil-based ink complying with the environmental requirments of VOC, free of lead and clorofluorcarbons.

ISBN: 976 - 8079 - 52 - 5

FOREWORD

By the Minister of Physical Development and Environment, Government of Barbados

As Minister with responsibility for Physical Development and Environment, I have the honour to present Barbados' First State of the Environment Report. The report is the first major synthesis document of its kind, since the 1992 Barbados National Report to the United Nations Conference on Environment and Development. The purpose of the present report is to provide an assessment of selected key environmental resources, indicators and themes, identified by a wide range of stakeholders to be of vital importance to Barbados, if the goal of sustainable development is to be achieved.

The principal themes examined are land resources, energy and mineral assets, freshwater, coastal and marine resources, biodiversity, atmosphere and climate, and waste management. All of these are intrinsically linked to our economic and social development, and ultimately are important determinants of the quality of life we enjoy.

It is the Government's wish that the report should serve as an accurate source of information to all citizens, as well as international interests. It is also designed to provide a platform on which future analyses can be built and a yardstick against which Barbados' stewardship in the area of environmental resource management can be objectively assessed.

I am grateful to the staff of the Ministry of Physical Development and Environment and the numerous other individuals and institutions both in the private and public sectors, whose untiring efforts have made this report possible. I look forward to your continued collaboration in future efforts.

The Hon. H. Elizabeth Thompson, M.P.

Minister of Physical Development and Environment

December 2001

ACKNOWLEDGEMENTS

The Ministry of Physical Development and Environment is greatful to all the officers from the various Ministries, Government Departments and Statutory Organisations, the Private Sector agencies, and Non-governmental Organisations that assisted in the collection of the data contained in the report and who reviewed and offered comments on the various drafts of this report.

Special recognition must go to Ms. Vernese Inniss who prepared this report and to the staff of the Ministry who finalized the report. We acknowledge the support of Mrs. Atheline Haynes, former Permanent Secretary, and Mr. John Wilson, Senior Environment Officer (ag) in the preparation of this report.

Special mention must also be made of the assistance of the United Nations Environment Programme, Regional Office for Latin America and the Caribbean, Mexico (UNEP/ROLAC). In this regard special appreciation is extended to Mr. Kaveh Zahedi of UNEP/ROLAC for his cooperation and assistance.

MISSION STATEMENT

of the

Ministry of Physical Development and Environment

"Promoting and facilitating the sustainable use of our resources, encouraging the involvement of all citizens and the integration of environmental considerations into all aspects of national development"

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF MAPS

LIST OF APPENDICES

1 INTRODUCTION

Barbados has adopted Sustainable Development as the guiding principle in the use and management of its natural resources. Application of this principle requires an approach to national development that integrates social, economic and environmental dimensions into the overall framework of national development planning and process. This State of the Environment Report provides an assessment of the Barbados environment, based on current knowledge, that would contribute to that process.

The Barbados State of the Environment Report 2000 is intended as a guidance document that gives an assessment of the state and trends along particular themes considered important in the Barbados context. It is the first synthesis document on the environment prepared since the Barbados National Report to the United Nations Conference on Environment and Development in 1992. However, it does not set a limit on the information that would use 1992 as the base year. Rather, it attempts to provide a historical context to the assessment of current state and policy, using trend data over a longer time frame where possible.

Information for the report was drawn as far as possible from studies conducted in Barbados on the relevant themes, or from government reports and documents based on those studies. In addition, a draft synthesis document prepared by the Ministry of Physical Development and Environment (Barbados SOE 1999) provided useful information on policy and programme initiatives.

The first section sets the background by providing an overview of the physical/geographic nature of the environment and the socio-economic development of the country. It outlines the development parameters that exert pressure on the natural environment including the dynamics of a growing population and associated economic activity.

The themes addressed are: land resources, energy and mineral resources, freshwater resources, coastal and marine resources, biodiversity, atmosphere and climate, and waste. Each theme is discussed in the context of the current condition of the environment (state); the driving forces and root causes (pressures) - in the case of Barbados these pressures have a historical context and an attempt was made to provide this; the impact on humans and ecosystems (impact); and the policy measures, implemented and/or planned, to address these issues (response).

The report ends with a look at future perspectives on policies for sustainable development.

2.1 Introduction

Barbados is a small coral limestone island, the most easterly in the Caribbean chain (Map 2.1) With a land area of 431 square kilometres, it measures 34 kilometres from north to south and 23 kilometres from east to west. The coastline is 97 kilometres long, and it has jurisdiction over a 167 000 km2 Exclusive Economic Zone.

The resident population in 2000 was estimated at 268 402[1] making it one of the most densely populated countries in the world, with a density of 623 persons per square kilometre. The World Bank classifies Barbados as an upper middle-income country, given its Gross National Product (GNP) per capita of US$8 620 in the year 2000[2]. This ranking is indicative of the adjudged substantial economic progress the country has made, considering its very limited natural resource base.

Consistent with normal man-environment relations, there is a clear relationship between the natural environment and socio-economic conditions including: population size, growth and distribution; economic activity such as tourism, industry, agriculture and mining; settlement patterns and physical development; social and recreational activities; incomes; education; and lifestyles in general. All of these have implications for patterns of consumption and production on the island, and for the pressures that are placed on the extraction of natural resources as well of the disposal of wastes within the natural environment.

Map 2.1: Location of Barbados in the Caribbean

Source: Adapted from media maps.com available at http://media.maps.com/magellan/images/CARIBB-W1.gif

2.2 Physical Context

2.2.1 Climate

On its eastern side Barbados is exposed to the entire expanse of the Atlantic Ocean. Lying in the path of the prevailing North-east Trade Winds, the island has a moderate tropical marine climate with average annual temperatures of 30-32 degree Celsius. The rainfall is seasonal with a wet season from around June to October. Average annual rainfall is about 56-60 inches, most of it occurring in the central upland plateau. During the rainy season the island is affected by tropical depressions or tropical waves that originate to the west of Africa, and progress in a westerly direction across the Atlantic Ocean. Several of these often develop into tropical storms or hurricanes that bring severe weather conditions to the island. Records indicate that Barbados has been affected by 12 hurricanes and 15 gale-force storms, since settlement in 1625[3]. The most destructive is believed to have been hurricane Janet in 1955, the eye of which did not pass directly over the island.

2.2.2 Physiography

Eighty-six per cent of the island is capped by a coral limestone formation which gives the landscape a gently rolling topography, interrupted at points by deep gullies and a series of almost vertical cliffs that are old coral reef formations. The gullies extend from the central upland region to the coastline, and form an integral part of the island's natural drainage system.

For descriptive purposes Barbados is divided into twelve physiographic regions, which are illustrated in Map 2.2. There are (1) the Upland Plateau which, at an elevation of 130-330 metres, contains numerous low terraces and deep gullies; (2) the Leeward Coast region to the west of this plateau is joined at its southern end to (3) the Lowland Plateau , and together they bound the upland plateau to the west, south-west and south. These two regions comprise terraces separated by sloping coral outcrops. To the south of this is (4) the Lowlands region which widens at its south-western and south-eastern extensions. The south-eastern extension is interrupted by (5) the St. Philip Plain, a flat area of relatively poor drainage. The southern portion of the island is dominated by (6) the Christ Church Ridge, an anticline which rises to over 130 metres above sea level. Immediately north of this ridge is (7) the St. George´s Valley, a relatively fertile synclinal structure at about 35 metres above sea level. A narrow coastal plain borders the west coast, (8) Below the First High Cliff, and extends along the south-west and the southern coasts of the island. At the northern tip is the flat area of (9) the St. Lucy Plain and, completing the regions that constitute the limestone portion, six-sevenths of the island, is (10) the St. John´s Valley in the east.

The remaining one-seventh of the island comprises the Scotland District, which includes its southern coastal extension of the Below Cliff Area. This may be regarded as the most distinctive physiographic region of Barbados. The coral limestone cap has been completely eroded from this region, exposing the complex mix of impermeable clays that lay beneath. Map 2.3 shows the geology of the island, illustrating the contrast between the Scotland District and the limestone regions. The Scotland District is marked by highly rugged terrain compared to the rest of the island, and contains some of the most scenic landscapes on the island. It is the core area of the proposed Barbados National Parks System and Natural Heritage Conservation Areas.

2.3 Socio - Economic Context

2.3.1 Demographic Characteristics

(i) Population and Population Growth

Since the 1950s Barbados has been able to control its rate of population growth through the successful implementation of an island-wide family planning programme. Since then, overall economic development has also contributed to the attainment of an average rate of growth of 0.3 per cent between 1980 and 1999, attributing to the country a population growth rate comparable with that of most developed countries. Over the same period birth rates declined from 16.6 to 14.5 per thousand, and the overall rate of natural increase from 8.5 to 5.5 per thousand[4].

The declining rates of natural increase have been accompanied by reduced death rates, attributed

largely to developments in primary health care. Infant mortality rates dropped from 24.5 per thousand in 1980 to 10.0 in 1999, while the overall death rate during the period averaged 8.4 per thousand. Figure 2.1 reflects the result of these combined factors in the latter half of the twentieth century

(ii) Structure and Composition

An analysis of the population structure for the census years 1970, 1980 and 1990 shows that the population under 15 years old declined from 87 100 in 1970 to 62 000 in 1990. The estimated total for this group for the year 2000 was 57 707, accounting for 21.5 per cent of the estimated 2000 population. In contrast, the population over 60 years of age increased from 27 700 in 1970 to 39 900 in 1990. This represents a change from 11.7 per cent of the total in 1970 to 15.3 per cent of the total in 1990 (BESR, 1998), and 14.9 per cent of the total estimated for 2000. Figure 2.2 shows the structure of the population for the year 2000.

This trend of a gradually aging population is expected to continue as fertility rates decline and life expectancy increases. It is notable that the population of working age between 15 and 60 increased from 128 600 in 1970 to 160 300 in 1990 and estimated at 179 892 for 2000.

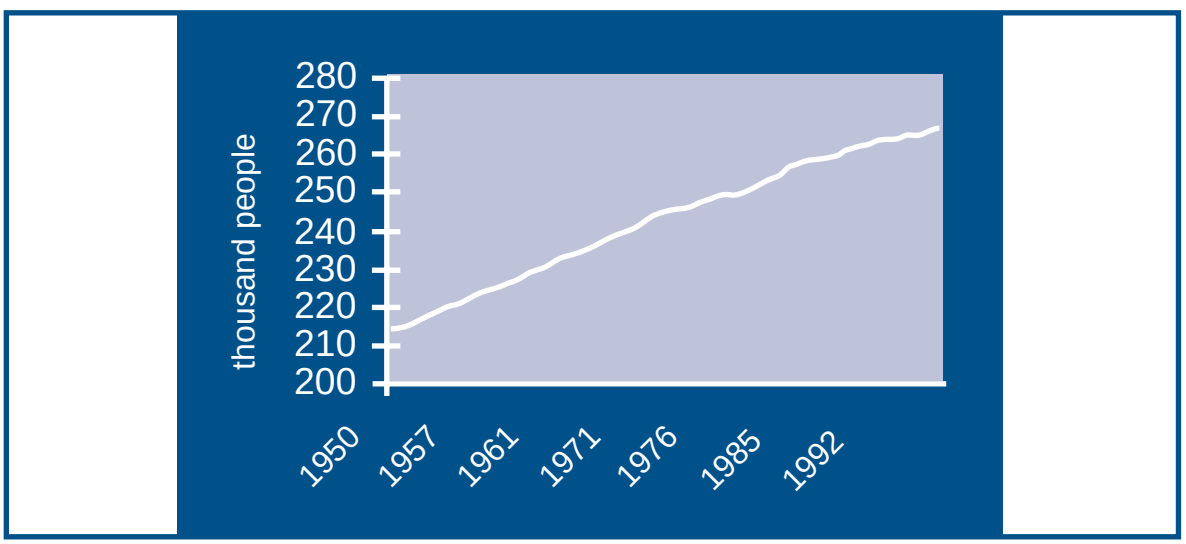
(iii) Education and Health

In light of the island's limited natural resources, the government of Barbados has consistently placed a very heavy emphasis on the development of its human capital. Government education budget allocation for the 1998/99 year was $310.5 million, up by 7.6 per cent over the 1997/1998 allocation of $280.3 million. While the school-age population between 5 and 18 has been on the decline for the past three decades, falling from 97 100 in 1970 to 66 800 by 1990, expenditure in this area has continued to be significant. As a result Barbados boasts a very high level of educational attainment, having a literacy rate of 97 per cent (or an illiteracy rate of 3 per cent)[5] among its over-15 age group of the population, compared to 12 per cent illiteracy for Latin America and the Caribbean and 10 per cent for the upper middle income countries as a group.

Barbados continues to place emphasis on primary health care, as reflected in the declining infant mortality rate and the relatively constant death rate. Adult life expectancy now stands at 76 years. Child malnutrition is present in 6 per cent of the population of children under 5 years[6].

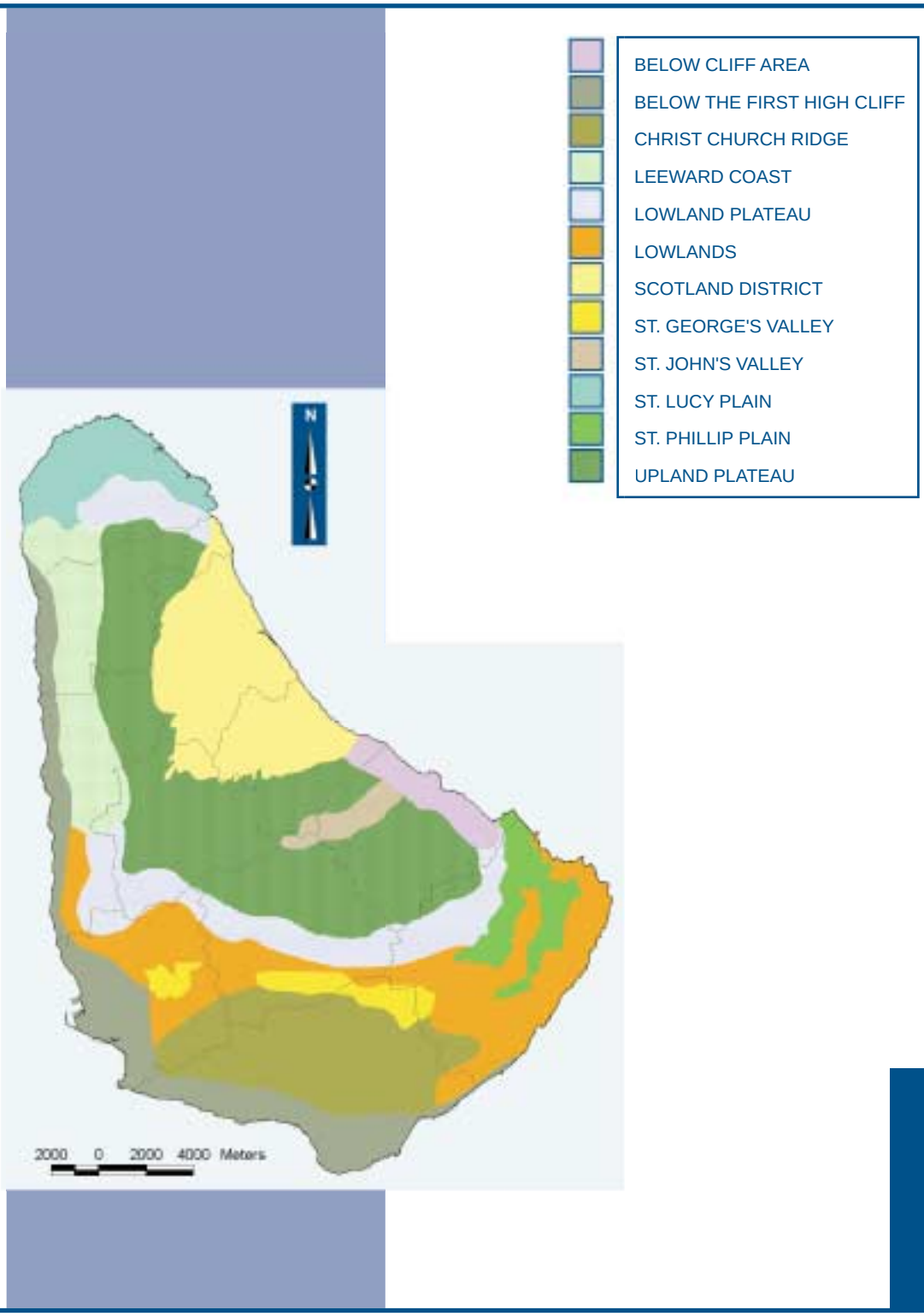
With respect to environment-related diseases, 23 cases of leptospirosis were reported and treated in

Figure 2.1: Population 1950-1998



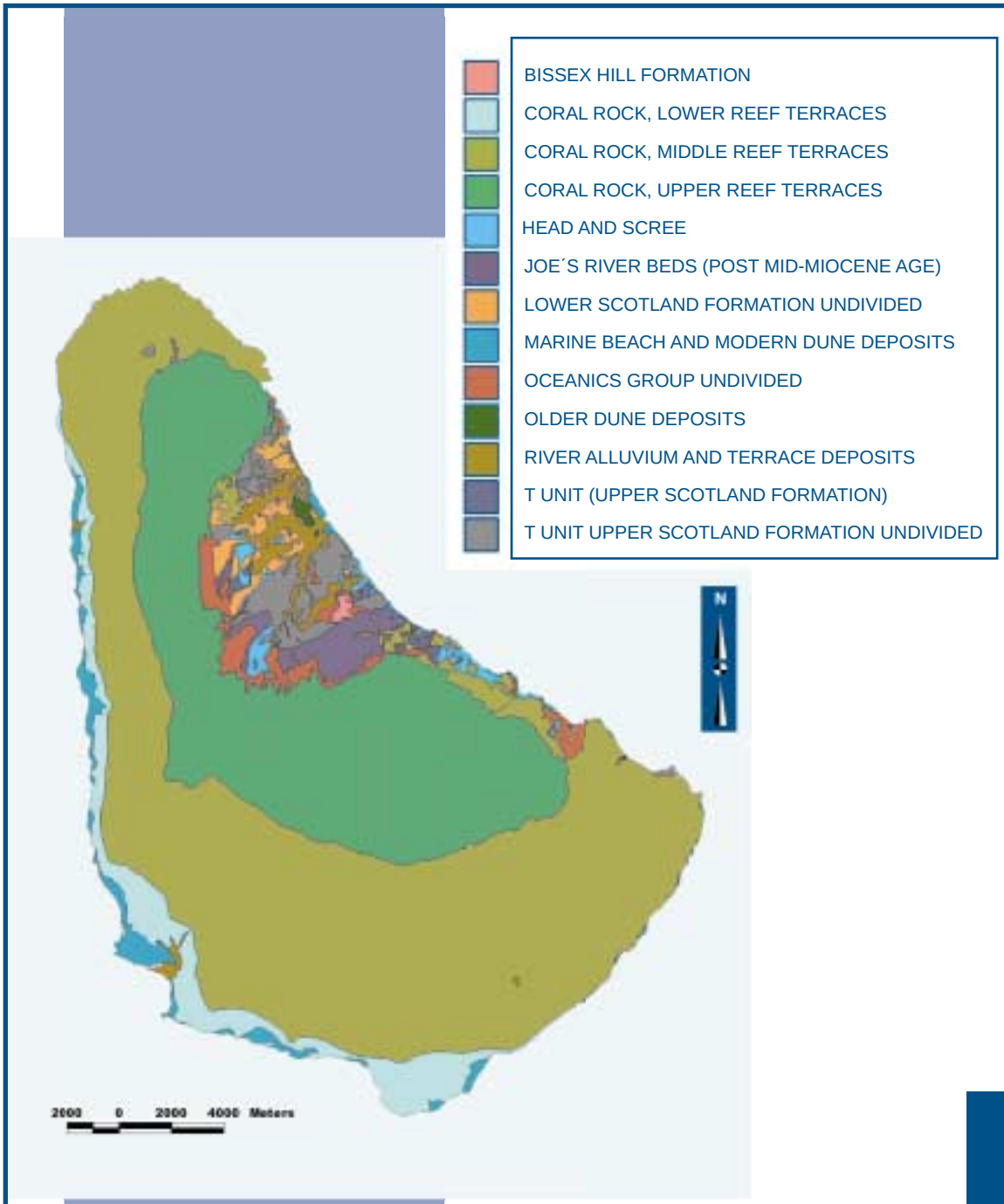
Source: Barbados Economic and Social Report 1998

Map 2.2: Physiography



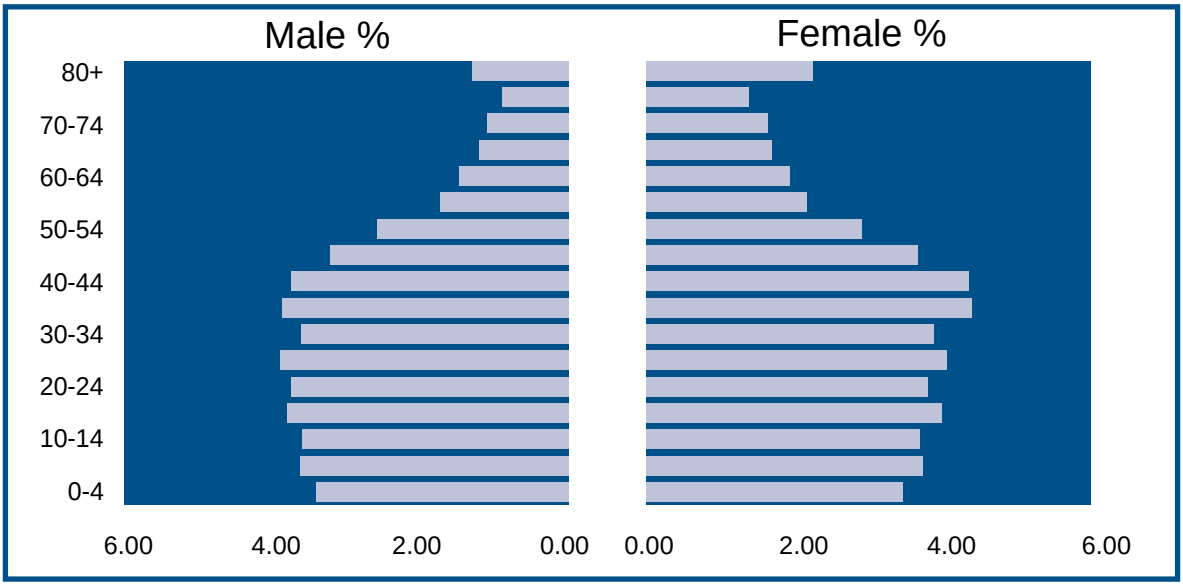
Source: The National Natural Resources Data Base, 1998.

ap 2.3: eology



Source: The National Natural Resources Data Base, 1998.

Figure 2.2: Population Pyramid 2000



Source: Barbados Statistical Services; based on 1990 Census.

1997, and these were down to 6 in 1998. Dengue fever is now considered an epidemic in Barbados, with 1 148 cases and 5 deaths recorded in 1998. The occurrence of all four viral strain-types of the disease has been confirmed. Mosquito surveillance activities conducted by the Ministry of Health revealed several locations of unacceptably high findings of the *Aedes* mosquito. The national vector control programmes, both for rodents and mosquitoes have been intensified (BSER, 1998).

(iv) Distribution and Settlement

The majority of the population is settled along the south-east, south and west coasts of the island, predominantly in the coastal areas of the parishes of St. Philip, Christ Church, St. Michael, St. James, and the southern reaches of St. Peter (please refer to Map 2.4). On an island-wide basis, there has been little change in spatial distribution. Some areas of growth do stand out, notably Christ Church, St. James and St. Philip, each of which experienced above normal rates of growth over the last 20 years. This is believed to be 'suburbanization' from the Bridgetown area. It is projected that this trend will continue, leading to the gradual increase in densities to the northwest, north and east of Bridgetown, while most other areas will remain relatively stable (Table 2.1).

Barbados' socio-economic development has been marked by increased demand for land for urban and suburban development, and declining amounts under agriculture. The Barbados National Report to Habitat II (1997) presents data suggesting that the percentage of land for residential and business development increased over the period 1966 to 1996, and notes that land previously identified for agricultural purposes has been subdivided for residential and business uses.

Directly associated with land subdivision is the demand for housing. A recent assessment of socio-economic conditions and trends[7] notes that in 1997 the existing housing stock numbered approximately 80 000, with an estimated growth rate over the next ten years in the region of 1 000 dwellings per year. Given the characteristically low densities with which new housing is being developed it is expected that, based on already approved subdivisions, significant amounts of high quality agricultural land is likely to be absorbed. In fact one scenario projects a need of 13 500 new residential lots, requiring 1 100 hectares of land[8].

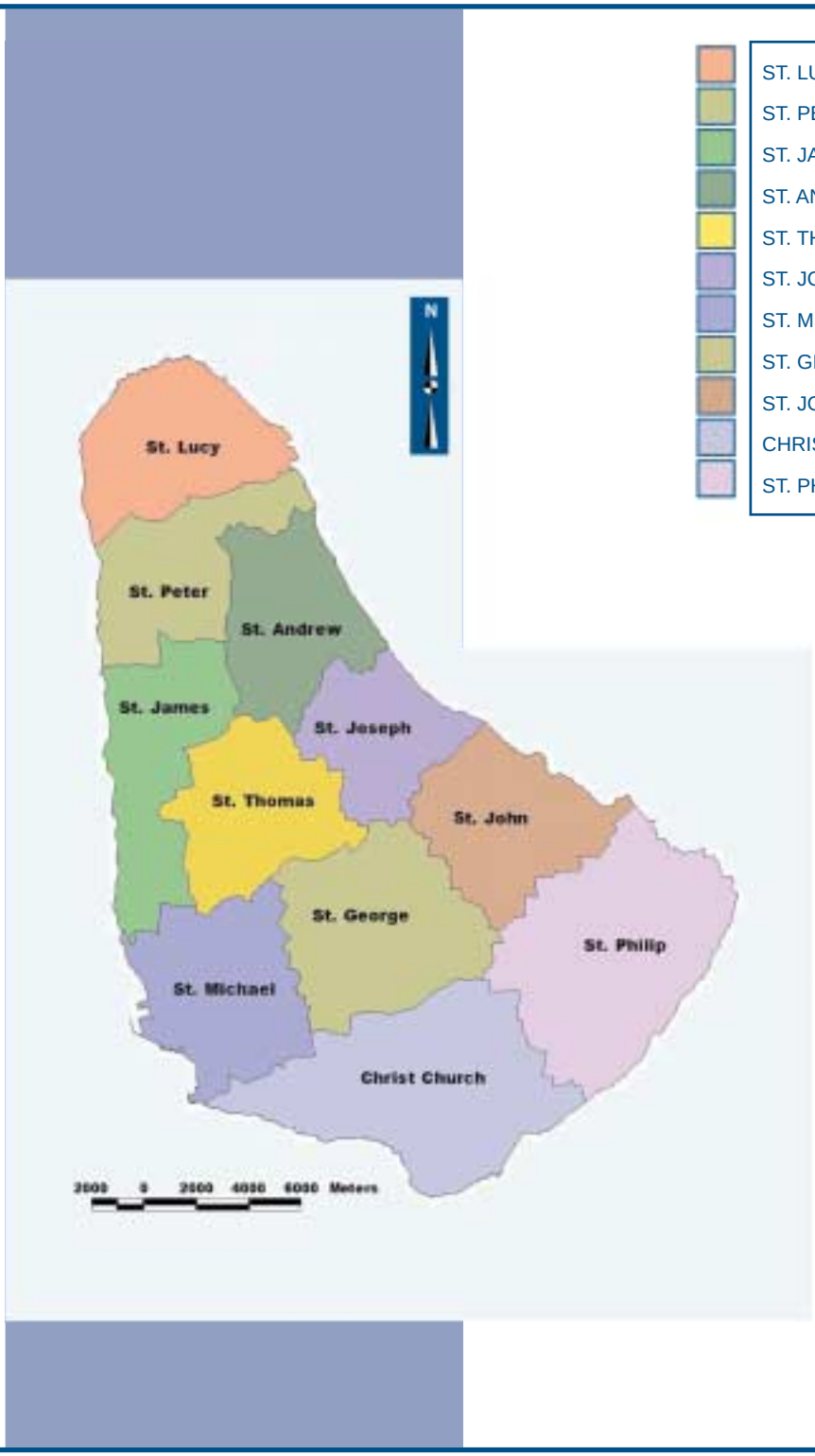
It is to be noted that these projections do not include residential developments associated with approved golf course developments in the tourism sector.

Table 2.1: Parish Population Projections

	Population				Change
Parish	1990	1997	2005	2010	1997-2010
St. Michael	97,516	95,600	92,300	87,900	-7,700
Christ Church	47,050	51,300	55,900	60,000	8,700
St. George	17,905	18,100	18,100	17,800	-300
St. Philip	20,540	21,700	22,800	23,600	1,900
St. John	10,206	9,900	9,400	8,800	-1,100
St. James	21,000	24,200	28,100	32,100	7,900
St. Thomas	11,590	11,800	11,900	11,800	0
St. Joseph	7,619	7,400	7,100	6,700	-700
St. Andrew	6,346	6,000	5,600	5,100	-900
St. Peter	11,263	11,300	11,200	10,900	-400
St. Lucy	9,455	9,600	9,600	9,500	-100
BARBADOS	260,491	266,900	272,000	274,200	7,300

Source: Willms & Shier, 1997a.

Map 2.4: Parishes



Source: The National Natural Resources Data Base, 1998.

2.3.2 Socio-Economics and the Environment

The main natural resources of Barbados are its arable land which has traditionally supported a strong agricultural sector, its coral sand beaches which have been the central attraction for the tourism industry, and the more recently exploited petroleum reserves that occur in scattered areas of the east and south-central parts of the island. Available marine resources support a small fisheries sector and also contribute to tourism.

In addition, population change and most forms of economic activity exert pressure on the environment. For example, while Barbados has in recent years placed much emphasis on developing its services sector, the growing importance of tourism in the national economy has seen the ratio of stay-over tourists to local population increase from 0.7:1 in 1970 to almost 2:1 in 1999[9]. The increased pressure from these numbers, along with growth in other sectors and the consumption patterns associated with increased incomes and the changing lifestyles of a generally more affluent population, demand a stronger focus on management of the environment and natural resource base.

The environmental pressures from these sources are also evident in the state of water resources, energy consumption, waste generation and disposal, and in the coastal and marine environment. For example, total potable water consumed in 1998 was 57.0 mn m^3 (million cubic metres) compared to 45.4 mn m^3 in 1988 and 39.7 mn m^3 in 1978. Given that Barbados has been ranked among the ten most water scarce countries in the world, the rates of increase in consumption hold important health and environmental implications. Additionally, energy consumption, which is commonly used as an indicator of economic growth, has also increased. Between 1990 and 1998 final energy consumption per capita rose from 5.7 boe (barrels of oil equivalent) to 8.9 boe.

An important implication of the foregoing population and development changes with regard to the environment is the generation and disposal of solid waste. This is an area of major concern because the availability of landfill sites, already limited by the small amount of land area and the high population density, is further restricted by the fact that all of the potable water resources are drawn from aquifers in the limestone. Over the last decade, therefore, the issue of waste disposal became the most controversial environmental issue in the country, and one which the government is seeking to address through implementation of a comprehensive waste management plan.

2.4 Conclusion

Given the physical limits of the natural resource base of Barbados, the demographic and socio-economic dynamics of the country are interacting in ways that demand careful management. This management is necessary to arrive at a balance that promotes sustainability while providing an acceptable quality of life for the people.

Barbados is now seeking to rationalise the environmental management structures and the processes necessary for achieving sustainable development. These efforts should see a closer integration of economic and social development and environmental management policies, programmes and strategies in the not too distant future.

Notes

1. Barbados Statistical Services population based on 1990 census data
2. World Bank, 2000. Available at http://wbln0018.worldbank.org/
3. This data is referenced up to 1996. Ellis Burnham; "Did You Know That Barbados…?" Available on the Barbados Tourism Encyclopaedia website at: http://barbados.org/diduknow.htm. It should be noted that the British landed on the island and claimed it in 1625, but started to establish settlement in 1627.
4. See 1 above.
5. See 2 above. The World Bank presents this as an "illiteracy rate" of 3 per cent of the over 15 population.
6. Ibid.
7. Willms & Shier, 1997a: *Environmental Management and Land Use Planning for Sustainable Development: Socio-economic Conditions and Trends.*
8. Ibid.
9. The Barbados Statistical Services records the 1970 population as 238 700 and the tourist stay over arrivals as 156 417, while the 1999 figures are 267 400 and 517 870 respectively.

3.1 Introduction

The term "land resources" is usually used to refer to natural resources such as soils, minerals, and a wide range of ecosystems that occur as part of the topography, terrain and physiography of the land. Pre-colonial Barbados was well endowed with a wide range of these resources as might be expected of most natural tropical island ecosystems. In modern Barbados, however, much of the original biodiversity resources have been drastically depleted, and non-living resources are impacted by several competing uses.

The state of land resources is fundamentally a function of its geological structure and topography. Related to these are such features as erosion patterns and rates, shoreline configuration, soil chemistry, direction and rate of groundwater movement, slope stability and others. These and other physical characteristics are important in influencing the natural as well as man-made systems that develop and impact on the land. The nature and extent of human impact on the land is closely related to these physical conditions, as well as to the occurrence of fertile soils and valuable minerals. In the case of Barbados, the demand for land for housing development and attractive sites suitable for tourism development are becoming increasingly important.

This section primarily reviews agricultural resources, particularly issues of soil stability, conservation and management. Other land uses are included as they relate to impacts on agricultural land. Non-living resources such as minerals, and living land resources such as forestry will be dealt with in subsequent sections.

3.2 Land Use

Land allocated for various uses in Barbados has undergone notable change over the past three to four decades. The clearest data related to these changes are contained in the Barbados Report to Habitat II (1996). According to that report, over the period 1966-1976 the land allocated for urban development increased from 21.2 to 37.6 per cent, while the amount of arable land declined from 57.7 to 46.2 per cent. In 1976, 62.2 per cent of total rateable[1] land was used for sugar plantations and tenantries, 26.4 per cent for residential with agriculture and commerce, 9.8 per cent for residential alone and 1.6 per cent for tourism, commerce and industrial activities. Recent data for 1995/96 indicate that 27.3 per cent of total rateable land was used for residential purposes, while 63.3 per cent was used for agriculture and 9.1 per cent for business activity.

It is difficult to ascertain clear trends in land use change from these data. However, recent projections suggest that land previously allocated to agricultural use has been, or is at risk of being, reassigned to residential and other development (for example in the areas of St. Thomas, St. George and St. Michael). A 1997 review of socio-economic conditions and trends[2], for example, projected that by the year 2010 some 13 500 new housing lots would be needed, requiring 1 100 hectares of land, unless the demand could be met from existing vacant lots. It is further projected that approximately 1 400 hectares of land will be needed over the next 30 years to accommodate the expanding population.

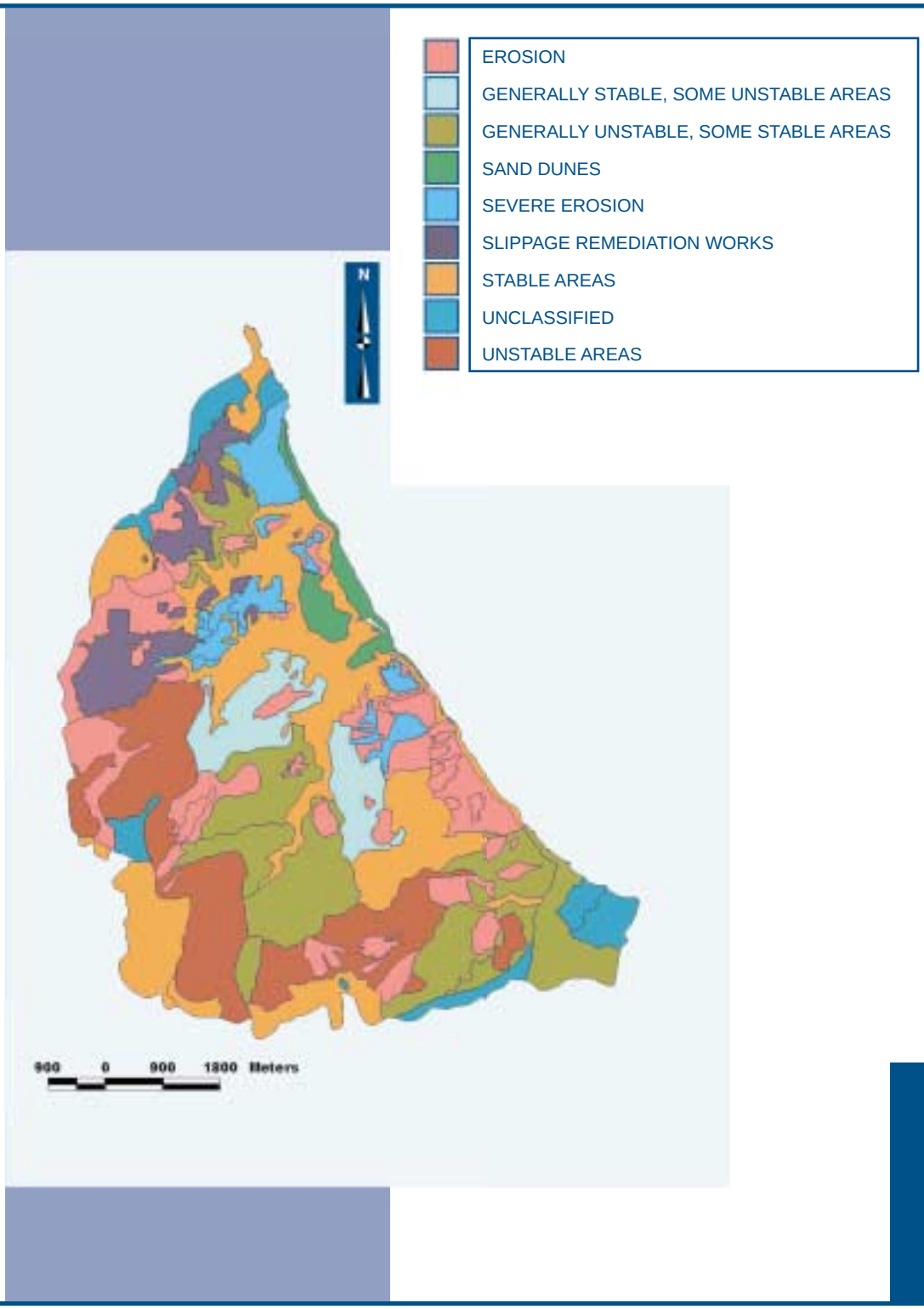
These changes give some indication of the pressures on Barbados' land resources that result in environmental impacts. Expanding settlement areas increase the coverage of hard surfaces that result in increased runoff and potential for flooding, while inappropriate agricultural practices lead to soil erosion.

3.3 Agricultural Land Use

The 1989 Agricultural Census indicates that about 80 per cent of the total land area (approximately 34 500ha) was allocated to agriculture, with the next highest allocations being natural pasture (7.55 per cent) and roads and buildings (7.18 per cent). By 1997 the National Report to the UN Commission on Sustainable Development (1996) recorded that the area under agriculture was 16 450 ha, while the 1997 review of socio-economic trends gave the figure as 21 000 ha in agriculture, of which 4 000 ha were idle. Both these latter reports suggest a substantial decline from the 1980 census figures.

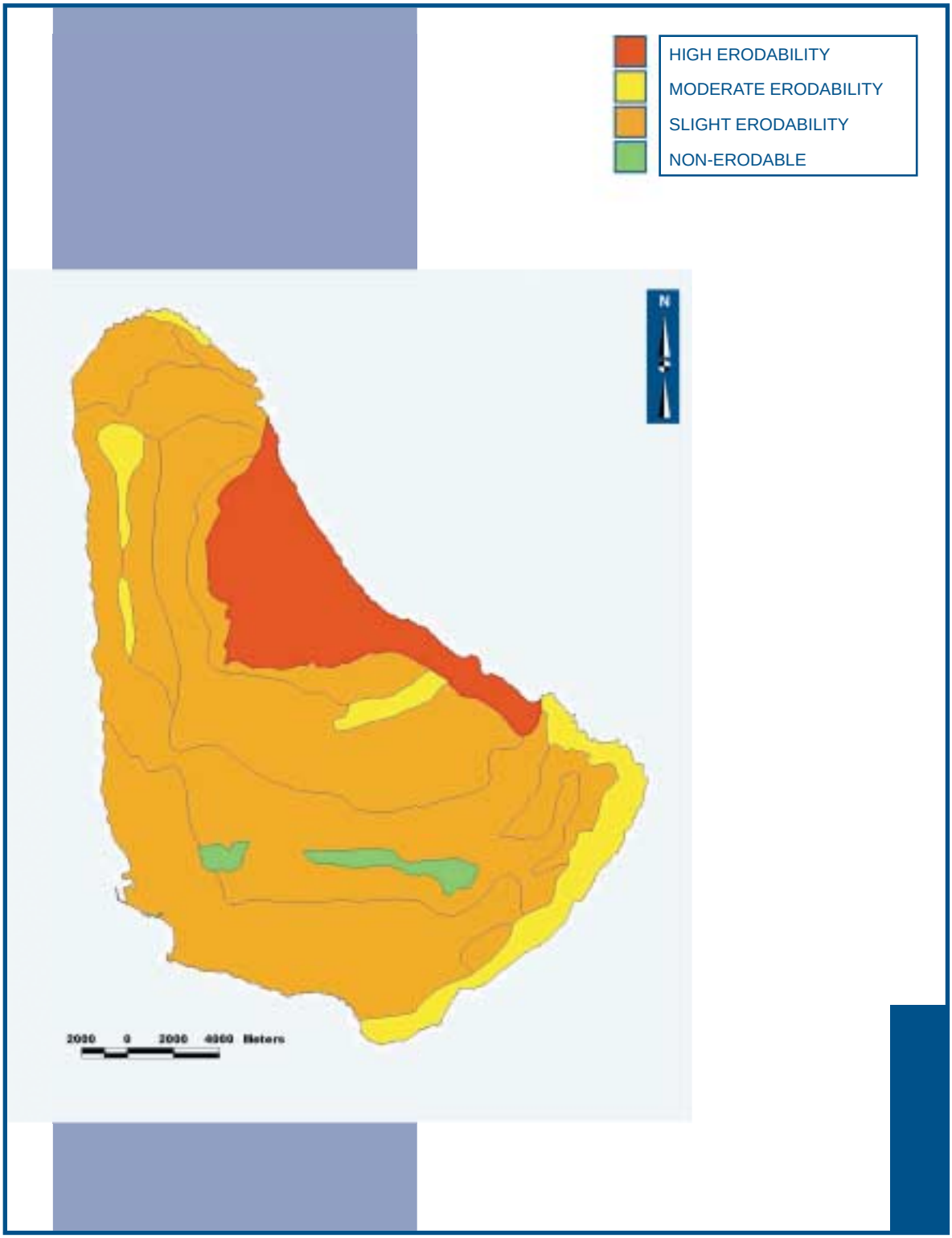
Other useful indicators of agricultural land use change are the change in acreage under sugar cane cultivation, change in the number of sugar estates and in the number of small holdings[3]. The area of sugar cane harvested declined from 20 200 ha in 1965 to 7 900 ha in 1993. The number of small holdings fell from 27 626 in 1961 with a total acreage

Map 3.1: Scotland District Slippage Rate



Source: The National Natural Resources Data Base, 1998.

Map 3.2: Island Wide Soils by Erodability Category



Source: The National Natural Resources Data Base, 1998.

of 12 546, to 16 951 in 1989 and an acreage of 7 880. Similarly, the number of estates declined from 286 in 1961 to 227 in 1989, with a corresponding decline in acreage from 71 910 to 45 395[4].

The decline in agricultural land is often attributed to socio-economic factors such as the growth in urban population and in non-agricultural activities in the economy, as well as declining values of agricultural commodities in international trade (e.g. sugar). Whatever the causes, the decline in acreage under agriculture as well as changes in agricultural practices also lead to increased pressure on, and declining quality of arable land in Barbados.

3.4 Impacts of Land Use

3.4.1 Land Slippage

The Scotland District area is naturally prone to land slippage due to its geologic and topographic characteristics. Historically this has been a major area of concern and, consequently, the focus of significant efforts to control human activity and stabilize the area. The Scotland District is composed of soft bedrock, soft and incompetent soils, steep and moderate slopes, and the issuance of ground water at the interface of the limestone cliff and underlying oceanic series to form surface water in this region. These factors all combine to cause mass movements of minor and major proportions.

The above-mentioned natural conditions are exacerbated by housing construction and inappropriate farming practices that involve the over-steepening and weakening of slopes. This has resulted in severe land slippage and associated damage to property and risk to life, particularly after prolonged periods of heavy rains. Map 3.1 shows slippage rates of lands in the Scotland District.

3.4.2 Soil Erosion

Map 3.2 shows the erodability of soils island-wide. The most highly erodable soils are clearly located in the Scotland District. Figure 3.1 shows erosion rates on plots of bare land over the period 1985 to 1990. However, the limestone regions have experienced significant levels of erosion due mainly to human activity, rather than to natural physical conditions as is the case in the Scotland District. The clearing of land and application of inappropriate agricultural techniques are the major causes of the problem.

The problems of topsoil loss began with extensive clearing of forest for agriculture during the colonial period, and consequent exposure of the underlying soil. The problem persists today due to several factors including[5]:

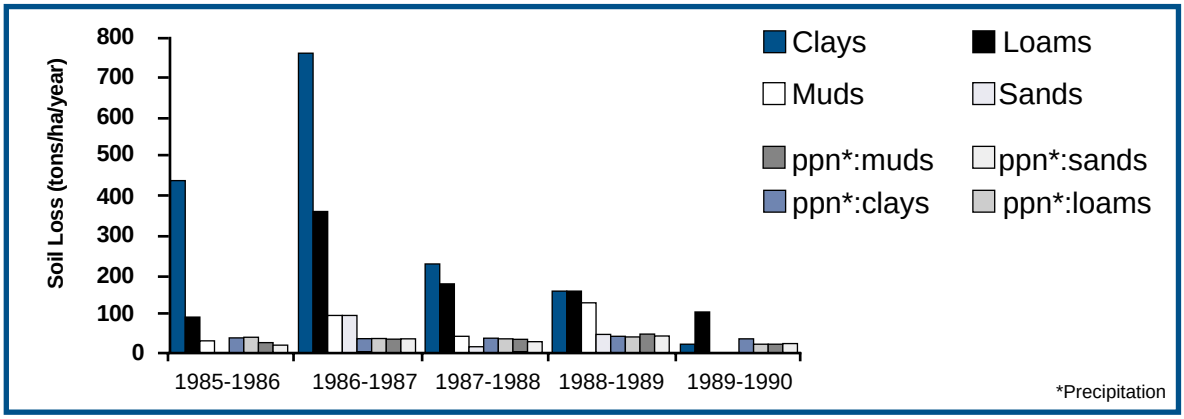
- The clearance of land for construction, which results in loss of surface shoots and subsurface roots, thereby increasing the vulnerability to landslides;
- The lack of maintenance and almost complete breakdown in the formerly extensive system of check-dams in gullies, and of cane-field suck-wells, both of which were used to direct surface water into the underground aquifer;
- The Use of non-specific herbicides that kill total ground cover and promote soil runoff, and
- The Replacement of the cane-hole planting system by cross-contour ploughing and furrowing, thereby encouraging runoff instead of water retention in the topsoil and aquifer.

These practices have several environmental impacts down-stream. First, the resultant runoff removes the topsoil and creates an environmental hazard in the near-shore marine area, especially to reef systems, and causes loss of soil structure and soil fertility in agricultural areas. Secondly, it carries pesticides and nutrient rich fertilizers to the sea, impacting negatively on the marine environment. Thirdly, it transports solid waste and organic wastes from gullies to the sea, with potential environmental and public health consequences.

3.4.3 Flooding

Surface drainage is a normal year-round occurrence in the Scotland District. In the limestone areas, however, prolonged heavy rainfall can cause flooding in certain known densely populated low-lying areas on the west and south coasts of the island. Annual runoff is estimated at between one and three per cent of precipitation. A major flood has historically occurred once every twelve years, but nuisance flooding occurs on an annual basis in flood-prone areas[6]. These areas are found in the

Figure 3.1: Soil Erosion on Bare Plots in the Scotland District 1985-90



Source: Soil Conservation Unit, 1992[7].

southern part of the island, across the St. George Valley and extending into areas around Hampton, Groves and River in St. Philip (Map 3.3. Also see Map 2.3 for Parish names).

The human activities that lead to flooding in Barbados include:

- clearance of vegetation;
- unauthorized construction on former wetland areas;
- unauthorized development in other flood-prone areas;
- urbanization which involves the spread of hard surfaces and causes increased runoff;
- inappropriate disposal of debris and solid waste in drainage structures and in natural gullies;
- failure to provide appropriate roadside drainage systems, and
- failure to provide adequate bridge and culvert capacity.

The result is the erosion of topsoil and the conveyance to the sea of this, along with animal waste and garbage from gullies, and pesticides and fertilizers. The potential environmental and health impacts include the spread of infection from stagnant water that remains after flooding, and contamination of groundwater and of near-shore marine areas. Also associated with flooding is blockage at outlets to watersheds, particularly in the Holetown, Speightstown, Brandons and Graeme Hall areas.

3.5 The Institutional and Policy Response

The overall responsibility for land-use planning resides with the Town and Country Development Planning Office (TCDPO) and its enforcement of the Town Planning Act (1963). The TCDPO also has responsibility for preparing the National Physical Development Plan every five years, to guide the efficient allocation of land among the various competing uses. The most recent is the revised 1998 Physical Development Plan (PDP), which covers a planning period extending up to the year 2010. With respect to developments affecting agricultural lands, the TCDPO is guided by the Ministry of Agriculture and Rural Development.

With respect to most activities associated with agricultural land, there is no direct government control. Existing legislation includes the Soil Conservation (Scotland District) Act (1959) which guides operations in that section of the island. This Act is executed by the Soil Conservation Unit (SCU) of the Ministry of Agriculture and Rural Development. Since 1957 the SCU has undertaken extensive slope rehabilitation works in the Scotland District. The Unit also reviews all development proposals involving permanent structures in the area, with the view to preventing construction in areas prone to erosion and land slippage.

Map 3.3: Surface Water

Source: The National Natural Resources Data Base, 1998.

The Agricultural Sector Plan (1993-2000) was prepared to ensure that practices within the agricultural sector serve to maximise productivity and ensure optimal use of land available for agriculture, promote the adoption of farming systems which are environmentally friendly, and ensure preservation of adequate areas of arable land for future generations. Strategies adopted under the Agricultural Sector Plan include the reservation of 45 000 acres of land for agricultural use, and provision of financial incentives to encourage the re-use of abandoned arable land for agriculture. Additional strategies for environmental protection and conservation include, among others, promoting measures to reduce soil erosion, proposed legislation for sound water and soil conservation strategies, promotion of organic farming and reduction in use of chemicals in agriculture, and farmer education programmes regarding the safe use of chemicals.

In general, the preferred strategy to reduce or eliminate adverse impacts of agricultural practices on the land is to educate agricultural operators about the issues and about alternative ways of meeting their production objectives. As part of this strategy the Ministry of Agriculture and Rural Development provides education and information pamphlets to the farming community. This activity is expected to continue and be expanded.

With respect to drainage control and flood prevention, the Drainage Unit of the Ministry of Public Works and Transport has responsibility for all aspects of evaluation of development, monitoring and reporting on such matters. This Unit functions under the Prevention of Floods Act (1952) which provides for flood prevention works and the designation of special flood areas.

A 1996 study of Storm Water Drainage in the Bridgetown urban area, the West Coast and the South Coast updated an earlier (1973) study. The 1996 study included recommendations regarding, among other things, groundwater recharge, control of storm water runoff from agricultural areas, and institutional and legislative matters. These recommendations are at varying stages of implementation.

The TCDPO also has responsibility under the 1963 Town and Country Planning Act, in areas relevant to the land use policies of the 1998 revised PDP. Specifically, the PDP requires, among other things, that all new construction and land clearing is done in accordance with a Sediment Control Plan, and that new development not be permitted in Observed Flood Areas unless storm water drainage deficiencies within the area have been corrected to the satisfaction of the Drainage Unit[8].

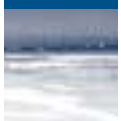
Finally, the proposed Environmental and Natural Resources Management Plan offers a number of recommended new management actions in all the areas of land resources management addressed in this section. These will be presented in the final section which deals with imperatives for action.

3.6 Conclusion

It appears that a considerable amount of the 80 per cent of total land area reported by the 1989 agricultural census to be under agriculture is changing fast. It is estimated that land continues to be alienated from agriculture at the rate of approximately 400 hectares annually, which is a much faster rate than the 80 hectares annually estimated in the 1988 PDP[9]. Several efforts are already under way to address the environmental implications of these changes. Further, the regeneration of natural vegetation on abandoned agricultural lands could have positive implications for biodiversity, runoff and aquifer recharge. However, given the importance of land and agriculture to the natural, cultural and economic character of the island, future policy could benefit from wider public discourse on the opportunities and constraints of competing land uses.

Notes

1. The Report does not provide a definition of “rateble land”.
2. Willms & Shier, 1997: Socio-Economic Conditions and Trends. Prepared as part of the project on Environmental Management and Land Use Planning for Sustainable Development. Minstry of the Environment
3. Farms under 10 acres in size.
4. Habitat II: Barbados National Report and Plan of Action, with statistics from the Censuses of Agriculture.
5. Willms and Shier, 1998. Environmental and Natural Resources Management Plan. Government of Barbados.
6. Soil Conservation Unit, 1992. Final Report: Ex-Post Evaluation of the Inter-American Development Bank/Government of Barbados Scotland District Soil Conservation Project.
7. Ibid.
8. Ibid.
9. See 2 above.



4.1 Introduction

Primary mining activity in Barbados involves the quarrying of limestone, sand, shale, clay and fossil fuels (natural gas and oil). Limestone occurs throughout the coral cap that covers the majority of the island except for the Scotland District where pockets of limestone occur, and is mined in pockets scattered about the north, west and southeast of the island. Sand and clay are found largely in the Scotland District. Hydrocarbon (fossil fuel) deposits are mainly in the southeast and central parts of the island.

The contribution of the mining and quarrying sector to Gross Domestic Product (GDP) is relatively small (0.6 per cent). However, it is an important part of the construction sector, which contributes six per cent of GDP. Similarly, domestic crude oil and gas production has played an increasingly important role in the energy sector since the 1970s.

4.2 Quarrying

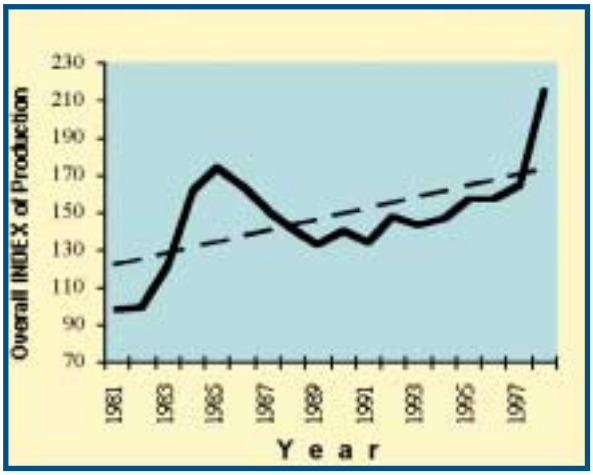
Available in abundant supplies, limestone is mined from 11 active quarries across the island. It is used for the production of cement and slaked lime, as building blocks, as aggregate in concrete blocks for building construction, and in road construction. Sand used for construction is scarce and has been overmined from the available sand dunes in the Scotland District, primarily from the Walkers sand dune. Comparable sand deposits are located in the "Murphy Formation" of the Scotland District. New mining strategies are being investigated to utilize these deposits.

Clay is mined at Greenland and is used in the cement, ceramics, tile and clay and brick industries. A shale quarry exists solely for the purpose of Portland Cement Production.

Estimates of total quarry reserves are not readily available but can be obtained from the Energy Division upon request. Information on the quantity of mineral resources extracted is available only as an aggregate index of production of the total mining and quarrying sector. Trends, using this highly aggregated data, are illustrated in Figure 4.1[1].

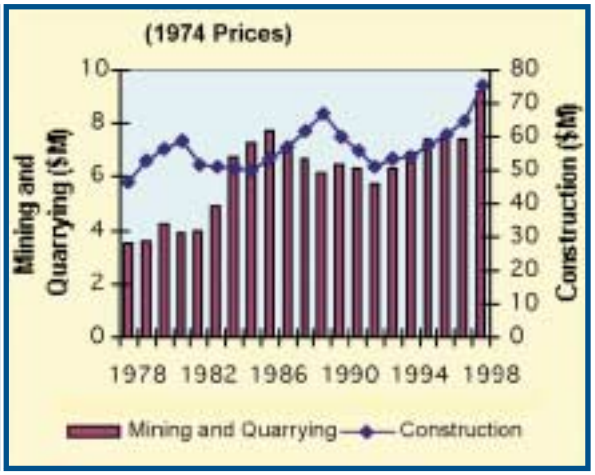
A comparison of the contribution of quarrying and mining to GDP with that of the construction sector shows some similarity in pattern[2], particularly since 1982 (Figure 4.2). While this is not conclusive, except for fuel and electricity from crude oil, quarry products are almost entirely used in the construction sector and therefore the comparison may be regarded as indicative of pressure on this resource. Expansion in the construction sector, such as that which has occurred since 1983, is associated with increased quarrying activity.

Figure 4.1: Index of Mining and Quarrying utput 1981-1998



Source: National Indicators Programme, Ministry of Physical Development and Environment.

Figure 4.2: Contribution of Mining and uarrying and Construction to GDP 1978-1998



Source: Barbados Social and Economic Report 1998.

4.3 Impacts of Quarrying

Indications of the occurrence of environmental impacts exist in the form of varying periods and intensity of "haze" over quarries, and dust deposits on buildings and vegetation in the vicinity of quarry sites. Observations of air quality conditions have given rise to concerns regarding the potential health and environmental impacts of noise and particulate matter emitted from quarry operations and the off-site transportation of the materials. While no studies exist to date to actually link operations to impacts, residents of some locations attribute respiratory problems to quarry operations.

Illegal mining in the coastal area of Walkers Savannah, St. Andrew has the potential for intense physical and ecological impacts in this sensitive coastal environment. The mining of the sand dune can expose the Walkers Valley to salt laden onshore winds, which can affect agricultural lands located there.

The visual impact and incompatibility of mining operations in this area, which falls within the proposed Barbados National Park, is also a major source of concern.

Other possible impacts include the loss of vegetative cover, creation of visible scars on the topography and the damage to or disappearance of sand dunes. These factors underscore the need for the implementation of feasible quarry abandonment rehabilitation programs.

4.4 Fossil Fuel Extraction

Barbados possesses some exploitable reserves of crude oil and natural gas, and produces liquid petroleum gas and condensate. Crude oil is the most important of these fossil fuels in terms of quantity and value. In 1991 proven reserves of crude oil stood at 3.3 million barrels, with 6070 million cubic feet of natural gas reserves. In 1998 these figures were down to 2.5 million barrels of crude oil and 4.60 cubic feet of natural gas. Production trends for both these resources are presented in Figure 4.3[3].

Oil exploration assumed considerable importance because of the experiences of the 1970s and 1980s oil crises. Up to the 1970s Barbados was almost entirely dependent on imports of oil to satisfy its fuel energy needs. The 1978 domestic production of 271 647 barrels of crude represented 26.6 per cent of total crude oil supply, and in 1997 the production of 327 806 barrels represented 20.2 per cent of supply[4]. With the closure of the local (Mobil) oil refinery in 1998, domestic crude oil is now exported to Trinidad and Tobago for refining, and all refined fuels are imported.

As Barbados' economy is largely a service-oriented one, energy consumption may be an important indicator of the environmental impact of relevant contributing sectors. Increased economic growth and socio-economic development, which are associated with expanding settlements and higher rates of construction, consumption and waste generation, are directly associated with energy consumption in all the key sectors. Figure 4.4 shows energy consumption trends from 1978 to 1998.

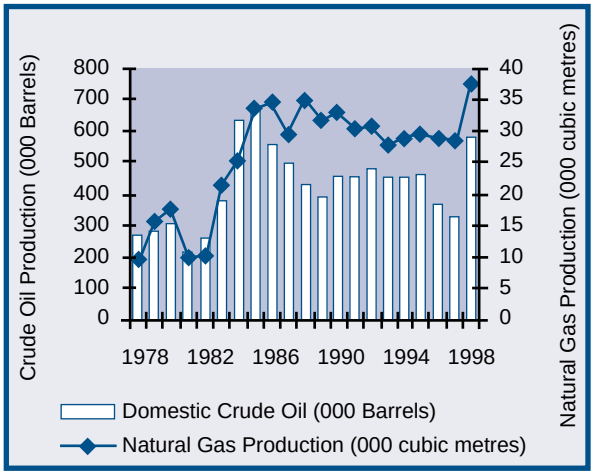
4.5 Impacts of Fossil Fuel Production and Consumption

The major crude oil extraction facilities lie in close proximity to the Hampton Pumping Station and the surrounding Zone 1 and Zone 2 water protection areas[5] in the south of the island. The discovery of traces of hydrocarbons in wells in this area is evidence of ground water contamination that demands close monitoring of petroleum operations, not only from extraction, but also from spillage and transportation.

The impacts of consumption are largely related to emissions from electricity generation, vehicular traffic, industrial and commercial use and residential consumption. These impacts are more likely to be manifested in air quality. At present these have not been quantified since routine monitoring and data collection are not yet in place.

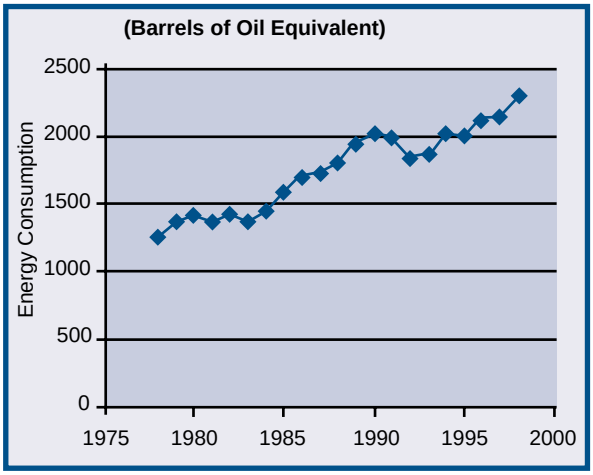
Other environmental problems are associated with the management of waste, in particular the disposal of waste oil from the numerous vehicle repair and maintenance shops across the island. Though these are mainly small-scale operations, there is concern that, cumulatively, inappropriate disposal could contaminate the water supply where operations are in Zone 1 water protection areas. The main challenge is one of monitoring and enforcing land use and health regulations.

Figure 4.3: Domestic Crude Oil and Natural Gas Production 1978-1998



Source: Barbados Social and Economic Report 1998.

Figure 4.4: Energy Consumption 1978-1998



Source: Barbados National Indicators Programme.

4.6 Policy Response

4.6.1 Institutional and Regulatory

Responsibility for the regulation of mining and quarrying in Barbados falls with several government agencies. These include: the Town and Country Development Planning Office (TCDPO) with respect to land-use planning and control; the Soil Conservation Unit of the Ministry of Agriculture and Rural Development regarding mining operations in the Scotland District; the Ministry of Labour with respect to workers' safety; the Ministry of Economic Development with respect to royalties; the Ministry of Public Works and Transport with respect to safety and transport of materials and the Energy Division of the Ministry of Physical Development and Environment (MPE) with respect to resource development and management, and the Environmental Engineering Division of the same Ministry with respect to pollution control.

Existing legislation that covers these activities include: the Town and Country Planning Act (cap. 240); the Soil Conservation (Scotland District) Act 1959 (cap. 396) as amended by the Soil Conservation (Scotland District) (Amendment) Act 1991 (1991-3), to the extent that several quarry and sand mining operations occur within the Scotland District; the Petroleum Winning Operations Act, 1951 (cap 281) which regulates the exploration and exploitation of oil resources; the National Petroleum Corporation Act 1981 (cap. 280); the National Petroleum Corporation (Supply of Natural Gas) Regulations 1982 (Regs. 1982); the Mines Regulation Act (cap. 350), and the Quarries Act 1963 (cap. 353).

Except for the Town and Country Planning and the Scotland District Acts, these sets of legislation do not specifically address environmental damage caused by mining operations and there is no apparent requirement of impact assessment[6]. The draft Environmental Management Act[7] offers a comprehensive and integrated approach to these and other current shortcomings. More specifically, the Quarries Act (cap 353) is currently being amended to allow it to more fully address arrangements for effective management of relevant natural resources, including monitoring of quarry operations and post-quarrying site rehabilitation and use.

4.6.2 Policies and Programmes

Apart from the regulatory dimensions, there are several policies and programmes designed to improve practices in the mining and energy sector in Barbados.

- The revised Physical Development Plan (1998) proposes implementation of strict controls in areas to be designated Natural Heritage Conservation Areas, such as occur within the Scotland District in relation to the proposed National Park. In addition, it requires the proponents of new mining operations to prepare Management and Closure Plans that address extraction and processing, topsoil removal and site rehabilitation after cessation of operations;

- Energy Production and Consumption
  A 1997 Green Paper on Energy called for specific actions in the areas of energy conservation, energy efficiency and alternative energy sources. In this regard, work has been initiated on the development, strengthening and/or amendment of various aspects of energy-related policy and legislation. An energy efficiency policy is being developed by the Energy Division in collaboration with the Barbados Light and Power Company Limited (the sole electricity generation facility in Barbados), to ensure that electrical appliances and other electrical equipment meet minimum energy efficiency standards. Demand Side Management is also being introduced to encourage electricity conservation.

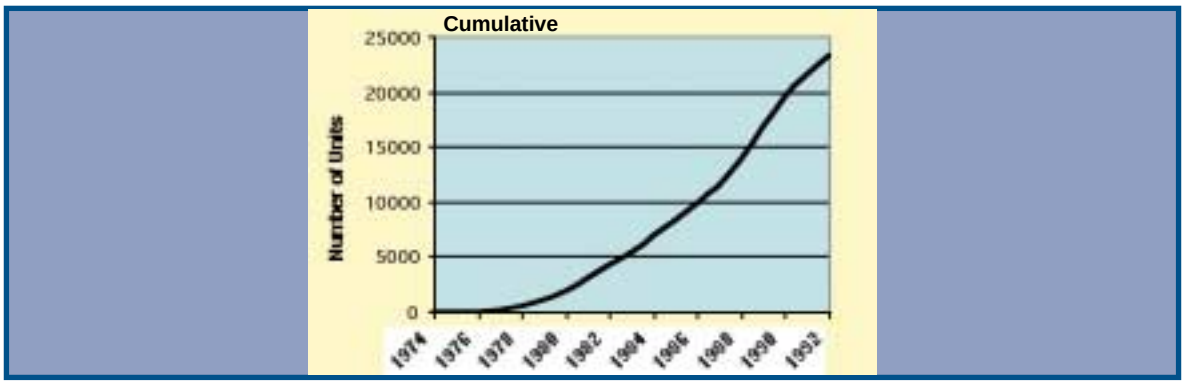
- Hydrocarbons/Fossil Fuels
  The expansion of natural gas production and supply that has taken place has clear environmental advantages not only because it is cleaner than other fossil fuels, but it also reduces the reliance on bottled gas and likewise the risks associated with its explosiveness and flammability.
  Related to promotion of the use of clean fuels is the national switch from leaded to unleaded gasoline. In 1994 the government of Barbados took the policy decision to phase out the use of leaded gasoline in the country, and set in train a number of fiscal and other incentives to enable this, including subsidising the price of unleaded fuel. Today this policy is fully in effect.

- Renewable Energy Sources
  One potentially beneficial policy direction taken with respect to energy is the exploration of renewable energy sources. Barbados' experience with renewable energy technologies spans thirty years, involving experimentation with solar thermal, wind, photovoltaic and wave energy. (See Appendix 1).

With a land area of 431 square kilometres and a tropical location, Barbados receives the equivalent of 2.8 billion kilowatt hours (kWh) of solar energy per day, or the energy equivalent of 1.74 million barrels of oil[8]. Given available technologies, this is considered a clean and abundant resource to be used to offset reliance on conventional fossil fuels. In the 1970s an industry in the manufacture of solar water heaters was started with two locally owned and operated companies. Today there are three companies operating, supplying over a third of all Barbadian households and exporting to several Caribbean countries.

Since the late 1970s impetus in this industry has been provided through a tax incentive to householders, resulting in a surge in the sale of solar

Figure 4.5: Solar Water Heater Installations 1974-1992



Source: Energy Division, Ministry of Physical Development and Environment.

water heaters. Figure 4.5 shows trends in solar water heater installations to 1992[9], the latest year for which consolidated data are available. The Energy Division estimated that in 1996 there were over 30 000 units installed, with a reported estimate of over 31 000 in 1999[10]. These trends suggest that the total figure will continue to grow.

More recently, in 2000, the decision was taken to move towards the establishment of a Centre for Renewable Energy (CEFREN) in Barbados. A collaborative effort of the Ministry of Physical Development and Environment and the Centre for Resource Management and Environmental Studies at the University of the West Indies, CEFREN is expected to oversee research and development, demonstration and training in renewable energy technologies, in order to determine their long-term contribution to sustainable energy development.

4.7 Conclusion

The extraction of minerals and energy resources is a primary activity with the potential for pervasive environmental impacts on air quality, on water supply and consequently on human health. While these impacts are difficult to monitor and to establish correlation and causality, the situation is exacerbated by the marked absence of data collection and management systems in these areas, the potable water quality monitoring system excepted. Future policy will need to address this as a matter of importance.

Notwithstanding the foregoing observations, Barbados has taken a very progressive stance with respect to energy policy. This holds both with regard to the emphasis on energy efficiency and energy conservation, and with the focus on renewable energy sources. The environmental sustainability of renewable energy is a given. As global trends continue to establish the economic viability of these sources, the stance taken by Barbados should position the country to take advantage of renewable energy technologies as they become more accessible worldwide.

Notes

1. Data obtained from Ministry of Physical Development and Environment, compiled as part of the United Nations Programme on Indicators of Sustainable Development.
2. Barbados Social and Economic Report, 1998
3. Ibid.
4. Ibid.
5. Ground water protection Zones are elaborated upon in the section on Freshwater Resources.
6. Working Paper on Environmental Laws of Barbados, 1997, prepared by Willms and Shier as part of the EMLUP Project.
7. Produced under the project on Environmental Management and Land Use Planning for Sustainable Development. government of Barbados, 1997.
8. Presentation By Oliver Headley to the Barbados National Consultation on Sustainable Development, 1996.
9. Energy Division, MEE.
10. CERMES (Center for Resource Management and Environmental Studies< UWI) and Ministry of Physical Development and Environment: Draft Proposal for Centre for Renewable Energy.

5.1 Introduction

Barbados' freshwater supply is primarily a function of its climatic and physical conditions. The island is characterised by a tropical maritime climate which has two pronounced seasons: one dry and one wet. The wet season, which lasts from around June to October, is the fundamental source of potable water on the island. The amount available for use is heavily influenced by the island's geological structure and thereafter by the distribution system in place for water supply. In considering the state of the island's water resources, it must be borne in mind that Barbados is ranked among the world's ten most water scarce countries.

5.2 Fresh Water Occurrence and Quantity Issues

Rainfall varies across time and space, even for a small island like Barbados. Map 5.1 shows rainfall distribution on the island, which averages 56-60 inches per year. The rainwater is distributed among groundwater, springwater, surface water and runoff. A 1978[1] water resources study estimated that, under average annual rainfall conditions of 60 inches, a total of 54.79 mgd (million gallons per day) is available, and 34.37 mgd in a drought year. The 1996/98 Water Resources Management and Water Loss Studies[2] have determined, based on an analysis of available data from 1947 to 1994, that an average annual rainfall of 56 inches represents the most reliable rainfall figure for Barbados[3].

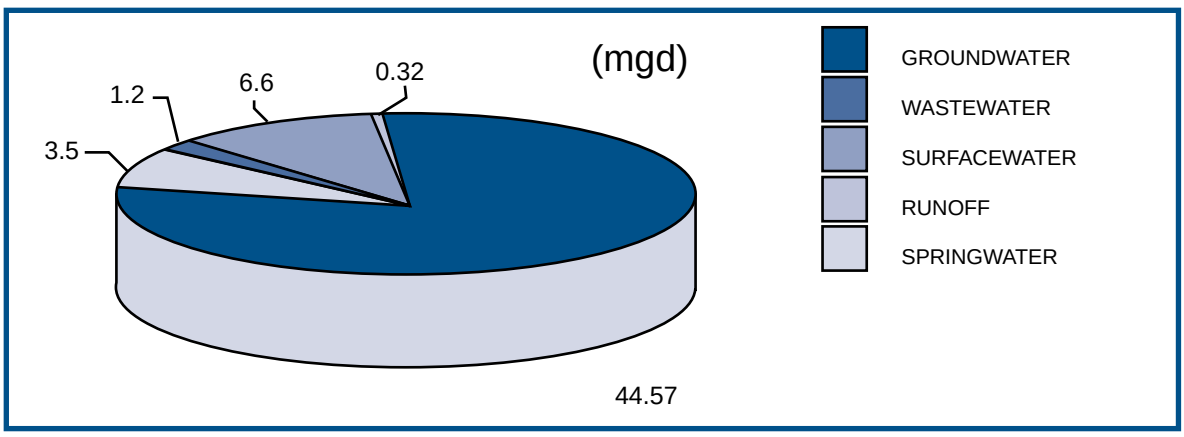
Based on this, the annual renewable freshwater resources have most recently been estimated at 225 410 m^3 or 49.59 mgd per day[4].

At its current population, these figures allow an available supply that is well under the 1 000 m^3 per capita set internationally as the limit below which a country is classified as "water scarce"[5].

Ground water accounts for by far the largest proportion (79 per cent) of the island's water resources (Figure 5.1), and for 98.6 per cent of its public water supply[6]. This is due to the fact that the limestone cap covers 86 per cent of the island. The limestone, which is up to 300 feet in thickness, is highly permeable, allowing for a well-developed aquifer system beneath the surface catchment areas (Map 5.2).

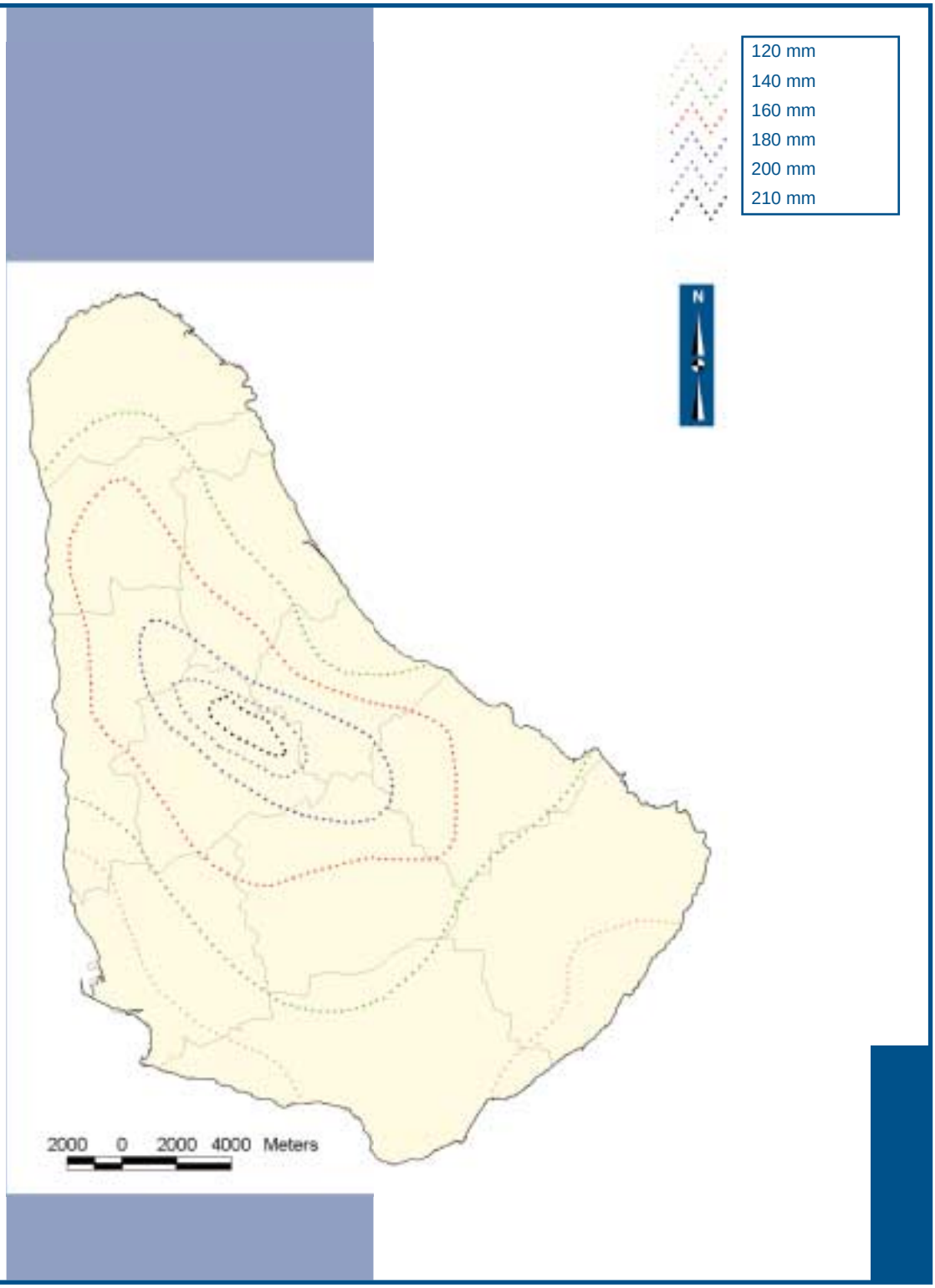
Once the rainwater has percolated through the limestone layer it flows from the central highlands towards the sea, following the slope of the interface of the limestone and underlying oceanics by means of both underground sheetwater and streamwater flow. As a result, the groundwater catchment areas are to the west and south of the central upland area of the island, correlating very closely with the surface catchment areas. Extraction for the supply system is by means of pumpage from wells or boreholes. The Barbados Water Authority currently pumps around 35 million gallons per day into the public supply system. Groundwater also reaches the surface through springs, two of which are used to augment the public supply.

Figure 5.1: Available Water Resources by Source 1996



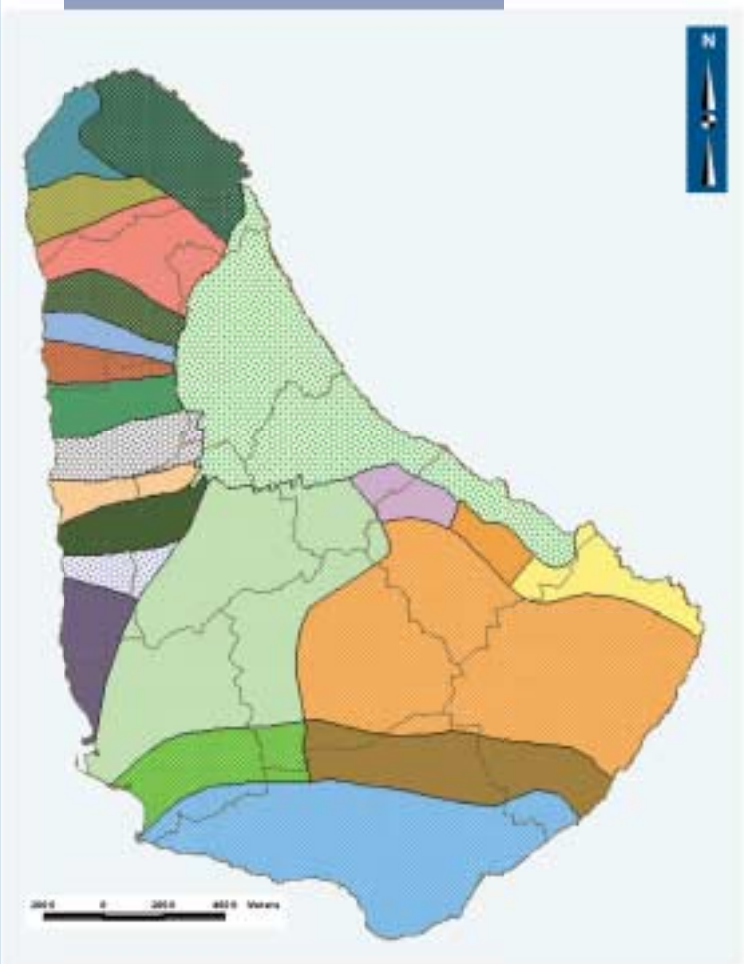
Source: Barbados Water Authority, 1996 and Klohn-Crippen Associates, 1977.

Map 5.1: Rainfall Distribution



Source: The National Natural Resources Data Base, 1998.

Map 5.2: Ground Water Catchments



- PARISH BOUNDARY
- ALLEYNEDALE
- ASHTON HALL
- BOURBON
- CARLTON
- CHRIST CHURCH
- CLERMONT
- CODRINGTON
- CONTENT
- HEYMAN'S
- MOLYNEUX
- NEW CASTLE
- NORWOOD
- PORTERS
- RAGGED POINT
- SCOTLAND DISTRICT
- ST. LUCY
- ST. MICHAEL NORTH
- ST. MICHAEL SOUTH
- ST. PHILIP NORTH
- ST. PHILIP SOUTH
- THE WHIM
- TRENTS

Source: The National Natural Resources Data Base, 1998.

5.3 Fresh Water Quality

The quality of potable water has met all international standards for safe drinking water. In general the water is clean, clear, tasteless and odourless.

Since 1963 a zoning system has been in place to protect the ground water against bacteriological contamination. It was not designed to protect against chemical pollution. The criteria used for demarcating the zones were the attenuation rates of bacteria based on travel times. This system divides the island into five water protection zones - Zone 1 to Zone 5 - with Zone 1 being the most restrictive with respect to allowed physical development, and Zone 5 having no such restrictions (Map 5.3).

The Zoning system, along with an effective disinfection system[7], has been partially effective in ensuring a biologically-safe water supply[8]. This is evidenced by the fact that indicator diseases such as cholera, dysentery, giardiasis or hepatitis have not occurred in Barbados on any significant scale, and the few cases of dysentery that have occurred have not been linked to the public water supply. It has been concluded, however, that the overall groundwater protection policy could be effective in controlling biological risks if operated in conjunction with an upgraded and properly operated chlorination system.

The public water supply covers the entire island in that 94 percent of the households are connected, and the remainder has easy access. There are a few complaints of taste and discoloured water in small sections of the distribution system, which may at times be attributed to maintenance problems. Sporadic observations of a chlorine taste in the water are occasionally made. In addition, some saltiness is detected in the Western catchment in the dry season, which may be indicative of high extraction levels from the aquifers. Table 5.1 shows the quality of public water supply.

Table 5.1: Public Supply Water Quality

Parameter	International Standard	Barabados Average	Catchment Average		
			St. Michael	St. Philip	West Coast
Nitrate_N (mg/L)	10	7.11	6.87	8.15	6.54
Chloride (mg/L)	250	112.6	63.5	68.7	183.9
Sodium (mg/L)	200	50.26	24.6	52.9	75.8
Sulphate (mg/L)	250-400	33.5	24.1	36.4	37.8
Phosphates	N/A	0.07	0.07	0.08	0.06
PH	8.5	7.6	7.37	7.35	7.33
Atrazine (ug/L)	3.0	0.46	0.38	0.61	0.37
Amertyne (ug/L)	3.0	0.13	0.087	0.302	N/A
Faecal Coliform (colonies/100ml)	<1/100	<1/100	<1/100	<1/100	<1/100
TDS* (mg/L)	500	426	335	423	618

Source: Barbados National Consultation on Sustainable Development, 1997---Technical Paper 2.2: Sustainable Water Quality Management. * TDS = Total Dissolved Solids

The ground water protection policy has little effect on the source control of nitrate and pesticide. Water quality risks from agricultural chemicals have seen upward trends in nitrate and atrazine concentrations, towards levels that are unacceptable for drinking water. While concentrations are still marginally compliant with international standards, there is the need for strict control on the release of chemicals in these areas.

5.4 Pressures on Fresh Water

The main areas of concern with respect to water resources management and the environment are water scarcity and protection of the groundwater resources. The sources of pressure include increases in demand that result in raising the abstraction levels at the various wells - particularly the Belle and Hampton pumping stations (Map 5.3) - and the risk of contamination from the following: agricultural activity, the petro-chemical industry, industrial facilities and hazardous wastes, urban development and domestic waste disposal, and solid and liquid waste disposal.

Additionally, the maintenance of the distribution system is a source of concern. The 1996/1998 Water Resources Management and Water Loss Study (WRMWLS), the most significant study of Barbados´ water resources of recent years, notes that bursts in the distribution network are frequently reported, averaging two to four reports a day. This is believed to be largely responsible for leakage losses, which are in the order of 62 per cent of the pumped volume[9].

5.4.1 Demand Pressures

The WRMWLS has concluded that, from a reserve estimated at 44.8 million gallons per day (mgd), 47.3 mgd of freshwater is abstracted for public (35 million) and private (12.3) supply. The studies further concluded that with business as usual (i.e. if nothing is done), total water requirements could reach 53.8 mgd (89.4 million m3) by 2016, of which 38.8 mgd or 64.5 million m3 will be needed for public supply and 15.0 mgd (24.9 million m3) for private abstractions[10]. Actual consumption trends from 1978 to 1998 are presented in Figure 5.2. Total consumption by sector is presented in Figure 5.3.

It is clear that Barbados' water demands exceed a sustainable yield. Under these circumstances the risk of salt-water intrusion into the aquifers due to over-abstraction constitutes a significant source of stress to the quality of the water supply.

5.4.2 Water Quality Pressures

(i) Agricultural Activity

Zones 1 and 2 under the current water protection policy are also areas of intense agricultural activity. It is considered that the current level of protection from pesticides and fertilizers applied within Zones 1 and 2 may need to be strengthened. The WRMWLS reported that agricultural practices have been responsible for most of the increase in nitrate loading since 1977. It also indicated that while atrazine levels are still below the WHO threshold for potable water, it is on the rise[11]. Any significant increase in the use of agricultural chemicals in these zones could compromise the safety of the water supply.

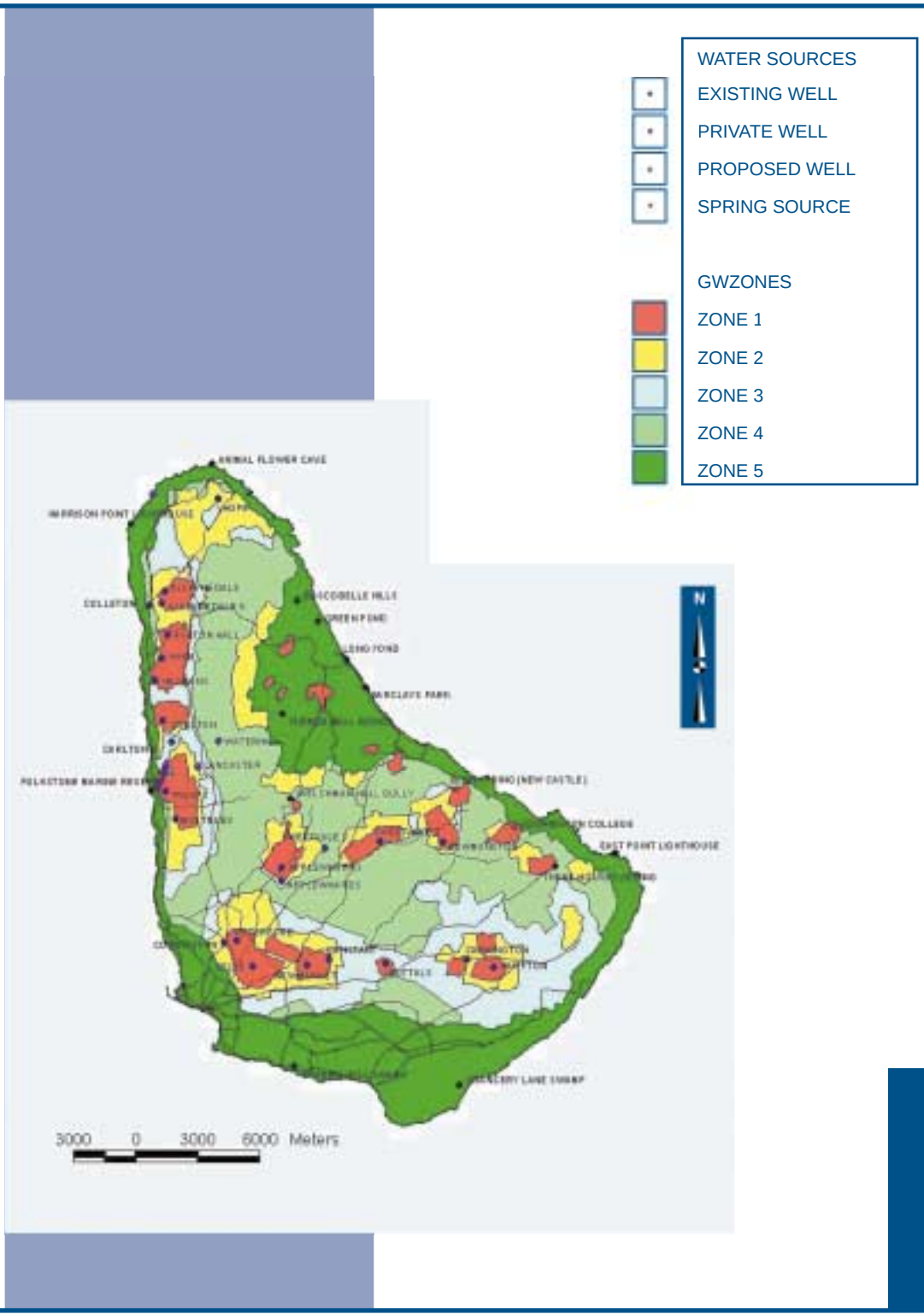
(ii) The Petrochemical Industry

The petrochemical industry comprises the drilling and storage of oil and petroleum based products. Bulk storage is regulated and occurs at petrol stations. The drilling of oil and its associated activities, however, are not similarly regulated. These activities occur predominantly in the Zone 1 and Zone 2 areas of the Hampton catchment, which accounts for approximately 25 per cent of the national water resources. They therefore present a significant threat, as has been confirmed by field investigations conducted in 1993 and 1997.

(iii) Industrial Activity and Hazardous Waste

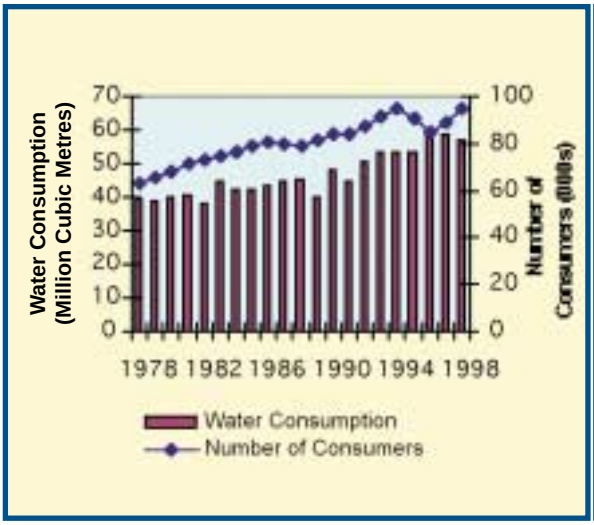
The encroachment of industry, including small-scale operations such as vehicle repair and maintenance shops, into highly protected water zones is an area of concern. A survey of industrial activity and their waste streams, conducted under the WRMWLS, found that 34 per cent of the industries surveyed operated within Zones 1, 2 and 3. The chemicals handled included lead oxide, nickel sulponate, photographic developer, perchlorethene, fenithronthion W/P, D/P, malathion dust, commodore W/P, dursban 4E and diazinon among others[12].

Map 5.3: Ground Water Zones, Wells & Springs



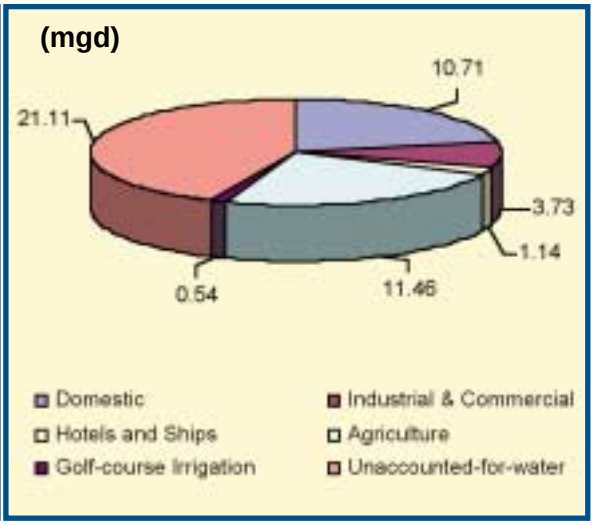
Source: The National Natural Resources Data Base, 1998.

Figure 5.2: Water Consumption and Number of Consumers 1978-1998



Source: Barbados Social and Economic Report, 1998.

Figure 5.3: Water Consumption by Sector 1996



Source: Barbados Water Authority 1997.

Another survey, conducted by the Environmental Unit of the Ministry of Physical Development and Environment, compiled data on, among other things, trends in the importation of hazardous chemical/substances in the island over the period 1995-1998. The data from responding firms show an increase in reported imports, from over 456 000 kilograms of solids in 1995 to over 2.56 million kilograms in 1998, and an increase in liquids from 3.43 million litres to 23.23 million litres. The solids included such chemicals/substances as sodium hypochlorite, lead oxide, ammonium sulphate and sodium silicate, and the liquids included naptha, calcium carbide, sodium sulphate, hydrochlorate acid, benzene sulphonic acid and liquid propane/butane. Particularly noteworthy is the inclusion of polychlorinated biphenyl (PCB)–1254, a persistent organic compound with severe public health and environmental health consequences.

The distributional analysis of the results of this survey was on the basis of parish rather than water protection zones, and waste generation and handling was not reported. However, the trends noted are useful in indicating potential pressures on the potable water supply and the need for an appropriate response.

(iv) Urban Development and Waste Disposal

As population pressure on the island increases, there is likely to be increase in the pressure for settlement encroachment on the areas protected by Zones 1 and 2 of the zoning policy. At present the safety of the water supply in these areas is ensured only by limiting encroachment in the Zone 1 areas and by the chlorination system. Thus the expansion of settlement would demand a careful analysis of ground water flow regimes and of the ability of biological agents to survive in these environments, as well as continuous monitoring and full enforcement of regulations in these areas.

Waste disposal in general can pose a serious problem for water resource protection. In Barbados the disposal method of choice is by landfill. Leachate from both official and unofficial landfill sites poses a threat to the groundwater supply. With respect to official sites - Mangrove I and Mangrove II - the first is unlined and therefore escaping leachate can potentially contaminate the groundwater, particularly the nearby Molyneux well. The second was engineered with a liner and recirculation system and should therefore be less of a threat.

In addition, unofficial operations have been identified in the vicinity of the Belle Zone 1 area and the

Hampton catchment. Such sites are not appropriately engineered and therefore pose a threat to the groundwater supply.

5.5 Policy Response

5.5.1 Water Quality Protection

Water quality protection is implemented at three levels. First, through the national water protection policy which targets the groundwater resource; second through a disinfection programme and the pumping stations; and third, monitoring the distribution system to ensure delivery of a safe product.

The 1963 Underground Water Protection Policy (revised in 1972) protects water catchment areas and the subterranean supply through the establishment of water zones. This zoning policy is based on bacteriological travel time of flow through the limestone to the pumping station. It is implemented through the collaborative efforts of the Barbados Water Authority, the Town and Country Development Planning Office, the Environmental Engineering Division (EED) of the Ministry of Physical Development and Environment, and the Public Health Division of the Ministry of Health.

Incorporated into the Zoning Policy is the Revised Policy on Private Sewage and Waste Water Disposal Systems, which seeks to control any development or liquid waste disposal systems that could be damaging to the national water resources.

The Zoning Policy was established under development conditions that were substantially different, in character and scale, from what currently obtains. The policy therefore needs to be reviewed to incorporate the potential impacts of the release of modern industrial chemicals and agro-chemicals into the environment.

Responsibility for monitoring and surveillance is shared by several agencies. The Barbados Water Authority has legal responsibility for monitoring and maintaining water quality standards.The Environmental Engineering Division (EED) has power to enforce standards on water quality and waste water discharge. The Coastal Zone Management Unit has powers of enforcement in matters relating to discharge into the marine environment.

The efforts of the above-mentioned agencies are hampered by the absence of a comprehensive legal framework or national water quality standard. Such a legal framework is provided in the draft Environmental Management Act now under review, while the national water quality standard is being discussed by the EED and the Caribbean Environmental Health Institute.

5.5.2 Water Scarcity

Several policies, programmes and strategies have been proposed or are being implemented to address the looming problem of water scarcity, using both short-term and long-term measures.

Since 1982, the Barbados Water Authority (Water Services) Regulations were enacted to facilitate promotion of the use of water conservation strategies including the temporary reduction of water pressure in the supply system, the temporary shut down of all or part of the system, and the temporary increase in the tariff blocks of the pricing system.

The 1990s saw a more concentrated focus on the problem following periods of serious water scarcity on the island. The 1996/8 Water Resources Management and Water Loss Studies (WRMWLS) were commissioned to address the growing concerns of quality and supply including:

- The rapidly increasing fresh water demand and consumption from residential, commercial, tourism and industrial developments;
- The increase in use of agricultural chemicals which have the potential to impact negatively on the quality of the potable water, and
- Reducing rates of aquifer recharge from rainfall due to increasing terrestrial runoff associated with urban development.

The results and recommendations of the studies have been reviewed and are being implemented, with a strong focus on the two main areas of (a) reduction in consumer use and (b) reduction in losses from the distribution system.

The 1997 Policy Framework for Water Resources Development and Management took into account the findings of the WRMWLS and of previous stud-

ies, and used these as the basis for developing a comprehensive water resources development and management plan to the year 2016 and beyond. The policy direction now includes a series of strategies in the areas of demand management, supply management and augmentation, institutional capacity building, and policy and legislation.

Additionally, the Government has constructed a desalination facility which is already in operation, and is projected to provide at least ten per cent of reserve capacity.

Finally, the draft 1998 Environmental and Natural Resources Management Plan proposes a number of institutional changes for a more streamlined and integrated approach to natural resources management, including specific recommendations for water resources management. This includes a look at the situation, in which the BWA functions as both the standard setter and the regulator of water supply. The recommendations, which took into account the Klohn-Crippen WRMWLS, are being reviewed as part of the consideration of a comprehensive environmental and natural resources management framework.

5.6 Conclusion

There are several concerns regarding water resources in Barbados. With respect to maintenance of quality and supply, they include: the rapidly increasing demand and consumption of residential, commercial, tourism and industrial developments; the increase in use of agricultural chemicals which have the potential to impact negatively on the quality of ground water; increased risk from the release of hazardous chemicals and substances into the environment; and reducing rates of aquifer recharge due to increasing runoff associated with urban development.

The Government has undertaken and is actively considering policy options to address these concerns in the areas of demand management, supply management and augmentation, institutional restructuring and capacity building, and policy and legislation.

There is some measure of urgency attached to finding sustainable solutions to water resources management, given in particular the scarcity issue. Timely policy response to, and implementation of findings and recommendations of recent studies will be key in this regard.

Notes

1. This refers to the "Barbados Water Resources Study" conducted by the Government of Barbados and Stanley Associates Engineering Limited and Consulting Engineers Partnerships Limited, Volumes 1-6, 1978.
2. The Barbados Water Resources Management and Water Loss Studies 1996-1998, prepared for the Government of Barbados by Klohn-Crippen Consultants Ltd. in association with Stanley Associates Engineering Ltd.
3. After analyzing the records in 30 year periods from 1947 to 1994, the consultants on the study concluded that of all the long range studies on record, the precipitation distribution analysis conducted by Rouse (1960) constituted the most reliable data set. It also corresponds most closely with the average annual precipitation value for the last 30 years, based on data from viable monitoring stations. The variation between this figure and that reported in the 1978 study appears to be due more to a matter of analysis and reliability than to a variation in actual rainfall amounts.
4. Barbados Water Authority, "Draft Policy Framework for Water Resources Development and Management in Barbados." Paper presented to the Planning and Priorities Committee of the Government of Barbados, August 12, 1997.
5. Barbados Water Authority. "Sustainable Water Resources Management – Recommendations". Paper presented at the Barbados National Consultation on Sustainable Development, November 1996/7.
6. Barbados Water Authority. "Sustainable Water Quality Management". Paper presented at the Barbados National Consultation on Sustainable Development, November 1996/7, and Klohn-Crippen, 1997, Barbados Water Resources Management and Water Loss Studies.
7. The zoning system and the disinfection system are collectively referred to as the Groundwater Protection Policy.
8. Klohn-Crippen, 1998. Report on Task 12: Development and Management Plan. For the Water Resources Management and Water Loss Study.
9. Ibid.
10. See note 4.
11. Government of Barbados, Environmental and Natural Resources Management Plan, 1998, prepared by Willms and Shier.
12. See note 5.

6.1 Introduction

The Barbados coastline measures 92 kilometres. It is surrounded by a narrow, insular shelf, with the 200m isobath lying between two and three kilometres offshore (Map 6.1). This shelf supports a variety of living reef systems and a great diversity of species.

The coastline and near-shore areas are important to the lives of many Barbadians. They depend on it for their livelihood, making it central to their existence. As a result, this environment is under stress from the many competing demands on its fragile ecosystems.

This section will address the subject in two parts. The first part will examine the coastal area, which is defined as the area extending two kilometres inland and offshore on the Atlantic coast, and the area encompassing the main coastal highway and the one-in-one- hundred-year flood inundation line on the Caribbean coast. The second part will examine the state of fisheries resources.

6.2 The Barbados Coastline: An Overview[1]

The west coast of Barbados is bounded by the Caribbean Sea - the Caribbean coast. This coastline is backed by inland limestone cliffs and is the focal point of the island's tourism industry as well as a large residential population. The Atlantic coast lies on the eastern side of the island and largely encompasses the Scotland District. It has extremely undulating topographic features. As a result, this coast is the least developed segment of Barbados.

Due to the presence of sustained strong wave and wind energy, as well as to high levels of sedimentation derived from soil erosion in the Scotland District, the Atlantic coast has less reef development than the Caribbean coast. It is, however, characterised by large areas of limestone pavements, which are dominated by gorgonian growth.

For more detailed analysis the coastline is further subdivided in to eight sub-area classifications as shown on Map 6.2. The southeast coast, Sub-Area 1, which extends from South Point to Kitridge Point, is fully exposed to Atlantic swells. There are no actively growing fringing reefs in this area, but there is a flat, shallow bank reef that extends 400-800 metres from the shore and runs parallel to the shore.

Sub-Area 2 runs from Kitridge Point to Consett Point, where near-shore marine habitats include coral rubble, algal and gorgonian pavement. Sub-Area 3 extends from Consett Point to The Choyce, falling entirely within the exclusively non-carbonate Scotland District. In Sub-Area 4, from the Choyce to North Point, the near-shore environment comprises mainly coral rubble, algal and gorgonian pavement. Sub-Area 5, from North Point to Maycock's Bay, contains the richest marine faunal communities including hard coral.

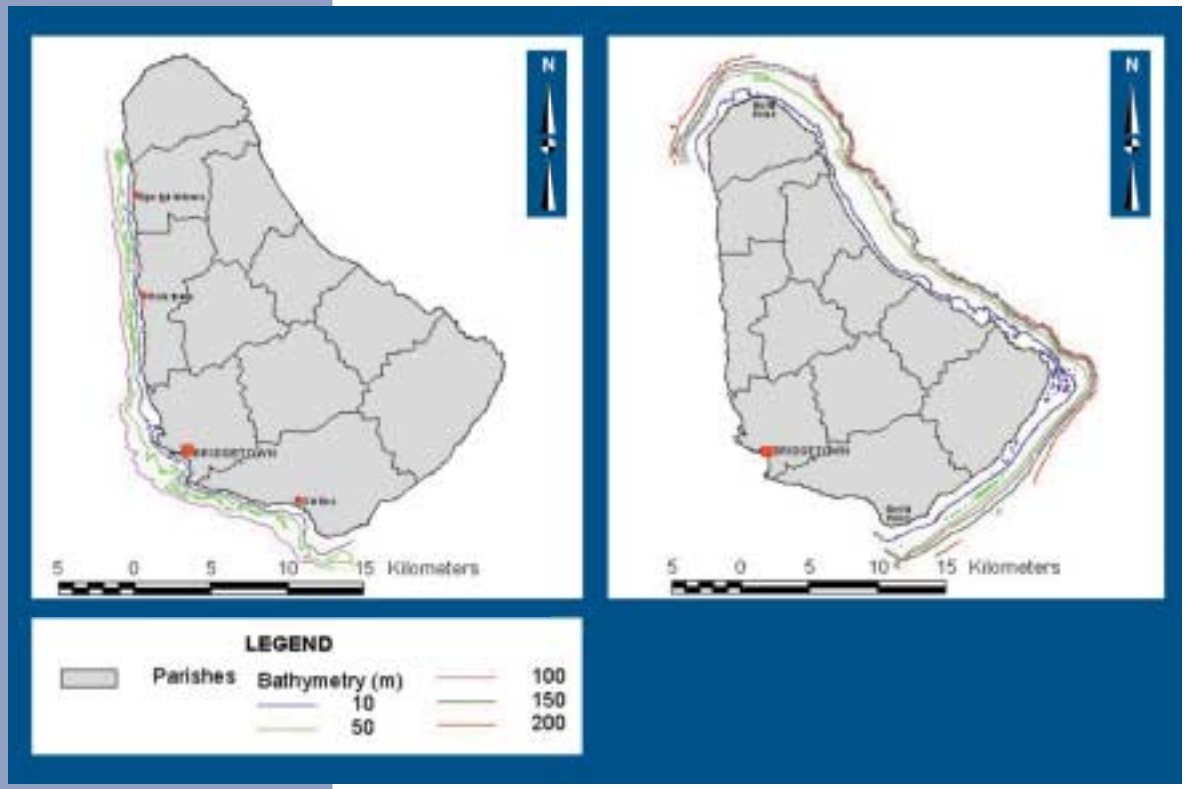
Sub-Area 6, from Maycock's Bay to Batt's Rock, has as its most distinctive immediate near-shore feature the bank barrier reef, which lies parallel to the coast between 800 and 1000m offshore. Sub-Area 7, Batt's Rock to Needham's Point, contains generally relic fringing reefs that extend to a gently sloping shelf, and extensive patch reefs in depths of 6-15m. Lastly Sub-Area 8, which extends from Needham's Point to South Point, contains one of the last remaining coastal wetlands in Barbados, consisting of an extensive inland swamp, a large beach area, sea grass beds and an offshore reef complex.

6.3 Pressures on Coastal Areas

The majority of the island's population and infrastructure is concentrated in the southwest urban corridor, and the Caribbean coast is the focal point of the island's tourism sector, as well as a large residential population. Development along this coast, which corresponds closely with coastal Sub Areas 6, 7 and 8, has occurred at some environmental cost including:

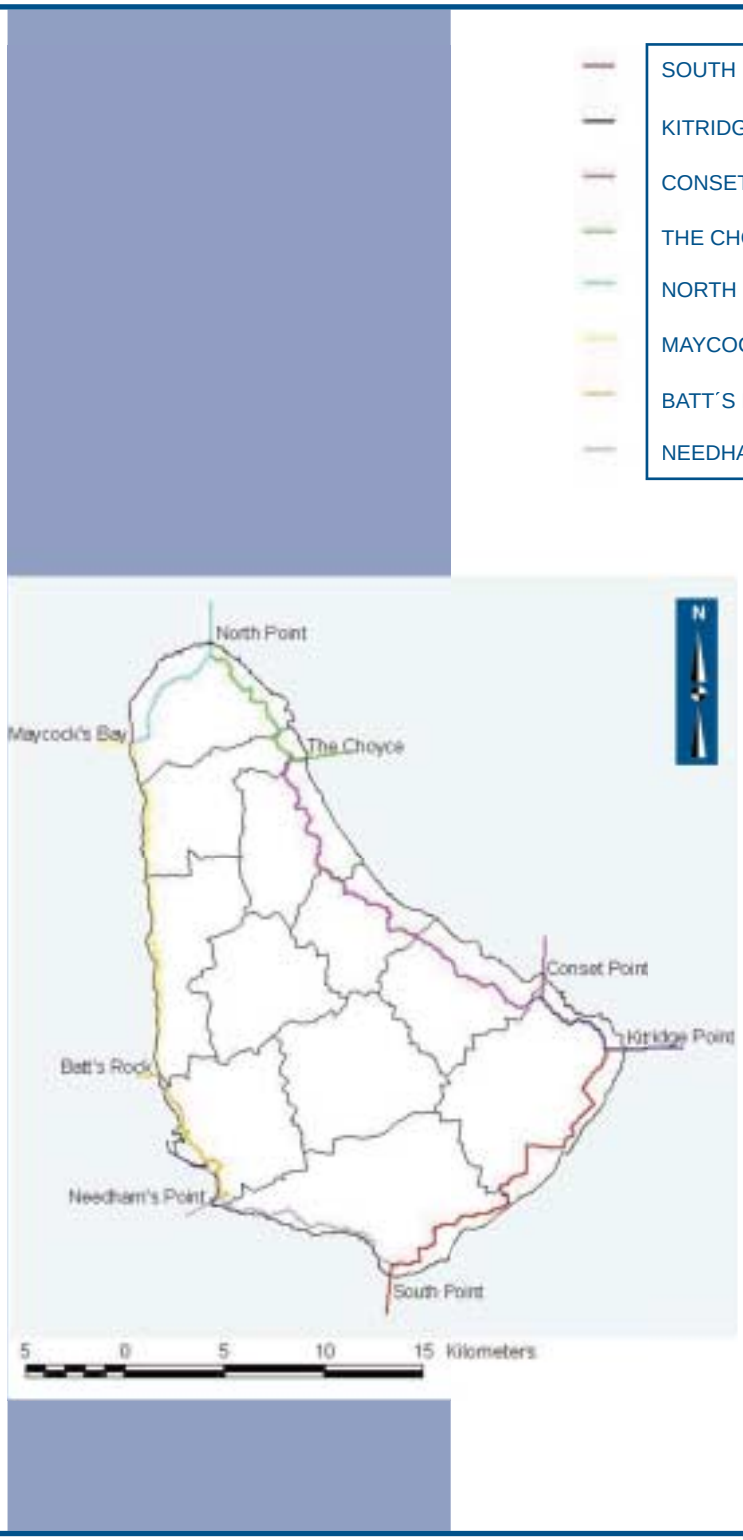
- Encroachment of buildings into the active beach zone;
- Loss and degradation of wetlands;
- Degradation of reefs and coastal water quality, and
- Loss of beach access.

Map 6.1: Coastal Bathymetry



Source: Coastal Zone Management Unit, Barbados 2001.

Map 6.2: Coastal Zone Management Sub-Areas



Source: Coastal Zone Management Unit.

With respect to the south-west urban corridor the major issues are:

- The spread of the urban corridor as a continuous coastal perimeter ribbon development with the four major towns acting as nodes. Along the west and south corridor are also found the major infrastructure and utilities, and

- Loss of economically viable agricultural/arable lands to tourism, residential and other infrastructural development.

It has been the land use policy, as articulated in successive Physical Development Plans, to encourage growth along this section of the coastline in order to allow for concentration of agriculture and water supply protection in the interior. As a result of the increasing pressure which this development has placed on the west and south coasts, the need has arisen for protective policies and guidelines.

6.4 Impacts of Coastal Land Use

In assessing the impacts of human activity on the state of coastal resources, it should be noted that several factors complicate the establishment of causal linkages. For example, the collapse of the black sea urchin population in 1983 due to disease resulted in increased growth in algae. Since this urchin grazes on algae that is harmful to coral, the increased algal abundance may be linked to coral reef deterioration and decline. Another contributing factor may be the decline in herbivorous reef fish, resulting in increased algal growth. While this is believed to be due to the human factor of over-fishing, it helps to highlight the difficulty in attributing coral reef deterioration to a single cause or to human activities[2].

Sub-Areas 1, 3, 7 and 8 show evidence of varying degrees of environmental impact. In Sub-Area 1, analysis of ground water, surface water and coastal waters revealed that wastewater discharges along the south east coast causes nitrate concentrations to rise by 0.25mg/l (milligrams per litre). There are also indications that this level will rise further due to agricultural changes. In Sub-Area 3 the main impact is the deposit of non-carbonate sediments in a north-westerly direction, derived from the Scotland District.

Sub Area 7 comprises the most extensive and concentrated area of coastal development in Barbados, and is dominated by the conurbation of Bridgetown. Land in the northern part of this area is important in industry, with the Harbour, Pine and Spring Garden areas comprising nearly 50 per cent of the total area of the industrial estates of the Barbados Industrial Development Corporation. The shoreline in this area has been substantially altered within the last four decades by the creation of a deep-water harbour.

Finally, Sub-Area 8 is an extensively developed urban corridor running from the outskirts of Bridgetown to the regional centre of Oistins and further westward to Atlantic Shores. Graeme Hall Swamp, the largest remaining area of natural vegetation in the coastal zone, occurs here. Significant deterioration of the patch reefs in this area over the last ten years has been reported, as well as decreases in the number of fish species.

6.5 Impacts on Ecosystems

6.5.1 Coral Reefs

Repeated quantitative surveys have been carried out on Barbados' coral reefs since 1982. Initial surveys were concentrated on the west coast, with the south coast surveys being included in 1987. Surveys are conducted every five years, the most recent having been repeated in 1992 and 1997. Health of the reef is generally indicated by live coral cover and coral species diversity.

Studies have revealed that both the west-coast fringing reefs and the patch reefs on the south-west coast have deteriorated considerably. During the ten-year period 1982-1992, coral abundance on the west coast was found to have decreased by an average of 34 per cent, and the number of coral species decreased by an average of 24 per cent. This is linked to the increase in the abundance of benthic algae by an average of 151.3 per cent over the period[3]. An underlying cause of algal growth may be eutrophication, and increased levels of suspended particulate matter (SPM) may also affect coral health. It is reported that about half of the west coast fringing reefs are exposed to levels of SPM that are considered stressful to corals[4]. Some improvement in the abundance and diversity of the fringing reefs was

observed, however, during the 1997 survey episode. The bank reefs are in relatively good health, although some deterioration has been observed. The planned west coast sewerage system should signal further improvement in reef condition in the future.

Studies conducted on nine south coast fringing reefs over the five-year period 1987-1992 showed a decrease in hard corals by an average of 14 per cent, a decrease in the number of species by an average of 35 per cent, and a decrease in the number of soft coral colonies by an average of 14 per cent[5]. Since then the impact of the Bridgetown sewerage system should have manifested itself, and the more recently installed south coast sewerage system is expected to have a positive impact on coastal systems in that area as well.

From initial surveys carried out on the east coast, it appears that the reefs there are healthy and support a rich and diverse community of marine flora in particular. The north coast marine systems are believed to be in near pristine condition.

6.5.2 Sea-grass Beds

Patches of sea-grasses are reported in Sub - Area 8 as an integral part of the mangrove and offshore reef complex, particularly at Hastings, Maxwell and St. Lawrence. The latter site is located in a shallow lagoon that is protected from high-energy waves by a reef rubble bank, and turtle and manatee grasses predominate[6]. This lagoon is the only area with significant sea-grass cover on the west, southwest and southeast coasts of the island. It is also the only location in Barbados where mangrove swamps, sea-grass beds, and deep hard coral reefs can be found in close association.

It is reported[7] that the area of sea-grass coverage in this lagoon has decreased and the beach area has increased over the 27 years from 1964 to 1991. In fact, in the last few years the beach has accreted so rapidly that sea-grass on the western end of the lagoon has been smothered by sand and replaced by a beach exposed at low tide.

6.5.3 Mangroves

Coastal and near-shore development has modified the littoral vegetation communities to the extent that these sites now have low species diversity. On the north and east coasts, wetlands and estuaries remain relatively intact, suffering more indirect impacts from upstream point and non-point pollution rather than direct physical encroachment or reclamation impacts.

The Graeme Hall Swamp is the most significant wetland remaining on the island. The swamp covers an area of 32 ha in one of the most densely populated areas of the island. Residential development surrounds it along the southern, eastern, western and north-western boundaries, a main coastal road runs between the swamp and the sea on the south side, and agricultural lands border the north-eastern side[8].

The swamp is divided into a western and eastern quadrant by a wide man-made track or roadway. The western quadrant comprises a brackish lake surrounded by a dense fringe of red mangroves *(Rhizophora mangle)* and white mangroves *(Laguncularia racemosa)*. The eastern quadrant contains a freshwater lake, in which there is a large stand of mature white mangroves and a network of man-made drainage canals.

This swamp is home to the widest variety of resident and migratory birds including the red seal coot *(Gallinula chloropus barbadensis)* and the yellow warbler *(Dendroica petechia)*, and it is the oldest nesting site in the island for the cattle egret *(Bulbulcus ibis)*. In addition, over 20 species of fresh and brackish water fish reside there, including the unique killifish *(Rivulus marmoratus)*[9].

Apart from the Graeme Hall swamp, there are other small patches of coastal wetlands remaining, generally on the seaward edge of watercourses. These include Heywoods Swamp, which is an estuarine mangrove swamp in healthy condition, and Brandon's Beach, a strand-wooded and basin mangrove forest with low species diversity, also in a healthy condition. Another area is the Chancery Lane Swamp, which has a significant variety of terrestrial vegetation. This site is threatened to be lost to development in the near future.

All available data conclusively indicate that mangroves and wetlands continue to suffer significant human impact, and areal coverage has declined substantively. The Graeme Hall Swamp, for exam-

ple, which has been heavily impacted over the last 150 years, is now the site of a mosquito control programme. This involves periodic clearing of vegetation from the freshwater dykes, cutting of mangroves that overhang the roadway and block the exit canal to the sea, intensive thermal fogging with Malathion, periodic opening of the sluice gate, and maintenance of the channel over the beach with heavy digging machinery. It has recently been privately developed as a bird sanctuary and interpretive centre, and the sewage treatment plant for the south coast has been constructed immediately east of the swamp.

Wetland systems continue to be threatened daily by proposed development, particularly for in-fill development within the urban southern and western coastlines, and from non-point sources of pollution.

6.5.4 Beaches

Beaches are a valuable resource, particularly on the sheltered west (Caribbean) and south coasts, which are the focus of the tourism industry. Most of the beach monitoring sites of the Coastal Zone Management Unit (CZMU) are concentrated on these coasts: approximately 35 along the west coast, 20 on the relatively short south coast, and 21 distributed on the remaining south-east, east and north coasts.

Records have shown increasing trends in beach width and beach volume in some places, such as at Welches on the south coast, and decreasing trends in others such as at Rumshop on the west coast. There is circumstantial evidence of beach gains on the south coast due directly to human activity. For example, the Oistins Fisheries Complex landfill advanced the shoreline and induced some growth of Oistins Beach immediately updrift of the landfill. Similarly Enterprise beach, popularly known as Miami Beach, was inadvertently created in 1973/1974 when the jetty that retains the beach was constructed to protect the now abandoned Oistins Coast Guard Station[10].

Notably, however, it is difficult, to attribute some trends to specific sources of impact, due to the complex interactions of natural beach dynamics and human activity.

6.6 Policy Response

Responsibility for coastal zone management lies with the CZMU of the Ministry of Physical Development and Environment. This unit, which was established as the result of an in-depth study of coastal issues and the institutional arrangements needed for effective management of the coastal zone, is a manifestation of the high priority placed on this subject by the Government of Barbados.

Two additional important products of that study were the Coastal Zone Management Act and the Marine Pollution Control Act, both to be administered by the CZMU in collaboration with other relevant agencies. These two sets of legislation, along with the Town and Country Planning Act, provide the legal basis for routine management and regulation of the coastal zone, including the implementation of policies such as:

- Planning for management of relevant resources and publication of the management plan;
- Requiring consultation by other government agencies in taking decisions that may affect coastal resources;
- Protection of linked ecologically sensitive coastal and marine areas and establishing regulations for governing activities in these areas, and
- Enforcement of the provisions of any legislation when breaches threaten coastal resources.

The proposed Environmental Management Act, which provides for the integrated and comprehensive management of the Barbados environment, incorporates the Coastal Zone Management Act and Pollution Control Act. This draft legislation is designed to be implemented jointly by the Director of Coastal Zone Management and the agencies responsible for environmental management and the Marine pollution control.

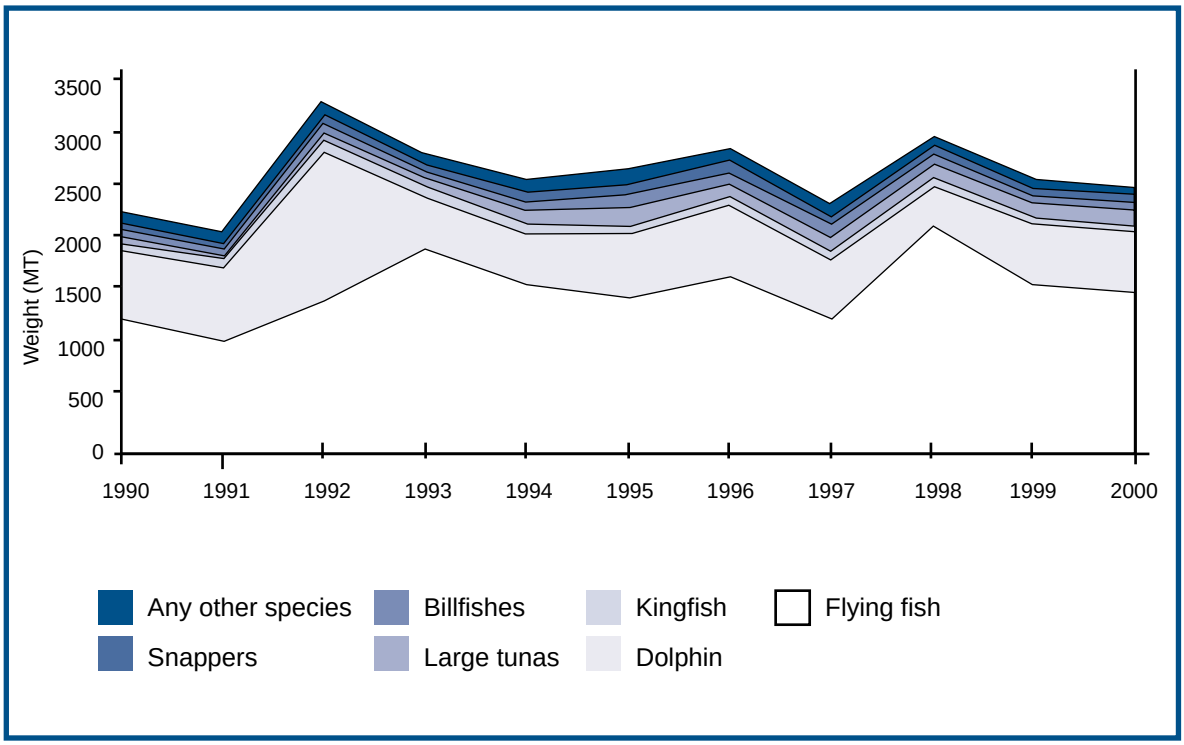
6.7 Fisheries Resources

Fishery resources are an important part of the local economy and culture, even though the total contribution of fisheries to GDP is relatively small (around one per cent annually). To facilitate

management, all local fisheries are divided into nine main categories. The status of a number of locally fished stocks is largely unknown. However, it is believed that presently, many local stocks of both near-shore piscine and shellfish species are either fully exploited or over-exploited. There is also international concern over the status of straddling stocks of large pelagic fishes such as tunas and billfishes that are also harvested by Barbadian fishers. The International Commission for the Conservation of Atlantic Tunas (ICCAT) is charged with the responsibilities of managing these stocks. Barbados became a member of ICCAT in December 2000 to facilitate a participatory role in the management of these valuable fisheries. Barbados continues to promote regional-wide fisheries management and to this end, actively participates in such regional organizations as the Caribbean Community (CARICOM) Fisheries Resource Assessment and Management Program (CFRAMP) and the Western Central Atlantic Fishery Commission (WECAFC). Table 6.1 provides a summary of the local fishery management categories and the status of the resources.

The main available indicators of resource status include data on overall fish landings and landings by species. Figure 6.1 shows the total annual landings of fish recorded at major landing sites on the island over the last eleven years. The graph shows that annual landings fluctuated over the period with the highest catch recorded during the period (31MT in 1992) immediately following the lowest recorded catch (21MT in 1991). The figure also indicates that that flyingfish continued to comprise the largest proportion of local annual fish catches (mean of 59 per cent) throughout the period. It should be noted that marked fluctuations in total fisheries landings over time, especially for multi-species fisheries, are not uncommon worldwide. Variations may result from myriad factors acting either singly or in concert including differences in fishing effort, fishing success and natural variations in the sizes of individual fish stocks.

Figure 6.1: Total Fish Landings Recorded at Major Landing Sites



Source: Fisheries Division, Ministry of Agriculture and Rural Development.

Table 6.1: Status of Fisheries Resources

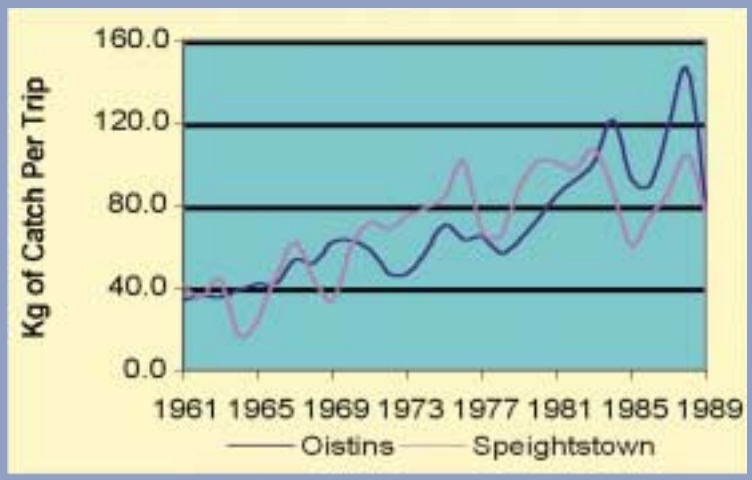
Fishery managed	Fishing methods	Area fished	Resource status
Shallow-shelf reef fishes (e.g. parrotfish, surgeonfish)	Fish traps, set nets, spear guns	Coastal coral reefs	Many south and west coast areas are considered overfished. Status of east coast resources is unknown.
Deep slope fishes (e.g. snappers, groupers)	Fish traps, handline	Deep slope bank reefs and shelf area	Unknown, but preliminary studies suggest that some areas may have potential for increased harvest.
Coastal pelagics (e.g. herrings, jacks, small tunas)	Handline, troll lines, cast net, seine net	Coastal	Unknown
Large pelagics (e.g. dolphin, tunas, kingfish, swordfish, shark)	Handline, troll lines, longline	Oceanic	Dolphin unknown. ICCAT assessment indicates some other species may be fully or over exploited.
Flyingfish	Gillnet, handline, dip net	Coastal, oceanic	Unknown. Preliminary evidence suggests potential for cautious expansion.
Sea urchins (i.e. sea egg)	Manual hand or rake	Coastal	Overfished.
Turtles (e.g. loggerhead, hawksbill, leatherback)	Entangling nets (fishery closed until further notice since 1998)	Coastal, oceanic (fishery closed until further notice since 1998)	Considered by international standards to be threatened.
Lobsters (e.g. spiny, spotted)	Fish traps, hand spears	Coastal	Unknown. Populations appear to be small.
Conch (e.g. Queen conch)	Manual	Coastal	Unknown. Populations appear to be small.

Source: Fisheries Division, Ministry of Agriculture and Rural Development, 2001.

Map 6.3: Fish Landing Sites

Source: Fisheries Division: Barbados Fisheries Management Plan, 2001.

Figure 6.2: Fishing Productivity, Speightstown & Oistins 1961 - 1989



Source: Mahon et al, 1990.

With respect to productivity of the fisheries, information is not continuous, nor is the coverage island wide. There are about 31 fish landing sites on the island, which are classified by the Fisheries Division as Primary, secondary and tertiary[11] (Map 6.3). Productivity of the resources was studied using catch landed by pelagic fishing fleets out of two of the primary sites - Speightstown and Oistins - between 1961 and 1989. The results, which are presented in Figure 6.2, suggest an overall increase in productivity at these sites over the period. It is not clear, however, whether the increased landings are due to increased stocks or improved fishing capacity.

6.8 Fisheries Policy

Owing to the important role that fisheries play in the local economy and culture, attention has been paid to the management of these resources for some time. Previously existing management regulations for the sea-egg, turtle and whale fisheries were consolidated in the Fisheries Regulation Act of 1904. This Act was repealed in its entirety and replaced by the more extensive Fisheries Act of 1993. In addition to these acts several other pieces of legislation relevant to fisheries have been put into force.

The Barbados Territorial Waters Act 1979 (cap 386), for example, contains provisions relevant to the protection of marine life, including the prohibition of fishing or extraction of living resources by foreign ships under "innocent passage", and empowers the Minister of Foreign Affairs to provide for the "regulation of fishing". The Marine Boundaries and Jurisdiction Act, 1979 (cap 387) provides a definition of fish, prohibits fishing within the 200 mile EEZ without the permission of, or an agreement with, the government of Barbados, and establishes penalties for illegal fishing[12].

The Fisheries Act 1993 consolidates the above provisions, and further provides for the Management and Development of Fisheries in accordance with statutory schemes. It also contains specifies conservation measures with respect to fishing gear and methods and provides for the protection of internationally endangered species such as marine turtles. The Act also gives the Minister responsible for fisheries the authority to create new regulations for the management of local fisheries when necessary.

The first Fisheries Management Plan (FMP) was published in 1997. A revised version was published in 2001. The FMP is developed in accordance with the requirements of the 1993 Act, "to ensure the optimum utilization of the fisheries resources in the waters of Barbados for the benefit of the people of Barbados"[13]. The document contains plans for the

continuous study, monitoring and assessment of fisheries resources in general, as well as strategies that focus on specific species. Its development and implementation is done, as required by the Fisheries Act, in collaboration with relevant agencies, interest groups and the fishing community, and is subject to public review.

6.9 Conclusion

Coastal and marine resources are vital to the Barbados economy and culture. In the past these resources have been negatively impacted by policies and practices that did not take into account their vulnerability and finiteness. In recognition of the importance of the resources, recent years have seen considerable attention paid to their protection and management. The challenge, currently and for the future, is to engage in careful monitoring and recording of the impacts of the existing policies to measure their effectiveness, and to implement changes where necessary, so as to effect the sustainable use of coastal and marine resources.

Notes

1. Most of this information on the state of the coast was obtained from the CZMU via the Ministry of Physical Development and Environment. Additional sources are cited where used.
2. Ibid.
3. Crowards (1997), citing the Bellairs Research Institute (1997), in *Environmental Indictors for Barbados: a Pilot Study for 1996*. This is a draft report prepared by the Caribbean Development Bank in collaboration with the Ministry of the Environment, under the Sustainable Development Indicators programme.
4. Ibid.
5. Ibid.
6. This site is studied as part of the CARICOMP (Caribbean Coastal Marine Productivity) network of monitoring projects, the other in Barbados being the Graeme Hall Swamp. Information was obtained from the following publication: UNESCO, 1998. CARICOMP – Caribbean coral reef, seagrass and mangrove sites. Coastal region and small island papers 3, UNESCO, Paris. Available at: http://www.unesco.org/csi/pub/papers/papers3.htm.
7. Ibid.
8. Ibid.
9. Ibid.
10. Coastal Zone Management Unit
11. Fisheries Division, Ministry of Agriculture and Rural Development, 2000. *Barbados Fisheries Management Plan*
12. Willms & Shier, 1997b, Working Paper on Environmental Laws of Barbados; prepared as part of the project on Environmental Management and Land Use Planning for Sustainable Development.
13. See 11 above.

7.1 Introduction

Due to its over three hundred years of settlement and extensive development, Barbados has remaining a very limited stock of biological diversity compared to that which was here originally. The island was extensively denuded during the colonial period, its original vegetation cover having been replaced largely by tobacco, cotton and sugar cane plantations. It now has a highly developed physical infrastructure and one of the highest population densities in the world. The combined effect of these factors is that there now remain very few places that can be considered remote, or that closely resemble their pre-settlement state. Any such areas remaining today are under threat from the encroachment of various forms of physical and human development.

The more recent sources of pressure on the island's biological diversity include: extensive land subdivision for residential development; commercial, industrial and tourism development; and agricultural activity. These competing uses exert pressure on the few remaining natural areas, and highlight the need for strong strategies to conserve and manage what remains of the island's biodiversity.

This section will provide an overview of the current knowledge about the status of terrestrial and marine biodiversity including natural vegetation and forest, rare and endangered species, as well as coastal, near-shore and benthic communities[1].

7.2 Terrestrial Biodiversity

Due to the limited amount of forest cover and other undisturbed natural habitats, the terrestrial fauna, particularly vertebrate fauna, is sparse. Some species of mammals, birds, reptiles, amphibians and insects, are classified as rare, or endangered. Despite a substantial history of research and documentation, however, there remains a lot to be learned about the ecology, habits, and status of much of the flora and fauna of Barbados.

7.2.1 Natural Vegetation

Within thirty years of first settlement in 1627, about 80 per cent of the forest cover was cleared for agriculture. A subsequent three centuries of plantation monoculture and extensive and intensive development activity have left the island with only pockets of its original natural vegetation. The decline of agricultural activity, particularly land under sugar cane cultivation, in the latter decades of the last century has seen a gradual regeneration of natural vegetation and secondary forests on abandoned agricultural lands, particularly in the Scotland District. The end use of gullies as a source of firewood has also allowed regeneration of natural vegetation.

(i) Major Plant Communities

The major natural plant communities have been classified according to the following types of environments, with which they are associated:

- Beaches, sand dunes and sandy beaches;
- Sea cliffs and sea rocks;
- Rocky land and inland cliffs;
- Gullies;
- Forests, and
- Coastal Wetlands.

Table 7.1 summarises the major species associated with each except gullies and forests.

The gullies are important environments for a large proportion of Barbados' biological diversity. These deep fissures in the coral cap provide more sheltered and moist conditions than occur in other parts of the island, and are host to vegetation characteristics that tend to be different from those in the ravines of the Scotland District. They tend to have a large and mature collection of native ferns, climbers, shrubs and trees as presented in Table 7.2.

The total tree cover on the island is reported to be two per cent or 800 hectares of the land area, including gullies, coastal wetlands, under-cliff woods and other planted woodlands. The Turner's Hall wood, occupying approximately 21 hectares in the Scotland District, is the least disturbed wooded area on the island and the best example of the original tropical mesophytic (semi-deciduous) forest. The under-cliff woods lie at the base of the coralline cliff that rims the Scotland District, and remnants of xerophytic coastal forests occur at Cluffs, Bath and Batts Rock.

Table 7.1: Major Plant Communities/Species

Flora (plants)	Ecosystem Types/Habitats	Representative Communities/Species
Terrestrial	Beaches, sand dunes, sandy beaches	Xerophytic vegetation *Philoxerus vermicularis, Ipoema pescaprae, Coccoloba uvifera*
	Sea cliffs	Halophytes and Grasses *Paspalum distichum, Sporobolus virginicus, Dactyloctenium aegypticum, Eleusine indica, Croton balsamifer, Jatropha gossypifolia, Lantana camara*
	Inland Cliffs	*Tabebuia pallida, Lantana involvucrata, Peperomia magnoliifolia, Bryophyllum pinnatum*
Marine	Coastal wetlands	*Rhizophora mangle, Laguncularia racemosa, Nelumbo nucifera, Eleocharis geniculata, Abilgaardia mosotachya, Fimbristylis ferruginea, Sporobolus virginicus, Philoxerus vermicularis, Conocarpus erectus*

Source: National Biodiversity Strategy and Action Plan- Assessment of Land Resources, Terrestrial Flora and Agricultural Biodiversity, 1998.

Table 7.2: Gully Flora

Type	Species
Ferns	*Pteris vittata, Adiantum tenerum, Neurodium lanceolatum, Polypodium Latum*
Shurbs	*Tecoma stans, Psidium guajava, Clerodendrum aculeatum. Solanum recemosum var. igneum, Pisonia aculeata, Coccoloba venosa, Miconia laevigata, M. cornifolia, Piper filatatum*
Climbers	*Turbina corymbosa, Merremia umbellata, M. dissecta, M. aegyptica, Jacquemontia pentantha, Clitorea ternatea, Arbus precatorius, Passiflora foetida*
Trees	*Ceiba pentandra, Maclura tinctoria, Hura crepitans, Citharexylum spinosum, Sapium hippimane, Cecropia Shreberiana, Inga laurina, Spondias mombin, Bursera simaruba, Aiphanes minima, Roystonea oleracea*

Source: National Biodiversity Strategy and Action Plan- Assessment of Land Resources, Terrestrial Flora and Agricultural Biodiversity, 1998.

7.2.2 Endemic, Rare and Endangered Plants

Of the 700 species of flowering plants known to exist on the island, only three species have so far been identified as endemic: the maypole (*Agave barbadensis*), a gully shrub (*Phyllanthus andersoni*), and a slender climber (*Metastelma barbadense*). None of these is rare or endangered. Twenty-three plants are considered to require protection at the national level. Of these 15 are known to exist at only one site and eight are considered rare or endangered. These are itemized in Tables 7.3 and 7.4.

7.2.3 Terrestrial Fauna

Compared to some of the larger Caribbean islands, the terrestrial fauna of Barbados is rather limited. The assessment conducted in preparation of the 1998 National Biodiversity Strategy and Action Plan (NBSAP) was restricted to mammals, birds, reptiles, amphibians and terrestrial invertebrates of social and economic importance, such as insects and allied arthropods. These taxa, and the species associated with them are summarised in Table 7.5 along with the other terrestrial fauna.

The bird fauna is much more diverse that the mammalian fauna, but it is dominated by migratory and winter resident species. Barbados lies along the flyway for the eastern North American migratory bird populations, and as a result over 150 species have been recorded on the island. These include seabirds such as gulls and terns, and shore birds such as plovers and sandpipers. The more notable winter residents are summarised in Table 7.5 along with the other terrestrial fauna.

The populations of resident avifauna have declined due primarily to habitat loss since colonization, and to predation by introduced mammals such as the raccoon, mongoose and the green monkey. At least 36 species of resident birds have been confirmed. These include sixteen exotics, eight of which occur naturally due to expanded range.

Table 7.3: Plants Known From Only One Site

Species	Family	Location
Philodendron scandens	Araceae	Turner`s Hall Wood
Dioscorea altissima	Dioscoreaceae	Turner`s Hall Wood
Annona glabra	Annonaceae	Turner`s Hall Wood
Hernandia sonora	Hernandiaceae	Turner`s Hall Wood
Capparis hastata	Capparaceae	Turner`s Hall Wood
Actinostemon caribaeus	Euphorbiaceae	Turner`s Hall Wood
Cissus erosa	Vitaceae	Turner`s Hall Wood
Conocarpus erectus	Combretaceae	Chancery Lane Swamp
Eugenia pseudopsidium	Myrtaceae	Turner`s Hall Wood
Eugenia lambertiana	Mrtaceae	Turner`s Hall Wood
Manilkara bidentata	Sapotaceae	Turner`s Hall Wood
Sideroxylon foetidissimun	Sapotaceae	Sion Hill Gully
Forestieria rhamnifolia	Oleaceae	Joes River Forest
Vitex dicarciata	Verbenaceae	Joes River Forest
Strumpfia maritima	Rubiaceae	Gemswick

Source: National Biodiversity Strategy and Action Plan- Assessment of Land Resources, Terrestrial Flora and Agricultural Biodiversity, 1998.

Table 7.4: Rare and Endangered Plants

Species	Family
Coccothrinax babadensis	Palmae
Spiranthes lanceolatus	Orchidaceae
Talinum fruticosum	Portulacaceae
Zanthoxylon spinifex	Rutaceae
Cedrela odorata	Meliaceae
Quaraibea turbinata	Bombacaceae
Guazuma ulmifolia	Bombaceae
Psychotria microdon	Rubiaceae

Source: National Biodiversity Strategy and Action Plan- Assessment of Land Resources, Terrestrial Flora and Agricultural Biodiversity, 1998.

Table 7.5: Terrestrial Fauna

Taxa	Species	Origin/Status
Mammals	Rats (*Rattus rattus, R. novegicus*) Green monkeys (*Cercopithecus aethiops sabaeus*) Mongooses (*Herpestes javanicus*)	Introduced and common
	Racoon (*Procyon gloveralleni*), Hare (*Lepus capensis*)	Introducesd and Rare
	Bats - six species *Monophyllus plethodon*	Indigenous Endemic sub - species
Birds	Osprey (*Pandion haliaetus*), Great blue heron (*Ardea herodias*), Little blue heron (*Floria caerula*), American redstart (*Setophaga ruticilla*).	Migratory (winter resident)
Reptilia	*Mastigodryas bruesi*	Regularly sighted
	Worm snake (*Leptotyphlops bilineata*)	Rarely seen but presumed extant
	Grass sanke (*Liophis prefuscus*)	Endemic, not sighted since 1961, presumed extinct
	Tree lizard (*Anolis extremus*), Leaf-toed gecko (*Phyllodactylus pulcher*)	Endemic, *A. extremus* common, *P. pulcher rare*
	Teiid ground lizard (*Kentropyx borkiana*), Small silver and black ground lizard (*Gymnopthalmus underwoodi*), Gecko (*Hemidactylus mabouia*)	Other extant species
	Giant tortoise (*Geochelons sp*)	Extinct
	Red - footed tortoise (*Geochelones carbonaria*)	Introduced, captive bred
Amphibians	Cane toad (*Bufo marinus*)	Introduces; abundandt and widespread.
	Whistling frog (*Eleutherodactylus johnstonei*)	Indigenousness controversial; prolific
Insects	Approximately 1 320 species	No data

Source: National Biodiversity Strategy and Action Plan- Assessment of Land Resources, Terrestrial Flora and Agricultural Biodiversity, 1998.

7.3 Impacts on Terrestrial Diversity

Plant communities provide habitats for terrestrial fauna. Though the value of these areas for roosting, nesting, feeding and protection of faunal species has not been quantified, the highly integrated nature of the ecosystems means that factors that negatively impact one aspect of the system would have repercussions for others.

The major threats to biodiversity continue to be most types of physical development. In the tourism sector the construction of hotels and marinas threaten native plant communities and nesting habitat for birds and sea turtles, inter alia. Golf course development also poses a threat in the areas under consideration So does the introduction of exotic species. Golf course development also poses a threat in that the areas under consideration often include abandoned agricultural lands that are being recolonised by natural vegetation.

Barbados has already suffered from the introduction of three predators of major significance to native avian and reptilian fauna, the green monkey, the mongoose and the cane toad. The mongoose and cane toad are largely responsible for the likely extinctions of *Liophis perfuscus* and *Mabuya mabouya*. The introduction of further exotic species into the wild is also potentially problematic.

Continued subdivision of marginal lands for residential development will also impact on recolonized locations. While there is no immediate threat to beach, dune and sandy bushland plant communities from residential developments, some existing development approvals will destroy locations such as the Chancery Lane wetlands if implemented. Driving vehicles on beaches causes considerable damage to beach vegetation and has severely impacted Long Pond, Batts Rock and several other beach areas. In addition, the repeated proposals for clearing illegally dumped garbage from gullies and for the creation of trails could place gully species at risk if not carefully implemented.

Free range grazing by cattle, sheep and goats has been a historic practice in rural Barbados. While no data is available by which to evaluate the impacts of this practice, it has been suggested that grazing suppressed the development of some shrubs and trees in gullies, thereby allowing grasses and other herbaceous plants to dominate. The diversity and abundance of vegetation on the landward side of the East Coast Road has been substantially affected by grazing.

Finally, over 300 years of plantation agriculture have reduced the extent of natural systems to small isolated patches, and created several monospecific agro-ecosystems, the most persistent of which has been sugar cane.

This long history of cultivation has contributed to decline in soil fertility. Subsequent increases in inputs of chemical fertilizers and pesticides as a means of improving productivity, have had unavoidable impacts on terrestrial flora and fauna. At the same time, agricultural research has contributed to an increase in the number of genomes of selected food crops for commercial exploitation, grasses for pasture improvement, and the propagation of helpful parasites for biological pest control.

7.4 Freshwater and Marine Biodiversity

The assessment of coastal and marine resources in its general context, which includes some aspects of marine biodiversity, is presented in the section on coastal and marine resources. Here a more detailed look will be taken at the status of the biodiversity of marine and freshwater ecosystems.

There are several marine and freshwater ecosystems that are known to support a rich diversity of species. These include wetlands and water catchments, rocky intertidal areas, seagrass beds and coral reefs. The marine component of the National Biodiversity Strategy and Action Plan[2] states that 990 genera and 1 548 species of organisms have been identified in these ecosystems (Table 7.6), and that several organisms have not yet been identified at the species level.

7.4.1 Wetlands and Water Catchments

As noted elsewhere, Graeme Hall swamp is the largest remaining wetland in Barbados. Examples of

	78		
	54		
	259		8 organisms not identified beyond family
	155		3 organisms not identified beyond family
	172		
	88		14 organisms not identified beyond family
	10		
	3		
	25		
	60		9 organisms not identified beyond family
	4		
	82		

its biodiversity have already been presented. A more detailed list of the fishes, crustaceans, insects, amphibians and aquatic flora is presented in Appendix 2. The most recent available study of the status of the swamp with respect to water quality[3] reported that the lake was "hypertrophic" due to high chlorophyll and nutrient levels, but that coliform levels were "within desirable limits" to permit swimming, fishing and other recreational activities. The water in the eastern canals, were highly alkaline, hard and nutrient rich.

The surface freshwater catchments for which limited biodiversity assessments have been undertaken are Bawdens, Long Pond, Green Pond and Hillaby, Bathsheba, Consett, Codrington, Three Houses and Culpepper. The status of the catchments is unknown, but studies are necessary since it is believed that they may be impacted by agricultural chemicals in drainage water. The known biodiversity in permanent and temporary freshwater catchments is dominated by several species of shrimp such as *Atya innocuous*, *Palaemon aztecus subtilis*, *Palaemon pandaliformis*, and others. (See Appendices 3a and 3b).

7.4.2 Rocky intertidal area

Rocky intetidal area straddles the marine and terrestrial habitats where the shore is washed by the sea at low or high tides. It includes rocky cliffs, pebble beaches, low-lying platforms, and tidepools, which provide habitats for a diverse collection of living organisms including algae, Cnidarians, Crustaceans, Mollusks, Annelids, Echinoderms and Fish. Lists of species found in these habitats are provided in Appendices 4a to 4d.

7.4.3 Sea grass beds and coral reefs

The status of sea grass beds and coral reefs has also been presented in the section on coastal and marine resources. With respect to the coral reefs, it is notable that quantitative surveys record increases in filamentous algae, a decrease in coralline algal cover and declining reef fish numbers. On the patch reefs there has been a significant loss of area covered by mono-species hard coral, while multi-species hard coral has shown signs of damage from boat moorings, bleaching and sediment smothering in several areas. Surveys have also indicated that multi-species soft coral patch reefs along the southwest coast are being seriously degraded and fish abundance has declined. This is attributed to deteriorating water quality and to over-fishing.

The bank reefs support rich and diverse colonies of hard and soft corals, a high density of sponges and a low density of macroalgae. It is reported (Delcan, 1994) that the bank reefs are in reasonably good health, although there is evidence of physical and sediment damage as well as over-exploitation. Sea turtles, particularly hawksbills, can be seen regularly on the bank reef

7.4.4 Benthic communities

The Benthic communities include a sponge and coral community, one that is rich in coelenterates, mollusks and echinoderms, and a community dominated by mollusks. Appendix 5 provides a sample of some of the biodiversity species of these communities, as well as species associated with the dominant fisheries.

7.5 Impacts on Marine Biodiversity

The National Biodiversity Srategy and Action Plan (NBSAP) reports that there are indications that the marine ecosystem is under threat primarily from land based sources of pollution transported by surface water runoff, groundwater discharge and direct discharge or dumping into the aquatic environment. The coastal and marine habitats and their flora and fauna are being degraded primarily by deteriorating water quality resulting from increased sedimentation, eutrophication and sewage pathogens, localized increases in temperature, decreases in salinity and perhaps increases in toxins, overfishing, physical damage and use of destructive fishing methods.

Freshwater ecosystems such as the Graeme Hall swamp are also under severe impact from human activity. Table 7.7 summarises the types and sources of pollution negatively impacting marine and freshwater ecosystems.

7.6 Policy Response

Until very recently, any policy relating to the conservation and management of biological diversity was integral to land use planning policy in the case of terrestrial resources, and marine legislation which

pre-dated the Coastal Zone Management Act (1998) and the Marine Pollution Control Act (1998). Today the Town and Country Planning Act (cap 240) 1963, is still pivotal to the national policy response and legislative strategy for protection of biological resources. However, several more focused initiatives have been taken both within the revised Physical Development Plan (1998), and the NBSAP (2000).

7.6.1 The Physical Development Plan, 1998

The Town and Country Planning Act provides the central mechanism for the regulation of land use, and in this regard it is relevant to the protection of biodiversity. It has in the past been used where possible to prevent encroachment of physical development into ecologically sensitive areas, consistent with the Physical Development Plan. The revised Physical Development Plan (1998), however, articulates the following among a set of objectives regarding the conservation and management of biodiversity:

- Establish National Heritage Conservation Areas for the protection of significant ecosystems such as remnant forests, wetlands, dunes, savannahs, and marine features;

- Protect, maintain and enhance natural heritage features in urban environments and seek to minimize adverse impacts arising from new development.

Other specific references to biodiversity include:

- Preservation of vegetation through incentives to increase tree cover in urban, rural and coastal areas;

- Creation of National Forest Candidate Sites and protection of existing forests, emerging forests and forest linkages in the National Park;

- Restriction of developments in forested gullies, and

- Requirement of tree preservation and replacement plans as part of the supporting documents for all development in the Integrated Coastal Zone Management Area, and enforcement of the Trees Preservation Act

A system of National Parks and Protected Areas has also been proposed. A comprehensive plan for its designation, including the institutional, legislative and management framework and plan for its implementation, has been developed and is awaiting final approval within the wider context of the Physical Development Plan. Unlike most of our Caribbean neighbours, protected areas for terrestrial biodiversity do not currently exist in Barbados; even to protect the critical habitats used by our most endangered species (e.g. sea turtles, snakes and lizards).

7.6.2 The Environmental and Natural Resources Management Plan and Draft Environmental Management Act

A major product of the Environmental Management and Land Use Planning for Sustainable Development Project (EMLUP), completed in 1998, was the preparation of an Environmental Management Plan (EMP) for Barbados, which is embodied within the Draft Environmental Management Act (EMA) that was also prepared under that study. The EMP identifies the following issues and opportunities that need to be addressed as a consequence of the pressures and impacts on biological diversity:

- Maintaining ecological viability of remaining natural habitats that are represented generally in small, isolated areas, including areas of natural forest (e.g. Turners Hall Wood, Hackleton's Cliff, Foster's Funland, Archer's Bay, Consett Bay). This should include projects designed to remove damaging introduced predators from sensitive areas;

- Maintaining the integrity of scenic vistas and areas, including the Scotland District, ridges, caves, coastal cliffs and public parks;

- Preservation of critical habitats for migratory and nesting species, as well as indigenous species including wildfowl, sea turtles and snakes;

Table 7.7: Source of Pollutants in Marine and Freshwater

	. nutrients from fertilizers, animal waste . pathogenic bacteria from animal waste . suspended matter from exposed soil . toxins from pesticides and herbicides
	. organic contaminants creating high biological oxygen demand (BOD) . point source discharge of effluent from sewage treatment plants, waste from rum distillery . sediments from sewage effluent . nutrients (nitrates and phosphates) causing eutrophication . chlorinated water from swimming pools . untreated domestic waste . discharge of heated water from power plant
	. nutrients and pathogenic bacteria from domestic waste . suspended matter from exposed soil during construction . seepage of nutrients into the coastal ground water from suck wells . toxins (heavy metals, chlorine, petroleum and other hydrocarbons)
	. use of dynamite in fishing . ghost fishing by lost fish traps . anchor damage from ships . storms and hurricanes
	. leachate containing nitrates, organic contaminants and heavy metals

- Rehabilitation of degraded natural systems including gullies, forests and dune areas;
- Control of the capture of threatened species including sea turtles and snakes;
- Control over shooting ponds;
- Improved understanding of the need for protection of reptiles and freshwater fish and shellfish;
- Improved control over the felling of trees during construction and clearance;
- Control over set fires, including for clearing fields;
- Controlling the export of rare and endangered terrestrial and marine species; and
- Control over the importation of non-indigenous species of flora and fauna.

7.6.3 The Coastal Zone Management Plan

The Coastal Zone Management Plan (CZMP), which is embodied in the 1998 Coastal Zone Management Act, provides for the conservation and management of coastal and marine biodiversity. It also provides for the designation of marine reserves, which may include submarine areas along with adjacent land that is ecologically linked, as restricted areas.

In addition, the CZMP provides for the conservation and management of Natural Heritage Conservation Areas (OS 2) and Coastal Landscape Protection Zones (OS 3) established under the 1998 Physical Development Plan. The CZMP also articulates the following policies:

- Preservation of existing vegetation by landowners through encouragement from the Coastal Zone Management Unit (CZMU);
- Protection and rehabilitation guidelines for coastal and marine habitats including coral reefs, seagrass beds, ravines and other freshwater ecosystems and littoral vegetation;
- Cooperation between the CZMU and the Fisheries Division in implementing the CZMP provision for regulating shallow-shelf reef and coastal pelagic fisheries, and for managing coastal habitats such as coral reefs and sea grass beds;
- Protection and management of turtle nesting sites, and
- Determination of threshold levels for marine water quality.

7.6.4 Fisheries Management Plan (1997), Fisheries Act (1993/96)

The Fisheries Management Plan (FMP), which is prepared in accordance with the Fisheries Act, provides for protection of the marine environment and conservation of marine biodiversity through the following:

- Integrating the fishing industry into the policy and decision making process on fisheries;
- Promoting the development and use of fishing gear and practices that minimize waste in the catch of target species and minimize by-catch of non-target species;
- Effective monitoring, control and surveillance of fishing activities;
- Protecting and restoring populations of endangered marine species, and
- Preserving rare and fragile ecosystems and ecologically sensitive areas, in particular coral reefs, estuaries, mangroves, seagrass beds, and spawning and nursery areas.

7.6.5 National Biodiversity Strategy and Action Plan 1998

Finally, and perhaps most pertinently, the Ministry of Physical Development and Environment has recently concluded a consultancy for the preparation of a country study on biodiversity, which involved the preparation of a Draft National Biodiversity Strategy and Action Plan (NBSAP). The study consolidated the body of documented knowledge on all aspects of the island's biodiversity, and established a database of terrestrial flora

and fauna. The draft NBSAP identifies priorities and initiatives for conserving biodiversity, as well as appropriate methodologies for implementation, and proposes management plans for specific species, including alien and exotic species.

7.7 Conclusion

The policy responses detailed above indicate the seriousness with which the Government of Barbados intends to approach the management of its very limited and pressured biodiversity resources. It is time that actions to implement these policies be undertaken in order to avoid further degradation of natural habitats and loss of native species. It is expected that, ultimately, a consolidated institutional structure to achieve a well-integrated approach to the management of biodiversity will be developed. Such an approach is laid out in the proposed Institutional Arrangements for Environmental Management and Land Use Planning in Barbados, another product of the EMLUP study, which proposes the creation of a Natural Heritage Unit responsible for the environment. With such a structure in place, supported by the legislative power of the proposed Environmental Management Act, the groundwork will be laid for achieving the goals of sustainable biodiversity management.

Notes

1. Most of the information presented in this section of the report is derived from the recently completed country study of biodiversity, which included preparation of a National Biodiversity Strategy and Action Plan (1998) and the Barbados National Report to the Conference of the Parties to the Convention on Biological Diversity (2000), both of which were prepared for the Government of Barbados by Simmons and Associates Inc. The latter included an extensive survey of the research and literature available on the Biodiversity of Barbados.
2. Simmons and Associates, 1998, National Biodiversity Strategy and Action Plan Technical Report: Marine Resources. Prepared for the Government of Barbados, Ministry of Health and the Environment.
3. For this Simmons and Associates cited Catteneo *et al.* (1988).

8.1 Introduction

The quality of the air affects human health, the appearance and value of property, and the vigour of natural communities. Air pollution can be pervasive, and is often unseen and not smelled. These 'undetected' components are often hazardous to human heath.

Up until the recent past air pollution was not considered a major concern in Barbados, owing to the relatively low elevation of the island and the continuous sweep of the Northeast Trade winds. In recent years, however, there has been growing concern about ambient air quality as the island has continued to develop and associated activities intensified. Increases in vehicular traffic, industrial activity and the incidence of Sahara dust have become the sources of growing concern about the quality of the air and its possible linkage to certain health problems on the island.

8.2 Sources of Air Pollution

Several types of air pollution have been reported including particulate, odours associated with gaseous emissions, and smoke[1]. However, no routine monitoring programmes have been established. One pilot monitoring study was set up in 1994, but has since then been discontinued[2].

8.2.1 Particulate

A significant contributor to atmospheric pollution is Sahara dust, which has a strong, visible background signature during the spring and summer months. Brought to Barbados by the Trade Winds, this is an area over which there can be no local control and which has not been studied, although a privately managed monitoring station is known to exist at Ragged Point in St. Philip. Areas for which there can be control are: particulate emissions; from construction sites; quarry operations; cane fires; the burning of refuse, including garden waste; vehicular emissions, and certain industrial operations such as auto-body shops and cement works.

8.2.2 Odours

The primary sources of odours have been the Mangrove Landfill; garbage collection trucks; sites of unauthorised disposal of animal and other organic waste in drainage suckwells, gullies and roadsides; vehicular exhaust, industrial stacks and aircraft, particularly during take-off.

8.2.3 Smoke

This is largely associated with other source problems including cane fires, vehicular exhaust, industrial stacks, aircraft, and the burning of refuse both within and outside landfills. Heavy industry can frequently be a source of air pollution as well.

Stationary sources of air pollution have been measured primarily with respect to the operations of the Barbados Light and Power Company Ltd. (BL&P). The Environmental Management Plan cites a 1994 Pan American Health Organization (PAHO) study which reports that the total BL&P emissions for 1992 were 4 590 tons of sulphur dioxide, 1 716 tons of nitrous oxide, and 373 tons of particulate. The study considered that the oil refinery, and industrial, commercial and residential heating sources were potentially significant contributors to emissions. A number of other concerns were also added, including silicate processing and flour and feed blending plants which emit particulates, as well as asphalt, concrete block and rum production factories, which emit sulphur dioxide, nitrogen dioxide and particulates.

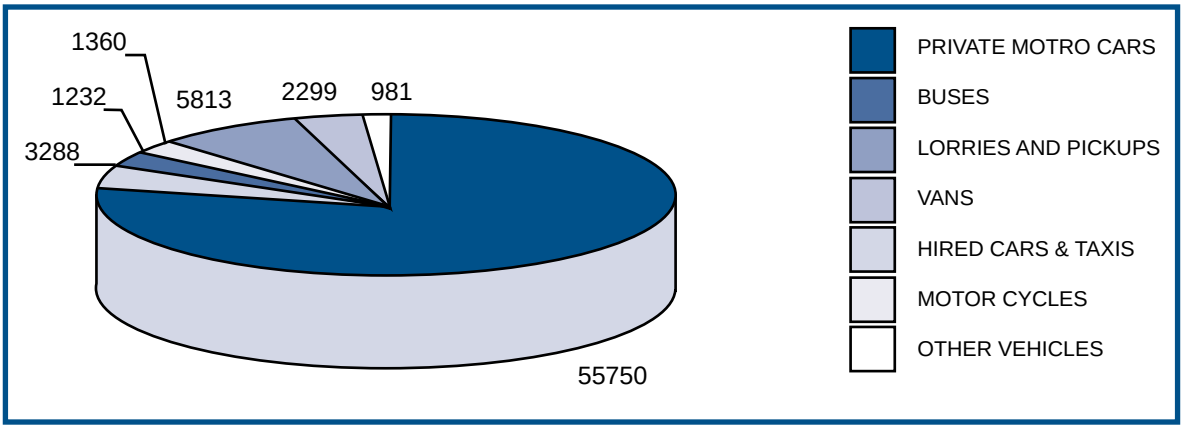
With respect to mobile sources, vehicular traffic on the island has been increasing steadily since the 1960s. Data from the Barbados Licensing Authority shows that the number of registered vehicles increased from around 17 000 in 1967 to approximately 34 000 in 1980, and from just under 40 000 in 1984 to about 57 000 in 1996[3]. Data for June 1999 gave a total of 73 723 registered motor vehicles on the island, an average of about one per 3.6 persons in the population. Figure 8.1 gives a breakdown of the vehicles by type for 1999[4].

The PAHO (1994) report on air quality estimated that emissions from vehicular traffic annually contributed 9,302 tonnes of hydro- carbons, 49,680 tonnes of carbon monoxide, 2.413 tonnes of nitrogen oxides and 50 tonnes of lead to the atmosphere.

8.3 Impacts of Air Pollution

The impacts of air pollution depend on local factors relative to sources. It is recognized that in many areas of the island the persistent easterly

Figure 8.1: Registered Motor Vehicles 1999



Source: Barbados Licensing Authority.

trade winds tend to assist in the rapid dispersion of pollutants[5]. It should be noted, however, that the trade winds can also spread smoke and particulate matter from cane fires and quarry operations westward to the more densely populated areas.

The central Bridgetown area, with its dense road and housing systems and the confounding effects of buildings, is considered to be an area of high ambient concentrations of pollution, especially from vehicular traffic[6]. In addition, except for the incinerator at the Queen Elizabeth Hospital, the large stationary sources of stack emissions are generally located on the windward coast, where advantage is taken of the offshore breeze. However, calm or onshore winds are known to retain and bring pollution from such sources onshore[7].

While studies worldwide have linked the types of pollutants mentioned to human health problems, no studies have been conducted or data exist to establish such linkages locally. Anecdotal reports suggest that the incidence of respiratory symptoms has increased in recent years. The rate of asthma, for example, is believed to be high by international standards. Establishing causes, however, is complicated by the range of factors that might be involved, including pollen, seasonal Sahara dust and indoor pollutants[8].

8.4 The Policy Response

There is clearly a dire need for reliable information in this area and on ambient air quality parameters in general, so that appropriate policies and management procedures can be developed.

The agency with the general mandate to monitor and control air quality in Barbados is the Environmental Engineering Division (EED) of the Ministry of Physical Development and Environment. In 1993 the Division conducted air pollution monitoring at the Grantley Adams Airport and in the vicinity of the Barbados Light and Power Plant. It also set up a pilot monitoring study in 1994, which has since then been discontinued. The Division has been directed to implement a systematic and ongoing programme of air quality monitoring, but has suffered from the persistent problem of insufficient capacity.

The 1992 Coastal Conservation Institutional Strengthening study and the more recent 1998 EMLUP study both made recommendations for capacity building of the EED to enable it to carry out this important work in area of air quality management and control. The EMLUP study recommends its restructuring to become the Environmental Protection Unit (EPU) within the Ministry responsible for environmental management, and supporting legislation has been prepared within the Draft Environmental Management Act.

The draft Environmental Management Plan also details an air quality monitoring programme to be implemented by the EED or proposed EPU. The programme is designed to provide data on ambient air quality that could be used to[9]:

- Determine the nature, extent and trends of air pollution in Barbados;
- Assist in determining appropriate standards for air quality and emissions;
- Support research on effects of air pollution on health, property and vegetation, and
- Provide a measure of the effectiveness of air pollution abatement activities, including the phase out of lead in the environment.

Several sites have been proposed for the initial phase of the programme, which also allows for expansion to include additional sites, including specific sources such as factories and emission stacks, utilities, quarries and landfill sites. Implementation was envisaged to occur throughout 1998, but it appears not yet to have started.

It seems at this point that strengthening of the EED is a necessary prerequisite for addressing air quality issues in Barbados.

8.5 Climate Change

The term "climate" is used in this section to refer to the phenomenon of climate change caused by accelerated warming of the earth's atmosphere due to increased concentrations of greenhouse gases. It encompasses the implications of climate change on the natural and built environment both as a result of natural fluctuations in climatic parameters such as the intensity, duration and frequency of weather phenomena, and through changes brought by human activity.

The international scientific consensus is that human beings have changed, and continue to change the balance of gases that form the atmosphere, particularly the "greenhouse gases" which include carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O). These greenhouse gases are vital to maintaining life on the earth, because they act as a blanket that prevents excessive cooling of the earth's atmosphere. The problem is that human activity such as the burning of fossil fuels and the destruction of forests, releases huge amounts of carbon dioxide into the air. Such human activity has increased dramatically since the industrial revolution. The result is a warming of the earth's atmosphere at a rate never before experienced in the history of the planet. This is expected to change wind and rainfall patterns that have prevailed for thousands of years, thereby affecting weather patterns and agriculture, and cause sea-level to rise.

Barbados and other small island developing countries are very concerned about the potential impacts of climate change, which include:

- Acceleration in the rate of change of mean sea level with associated possibilities for increased coastal flooding and shoreline instability; and
- Possible changes in weather patterns, including the potential for increases in the intensity and frequency of tropical storms and hurricanes, and in precipitation patterns, with potential impacts on agriculture and on groundwater recharge and public water supply.

It is widely postulated that some effects could be quite dislocating for the inhabitants of many small islands. Various socio-economic sectors, including tourism, infrastructure, agriculture, water resources, and human health - all of which are sensitive to fluctuations in rainfall, temperature, and sea level - could also be negatively affected[10].

8.6 Policy Response to Climate Change

Response to the problem of climate change takes the form of mitigation and/or adaptation strategies. There is very little that small island countries can do by way of mitigation, since their contribution to global greenhouse gas emissions is quite small. Barbados' per capita CO_2 emissions trends since 1970 are shown in figure 8.2 . In fact, in 1996 the average per capita emissions for 32 island countries that are members of the Alliance of Small Island States (AOSIS), was 0.9 metric tons of CO_2 equivalent, compared to 6 tons per capita for most developed countries and over 19 tons per capita in the case of the USA.

The emphasis for island countries with respect to domestic policy has to be adaptation. In this regard, Barbados is already well advanced in terms of both the analysis of coastal impacts and in the preparation of an institutional and planning frame-

work for Coastal Zone Management. In the last two decades Barbados has undertaken three major coastal zone management projects - 1983-84, 1991-95 and 1996-98 - with assistance from the Inter-American Development Bank. These projects, which have included coastal vulnerability analyses, have culminated in a Coastal Zone Management Plan for the entire coastline. Design standards for coastal structures and setbacks have been developed, taking into account assumed future changes in sea level, flooding associated with 50-year and 100-year storm events and, in the case of setbacks, projections for shoreline erosion. Setback policies are also incorporated into the Physical Development Plan (1998)[12].

In addition, at the regional level Barbados is participating in the GEF-funded project: Caribbean Planning for Adaptation to Climate Change. Barbados is the site of a pilot study on Coastal Vulnerability and Risk Assessment, in which the Coastal Management Unit (CZMU) is responsible for monitoring sea level changes around the island. Three tidal gauges digitally record tidal data which is analysed by the CZMU. This data is also regularly submitted to the Permanent Service for Mean Sea level (PMSL) and the Tropical Ocean Global Atmospheric Project (TOGA).

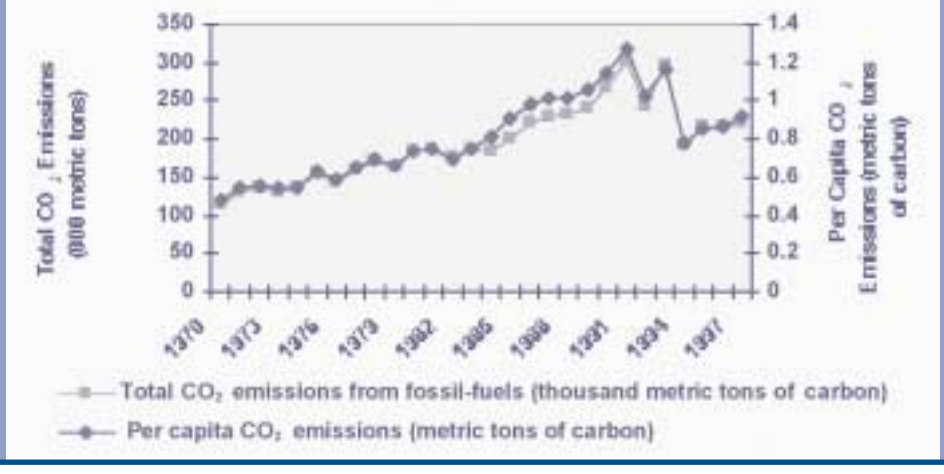
A Global Positioning System (GPS) has also been installed and calibrated at the CZMU headquarters. As a participant in the Global Level of Sea Surface (GLOSS) programme which coordinates global monitoring of the sea surface, the GPS data is submitted to the US National Oceanic and Atmospheric Association (NOAA) for processing.

At the international level, Barbados has ratified the United Nations Framework Convention on Climate Change (FCCC), and is an active member of the Intergovernmental Panel on Climate Change (IPCC). Barbados participates regularly in the Conferences of the Parties to the FCCC and its subsidiary bodies, and does its part to keep the international community focused on adopting policies that lead to the real and concrete reduction of global greenhouse gas emissions.

8.7 Conclusion

The subject of atmosphere and climate change is, logically, a two-level one: a local issue - atmospheric pollution, and a global issue - climate change. On the former it is clear that, given the pace of physical and socio-economic development of the country, clean air can no longer be assured by natural processes alone. It is timely that implementation of the recommendations of studies on the subject be actively considered. On the global

Figure 8.2: Total and Per Capita CO_2 Emissions 1970 - 1997



Source: Oak Ridge National Laboratory, Carbon Dioxide Data Analysis Center, 1999.

issue of climate change, the key challenge for island countries like Barbados is to devise a strategy to pressure larger emitters to effectively reduce their emissions. For, with the large emitters so heavily focused on least-cost, market-based approaches to stemming global warming due to climate change, actions that will halt the impacts of sea level rise are, in effect, delayed. This means that Barbados must plan to raise funds to meet adaptation costs, which at present are estimated to be beyond the capacity of the national budgets of island countries.

Notes

1. Willms and Shier, 1998a: *Environmental and Natural Resources Management Plan*. Prepared for the Government of as part of the EMLUP studies.
2. Caribbean Development Bank, 1996: "Environmental Indicators for Barbados". A pilot study conducted as part of the UN Commission on Sustainable Development's Environmental Indicators Programme.
3. Ibid.
4. Barbados Licensing Authority
5. See 1 above.
6. Willms and Shier, 1998a: *Environmental and Natural Resources Management Plan*, citing PAHO 1994.
7. See 1 above.
8. See 2 above.
9. See 1 above.
10. IPCC 2001. *Special Report on The Regional Impacts of Climate Change: An Assessment of Vulnerability*. Chapter (9) on Small Island States.
11. Source: Oak Ridge National Laboratory, Carbon Dioxide Data Analysis Center. 1999. "National CO2 Emissions from Fossil-fuel Burning, Cement Manufacturing [omitted for this report], and Gas Flaring." Available at http://cdiac.esd.ornl.gov/ftp/ndp030/nation96.ems.
12. see 1 above

9.1 Introduction

Barbados enjoys a high per capita income, high standard of living, it also produces and imports large volumes of a variety of packaged foods and consumer items. This, combined with the high population density within a limited land area and annual stay-over tourist arrivals that almost double the local resident population, generates significant volumes of solid waste that presents problems of management and disposal. Further, in compliance with its obligations under the International Convention for the Prevention Pollution from Ships (MARPOL 73/78), ship-generated waste is accepted at the Bridgetown harbour for national disposal.

Barbados is faced with the problem of managing and disposing of increasing volumes of waste, including hazardous waste, within the context of very limited physical and economical options for disposal.

9.2 The Nature of the Problem

9.2.1 Solid Waste

The main form of solid waste disposal is through landfilling, with the main facility being located at Mangrove Pond, St. Thomas. A new landfill has been constructed at Greenland, St. Andrew, but is not yet operational.

A basic issue lies in assessing and handling the growing volumes of waste generated by the public. Data on waste volumes and waste characterization appears to be limited, however, due perhaps to the fact that efforts at comprehensive management and collection are still quite recent. A gate survey conducted by Stanley Associates in 1993 as part of the ongoing Integrated Solid Waste Management Study conducted for the Government, revealed that 265 tonnes of municipal solid waste were disposed of per day over a seven-day period, at the Mangrove Pond landfill site[1]. A Summary of the composition and sectoral sources of this waste is provided in Table 9.1.

Since then another study has estimated a total of 130 000 tonnes or 492 kilograms of waste per capita generated in 1996[2], representing an increase of 14 per cent over an earlier (1990) estimate, or an average per capita rate of increase of 12.5 per cent in six years[3].

Scrap metal is disposed of at Bagatelle in St. Thomas. Additionally, there is a derelict vehicle removal programme co-ordinated by the Environmental Engineering Division (EED) of the Ministry of Physical Development and Environment. The Programme offers island wide coverage and systematically removes abandoned vehicles. Additionally, removal services are offered to persons who have derelict vehicles, upon request. In 1998, 316 derelict vehicles were collected for disposal. Bulky waste is also generated from construction sites. In 1998 a total of 7 140 loads were received at the bulky waste disposal site, an 18.1 per cent increase over the 1997 total of 6,045 loads[4].

Other forms of waste handled include blood and grease from the public abattoir, which is disposed of at a separate site at Lonesome Hill, St. Peter. Ship- and aircraft-generated waste, which is incinerated on site at the Bridgetown Port and the Grantley Adams Airport respectively. The incinerator ash is disposed of at the Mangrove Pond landfill.

Sewage sludge generated by the Bridgetown Sewage Treatment Plant has been disposed of at Spencer's in Christ Church since 1982. In 1992 1.44 million U.S. gallons were generated[5].

9.2.2 Hazardous Waste

The Stanley Study on Hazardous Waste reported that in 1996 737[6] tonnes of hazardous material moved through the Port Authority. Of this 56.6 per cent were in the form of pressurized gases with little or no potential for generating recoverable residuals. 43.4 per cent was in the form of liquid or solid compounds with the potential for generating a recoverable solid or liquid hazardous waste. Some of the potential hazardous wastes include: acids, alkalis, solvents, pesticides, heavy metals and ink and dyes.

Lead acid batteries, used oil, along with asbestos are considered part of the hazardous waste steam,. The management of hazardous waste, is being addressed as part of the Integrated Solid Waste Management Programme (ISWMP).

Table 9.1: Solid Waste Composition: 1994 Survey Results

Materials Categories	SSA Residential (kg)	SSA Commercial (kg)	Private Commercial (kg)	Total MSW (kg)
Paper	27,378	4,157	22,674	54,210
Plastics	16,241	1,895	4,790	22,926
Glass	9,700	509	3.653	13,862
Ferrous Metals	7,814	220	2,318	10,351
Non-Ferrous Metals	1,018	93	739	1,850
Organic (non-yard) Waste	52,826	2,927	30,973	86,726
Yard Waste	31,585	532	36,757	68,874
Other	2,769	71	2,268	5,108
Hazardous (including spent containers)	314	9	624	947
Special Wastes	0	0	281	281
Total Composition (Tonnes)	149.65	10.41	105.08	265.14

Source: Stanley and Associates Engineering Ltd. 1994. Integrated Solid Waste Management Programme: Technical Addendum No.1.

A medical waste management programme is being put in place through the collective efforts of the personnel involved in the design and implementation of the HIV Aids Programme and the ISWMP of the Ministry of Health.

9.3 Impacts of the Problem

In spite of a long established system of waste management which includes government programmes as well as private entities and business houses, waste management has proven to be a major challenge over the past decade. This is manifested in several ways including:

- Dumping by private citizens and business houses in gullies, quarries and on roadsides, both on a large and small scale. This however, has been a historical problem;
- Island wide littering caused by negligent disposal of small items such as plastic cups, plates, bags and take-away lunch boxes;
- Large quantities of packaging, much of which is non-biodegradable, generated through foreign imports and local producers and retailers;
- Trash left along highways and sidewalks by vendors and improper placement of garbage bins by householders (to a lesser extent);
- Inadequate storage and covering of waste, including hazardous materials.

Other impacts include vector control problems including health issues, associated with mosquitoes, rats and mice, and with illicit dumps and stockpiles of vegetation, tires and old containers. The campaign against the dengue endemic has targeted the removal of such material that act as breeding grounds for mosquitoes. Leachate infiltration into the groundwater aquifer from illegal dump sites in gullies is a persistent worry.

9.4 Policy Response

Traditionally, in Barbados Solid Waste Management had been the responsibility of various agencies in the public sector principally because solid waste management issues affect both health and environmental concerns. Most of these agencies fall under the Ministry of Health, but there are agencies under other Ministries that hold responsibility for some solid waste management issues.

This led to a lack of integration and co-ordination, duplication of tasks, overlapping responsibilities, and inconsistent policy recommendations with respect to solid waste management. For this reason, the Integrated Solid Waste Management Programme (ISWMP) was conceived. The ISWMP is a comprehensive project, and provides for the preparation of a long-term (20-year) vision for managing solid waste on the island. The main objective of the programme is based on sustainable practices that encourage waste reduction, re-use and the appropriate treatment and disposal including recycling.

9.4.1 Institutional

In early 1993, recognising the need for comprehensive Solid Waste Management in Barbados the GOB entered into an agreement with the Inter-American Development Bank to undertake an integrated Solid Waste Management Programme, using an independent consultant.

The key issues that were identified were:

- Lack of an integrated approach to collection and disposal of solid waste;
- Littering;
- Illegal dumping;
- Handling and disposal of special waste;
- The need for organisational change, and
- The need for a cost recovery mechanism.

Currently attention is focused on implementing the programme, which comprises the following physical and non-physical components:

Physical:

- Construction of a new National Sanitary Landfill at Greenland, St. Andrew;
- Construction of a Waste Transfer Station, a National Composting Facility and Hazardous Waste Storage Facility at Vaucluse, St. Thomas. Conceptual designs have been prepared for these facilities;
- Construction of a Bulky Waste Facility at Bagatelle, St. Thomas is currently underway and further construction will take place in the future, as needs change; and
- Various road upgrades to accommodate traffic to and from the landfill, transfer station and other new facilities.

Non-Physical:

- Institutional strengthening of key government agencies responsible for delivery of services related to waste management;
- Policy development and drafting of appropriate legislation to support effective implementation of the programme;
- Economic instruments and incentives for cost recovery and to encourage compliance with the requirements of the programme, including taxes, tipping fees, levies and export of recyclable materials; and
- Public education/awareness programmes that target consumers, businesses and manufacturers.

9.4.2 Programmatic

(i) Solid Waste

Several Government agencies share responsibility for the management of wastes in Barbados:

a) The Sewerage and Solid Waste Project Unit (SSWPU) of the Ministry of Health is responsible for establishing the framework for and the initial overall implementation of the ISWMP. The Unit continues to implement the programme and will hand over the various components to the appropriate Government Agencies that will carry out the long-term implementation/management of these components.

Under the ISWMP, the SSWPU is charged with the development of solid waste management legislation and environmental education with respect to solid waste management. The Division of Economic Affairs, of the Ministry of Finance and Economic Affairs (MFEA) administers international financing associated with the

Programme and offers advice and guidance in respect of economic instruments and research in solid waste management.

b) The Sanitation Service Authority (SSA) of the Ministry of Health has responsibility for the collection and disposal of Solid Waste from homes island wide as well as from government agencies. Additionally the SSA has a commercial arm, which offers service to the private sector in addition to services offered by private waste collectors. Under the ISWMP, the SSA will be less involved in the disposal of waste, but will manage the private sector agency that will operate the disposal facilities. The SSA will retain responsibility for the collection of municipal solid waste.

c) The Environmental Engineering Division (EED) is responsible for monitoring and enforcement issues that pertain to solid waste management. The Environmental Health Officers (EHOs) of the Ministry of Health assist with the monitoring and enforcement in respect of solid waste management.

d) The Office of the Attorney General drafts and revises solid waste management legislation and provides advice to Government with respect to legal issues in solid waste management. In addition, a number of agencies such as the Royal Barbados Police Force, Customs and Excise Department and the Barbados Defense Force, as well as the Judiciary, play critical roles in the enforcement of solid waste management legislation.

e) The Ministry of Public Works and Transport has responsibility for road construction and maintenance of roads that lead to the disposal facilities.

(ii) Hazardous waste

Under the Solid Waste Management Programme a Chemical Waste Storage facility is being constructed to provide for appropriate safe storage of hazardous waste prior to its shipment off island as it is envisaged that under the ISWMP, that treatment of hazardous waste will take place off island. Currently, chemical waste is treated and disposed of locally where possible. For other cases arrangements have been established with external agencies to ship hazardous wastes abroad.

In addition to the above, a Chemical Substances Technical Working Group (CSTWG) was established within the MPE with the specific mandate of developing a policy on the management of chemicals and hazardous substances. However hazardous waste will be handled as a solid waste matter under the ISWMP.

9.4.3 Legislative Suppor

A number of existing pieces of legislation exist to address the various issues of solid waste management. These include:

- The Health Services Act (Cap 44) and its associated collection and disposal of refuse regulations. The Act defines the regulatory framework for solid waste management in Barbados while the regulations address landfill siting, littering and dumping, waste containment and waste collection and transportation. Importantly, penalties are set for contravention of the Act. The Nuisance Regulation, The Rodent Control Regulation and the Disposal of Offensive Matter Regulation provide control over littering and dumping;

- The Underground Water Control Act regulates disposal of sewerage or waste into the ground via water wells;

- The Returnable Containers Act (1987) creates a system for recycling beverage containers;

- The Environmental Levy Act (1996-8) which provides for the imposition and collection of a levy on specific goods to assist in defraying disposal costs, and to encourage Barbadians to recycle;

- The Marine Pollution Control Act (1999) address pollution of the marine environment from all sources;

- The Sanitation Service Authority Act-Sanitation Service Authority (fees, Amendments) Regulations (1996), which allows for the charge of $25.00 per tonne for the deposit and disposal of refuse at any refuse disposal site;

- The Comprehensive Solid Waste Management Act now being promulgated will rationalize solid

waste management issues and will complement other pieces of related legislation, and

- The proposed Environmental Management Act will empower the present and proposed departments of the restructured Ministry of Physical Development and Environment(MPE) and establish regulatory frameworks for environmental management issues, which are not presently embodied in legislation.

9.5 Sewage/Waste Water

Contamination of coastal waters and deterioration of coral reefs have been linked to inadequate disposal of waste water. The major source is the power generating facility at Spring Garden, which is estimated to produce over 80 per cent of all west coast waste water - around 440 000 m3 per day - from its cooling operations. The residential sector is estimated to produce over 50 per cent of the total for the south and west coast, hotels more than 25 per cent, and institutional sources (schools, hospitals, government buildings) over 7 per cent. The industrial sector produces less than five per cent, but this may contain toxic compounds[7].

Along the coast where a sewage system is not yet established, the main forms of waste water disposal are by suckwells (holes dug into the underlying coral), soakaways in sandy areas, packaged treatment plants used by some hotels, septic tanks, and pit latrines mainly in lower income residential areas.

The longest operated treatment facility is the Bridgetown plant located at Emmerton. Available data indicate an annual increase in sewage treated of over 30 per cent per year between 1990 and 1993, and of 38.2 per cent in 1995. This was followed by 12.3 per cent decline in 1996 for reasons that are not clear[8]. This plant is reported to have 100 per cent connection in its service area, and to have contributed to recent improvements in near-shore reef habitat conditions.

There is significant on-going investment in sewage disposal facilities, with the objective of stemming the contamination of coastal water, preventing contamination of ground water, and generally improving sanitary conditions on the island. The City of Bridgetown is already sewered and a south coast sewerage system is nearing completion. At the end of 2001, work on the theatment plants and marine outfall was 100 per cent complete while work on property connection and the collection system were 90 and 60 per cent completed respectively. By the end of 2002 the system should be fully functional. To date cost of works stands at aprroximately Bds. $165 million! With this system sewage is to be piped from a 12 km strip of the southern coastline, extending about 500 metres inland, to undergo primary treatment before being discharged 1.1 km out to sea.

9.6 Conclusion

The new policy regime for waste management seeks a balance of conventional command and control measures with incentive-based and education policies. Monitoring and enforcement will still need to be important aspects of implementation for these policies.

At the same time, the broad based, comprehensive public education programme is intended to change consumer attitudes and behaviours in terms of reducing the volume of waste generated, to foster more appropriate waste disposal habits, and to reduce the extent of littering and illegal dumping on the island.

Notes

1. Stanley and Associates Engineering Ltd. 1994. Integrated Solid Waste Management Programme: Technical Addendum No.1.
2. Barbados National Report to the UN Commission on Sustainable Development, 1997.
3. Environmental Indicators for Barbados: A pilot study for 1996. Prepared by the Caribbean Development Bank in collaboration with the Ministry of the Environment, Under the UNCSD Sustainable Development Programme.
4. Barbados Economic and Social Report, 1998.
5. See 1 above.
6. Ibid.
7. See 3 above
8. Ibid.

10. IMPERATIVES FOR ACTION

It is clear from the information presented in this report that a number of forward looking initiatives are being implemented or have taken place over the last ten years, that augur well for the future protection of the Barbados environment. Cases in point include:

- The Integrated Coastal Zone Management (ICZM) programme which has now produced an ICZM Plan for the entire coastline as well as the institutional structure and legislation for its implementation;
- The Water Resources Management and Water Loss Studies;
- The Integrated Solid Waste Management Programme;
- The Sewage Treatment Systems established for Bridgetown and the South coast and now in train for the West coast; and
- The Biodiversity country study and the National Biodiversity Strategy and Action Plan.

There are also important initiatives in the areas of fisheries management and renewable energy sources. In any event, all these initiatives have generated specific policy recommendations that are in various stages of implementation.

While continuous assessment of the sectoral issues covered in this report are critical to an effective environmental management system, the government of Barbados has long recognized that an approach that integrates sustainable development principles in national planning is equally important to the country's long-term development. It has sought to establish such an approach through a framework comprising the establishment of a National Commission on Sustainable Development (NCSD), the implementation of a National Strategic Planning (NSP) process, and the execution of a comprehensive Environmental Management and Land Use Planning (EMLUP) study.

The NCSD, an advisory body to the Minister of the Environment, facilitates national level coordination on sustainable development as part of its mandate. The NSP aims to facilitate the incorporation of social, economic and environmental issues into national development planning, and to respond to changes at the regional and international levels in a more dynamic way; and the EMLUP study constituted an in-depth look at the broad range of environmental issues in the country.

Of the important work being conducted under the NCSD, mention must be made of the National Sustainable Development Indicators Programme. Conducted by the United Nations Department of Social Affairs (UNDESA) within the UN Commission on Sustainable Development, this programme has distilled 170 indicators that are now being tested to determine their technical feasibility. This activity, for which a database is currently being developed, will ultimately be a valuable asset in the periodic updating of this and subsequent State of the Environment Reports. Reliable data on environmental parameters are vital for the accurate assessment of the state of the environment, and development of appropriate and effective policies and strategies for environmental management and planning. In this basis, the National Indicators Programme must be one of the imperatives for future action on the part of the Government of Barbados.

Perhaps the most cross-cutting effort to date is the comprehensive study on Environmental Management and Land Use Planning for Sustainable Development (EMLUP), which offers up an integrative framework for moving forward. The outputs of this project included, but were not limited to:

- A revised Physical Development Plan that provides detailed guidance on land use planning;
- An Environmental Management Plan that provides an integrative approach to environmental sustainability;
- Comprehensive environmental legislation with enforcement procedures;
- An Institutional Framework for Environmental Management that targets integration of policies, procedures and action of all relevant agencies;
- A National Park Development Plan including an assessment and classification of sensitive ecosystems and proposals for their protection; and

- Establishment of a Geographic Information System as the foundation for the development and maintenance of a long-term National Natural Resources Data Base of biophysical, cultural an other planning-related information.

The products of this study are still in a phase of review and approval, with concrete decisions yet to be taken on aspects that would then initiate significant progress in other areas. Enactment of the draft legislation and establishment of the institutional structure, for example, would provide the authoritative foundation for implementing the Environmental Management Plan.

A near-term imperative for action, therefore, is the *articulation of firm policy decisions regarding the products of the Environmental Management and Land Use Planning Studies.*

In addition to this, several specific areas need attention. The basic studies used in preparing the report identify areas where action is necessary. The Environmental Management Plan incorporates the recommendations of the relevant studies to produce a series of "Recommended New Management Actions" for improvement of the environment along a number of themes, including those used in this report. Apart from the institutional and regulatory needs, there is a general need for data to better assess the state of various aspects of the environment, particularly for periodic reporting, and to generate the information needed for policy development and action. Among the major needs are:

- An up to date census of agricultural landuse - along the lines of the 1989 agricultural census;

- An assessment of reserves of non-hydrocarbon minerals - clay, sand, limestone - and projections of future demands;

- Establishment of a monitoring and data collection system on soil erosion and soil loss in both the limestone regions and the Scotland District;

- Preparation of a comprehensive ground water monitoring programme that, among other things, track trends in water quality parameters and establish the effectiveness of existing, or need for additional, pollution control measures;

- Establishment of a comprehensive air quality monitoring and data collection programme. See the section on atmosphere and climate; and

- Continue to pursue the development of a policy and programme on the management of chemicals and hazardous substances already initiated by the Ministry of the Environment.

One area of need that cuts across the themes presented in the report, is the need for a broad-based education and public awareness programme on the environment, its state and its importance and role in the livelihoods and quality of life of the people. The Ministry of Physical Development and Environment, through the National Commission on Sustainable Development, is currently preparing a National Policy on Sustainable Development. The policy aims to sensitise all persons about the need to make wise choices daily, at the individual, household, business, community and national levels, because these choices affect national development. This is an important goal because it not only recognizes that sustainability, and thus effective environmental management, is not achievable without people/community participation, but it also recognizes that without the appropriate level of awareness and education, the people cannot effectively participate.

REFERENCES

Barbados Water Authority. "Draft Policy Framework for Water Resources Development and Management in Barbados." Paper presented to the Planning and Priorities Committee of the Government of Barbados, August 12, 1997.

Barbados Water Authority. "Sustainable Water Quality Management." Paper presented at the Barbados National Consultation on Sustainable Development, November 1996/7.

CERMES (Center for Resource Management and Environmental Studies) UWI, and Ministry of Physical Development and Environment, (1999). Draft Proposal for Centre for Renewable Energy.

Crowards (1997). Environmental Indictors for Barbados: a Pilot Study for 1996. Draft report prepared by the Caribbean Development Bank in collaboration with the Ministry of the Environment, under the National Sustainable Development Indicators Programme.

Fisheries Division, Ministry of Agriculture and Rural Development, 1997. Barbados Fisheries Management Plan: Schemes for the Management and Development of Fisheries in the Waters of Barbados.

Headley, O. (1996). Energy for Sustainable Development. Presentation to the Barbados National Consultation on Sustainable Development, 1996.

Klohn-Crippen Consultants Ltd. in Association with Stanley Associates Engineering Ltd. (1997). Draft Report on Task 2: Reliable Yield Analysis for the Water Resources Management and Water Loss Studies. Barbados Water Authority / Ministry of Labour, Public Works, Community Development and Sports.

_____ 1997. Report on Task 3: "Water Quality Analysis."

Klohn-Crippen Consultants Ltd. in Association with Stanley Associates Engineering Ltd. (1998). Water Resources Management and Water Loss Studies. Barbados Water Authority / Ministry of Labour, Public Works, Community Development and Sports.

Mahon, R.; Murphy, F.; Murray, P.; Rennie, J and Willoughby, S (1990). Temporal Variability of Catch and Effort in Pelagic Fisheries in Barbados, Grenada, St. Lucia and St. Vincent: with particular reference to the problem of low catches in 1989. Food and Agricultural Organisation of the United Nations, FI:TCP/RLA/8963, Field Document 2, Barbados, March 1990.

IPCC (Intergovernmental Panel on Climate Change) (2001). Special Report on The Regional Impacts of Climate Change: An Assessment of Vulnerability.

Ministry of Health and the Environment. Barbados National Report to the UN Commission on Sustainable Development, 1997.

Ministry of Finance and Economic Affairs (1999). Barbados Economic and Social Report 1998.

Ministry of Public Works, Transport and Housing (1996). Habitat II: the Barbados National Report and Plan of Action.

Oak Ridge National Laboratory, Carbon Dioxide Data Analysis Center. (1999). National CO_2 Emissions from Fossil-fuel Burning, Cement Manufacturing [omitted for this report], and Gas Flaring. Available at http://cdiac.esd.ornl.gov/ftp/ndp030/nation96.ems.

Simmons and Associates (1998a). National Biodiversity Strategy and Action Plan Technical Report: Executive Summary. Prepared for the Government of Barbados, Ministry of Health and the Environment.

Simmons and Associates (1998b). National Biodiversity Strategy and Action Plan Technical Report: Marine Resources. Prepared for the Government of Barbados, Ministry of Health and the Environment.

Simmons and Associates (2000). Barbados National Report to the Conference of the Parties to the Convention on Biological Diversity. Prepared for the Government of Barbados, Ministry of Health and the Environment.

Stanley and Associates Engineering Ltd. (1994). Integrated Solid Waste Management Programme: Technical Addendum No.1. Report prepared for the Ministry of Health, Government of Barbados.

UNESCO (1998). Caribbean coral reef, seagrass and mangrove sites. CARICOMP – Coastal region and small island papers 3, UNESCO, Paris. Available at: http://www.unesco,org/csi/pub/papers/papers3.html

Willms and Shier (1997a): Environmental Management and Land Use Planning for Sustainable Development: Socio-economic Conditions and Trends. Report Prepared for the Ministry of Health and the Environment.

Willms and Shier (1997b): Environmental Management and Land Use Planning for Sustainable Development: Working Paper on Environmental Laws of Barbados. Prepared for the Ministry of Health and the Environment.

Willms and Shier (1998a). Environmental Management and Land Use Planning for Sustainable Development: Environmental and Natural Resources Management Plan. Government of Barbados.

Willms and Shier (1998b). Environmental Management and Land Use Planning for Sustainable Development: The National Natural Resources Data Base: Biophysical, Cultural and other Planning-Related Information. Report Prepared for the Ministry of Health and the Environment.

World Bank (2000). Country Brief : OECS and Barbados. Available at: http://wbln0018.worldbank.org/.

Appendix 1: Experiments in Renewable Energy Technologies in Barbados

Windmills from the seventeenth century ground sugarcane and the eighteenth-century windmill at Morgan Lewis is now completely restored; for the first time in fifty years it ground sugar cane again on December 5, 1999.

In the 1960s Brace Research Institute of McGill University did research and development work in Barbados on solar crop drying and wind power for pumping.

Since 1969 the Solar Energy Project at the University of the West Indies has done research, development and outreach work on solar distillation, solar crop drying, solar cooling and solar cooking with solar thermal devices and has more recently used photovoltaic (PV) power for solar electricity production.

In the mid-nineteen seventies the Barbados Government used Isreali technology to set up solar air conditioning based on adsorption chillers at the Ministry of Agriculture, Graeme Hall and the Government Laboratory, Culloden Road.

There are over 31,000 solar water heaters installed on homes, businesses and hotels in Barbados with three manufacturers in operation. This industry was started in the 1970s with Mr. James Husbands of Solar Dynamics and Mr. Peter Hoyos of SunPower.

In 1986 the Government of Barbados, with funding from the Inter-American Development Bank set up a 250 kW wind turbine at Lamberts in St. Lucy as a demonstration device to check the feasibility of generaating electricity from wind.

Sugar factories generate all their electricity from bagasse and, if the sugar industry can be kept financially viable, this source of electricity can be expanded.

A 1.1 kW solar ice maker powered by PV is now running at the University of the West Indies (UWI), CaveHill.

Thirteen (13) solar stills have been constructed for secondary schools in Barbados, with a further 20 being built for the Faculty of Science and Technology at the UWI.

Training courses in solar distillation, solar water heating and solar crop drying have been conducted in several Caribbean countries.

The Barbados Light and Power Company has acquired a 2kW PV system which is to be set up at one of their installations. This will be tied into the island's electric grid.

A 17.3 kW PV system has been set up to power the lights at Harrison's Cave, and has been operating since December 1999. This is also a grid-tied system.

A farmer's cooperative in St. Andrew, with assistance for the UWI, is establishing a renewable energy park where several clean technologies will be utilized and demonstrated.

In 1994 a workshop on solar photovoltaic power for participants from regional countries was conducted at the University of the West Indies with support from the Latin American Energy Orgainsation (OLADE).

Appendix 2: The Biodivesity of Graeme Hall Swamp

List of Fish Species		
Atherinomorus sp.	*Erotelis smaragdus*	*Poecillia reticulata*
Caranx bartholomaei	*Gobionellus boleosoma*	*Poecillia sphenops*
Caranx latus	*Gobionellus fasciatus (Gobionellus)*	*Polycentropsis abbreviata*
Centropomus sp.	*Megalops atlanticus*	*Polycentropsis abbreviata*
Cichlasoma bimaculatus	*Mugil curema*	*Polycentrus shomburgki*
Cichlasoma octofasciatum	*Mugil sp.*	*Rivulus marmoratus*
Euinostomus gula	*Oreochromis aureus*	*Sphyraena sp.*
Euinostomus sp.	*Oreochromis mossambicus*	
Elops saurus	*Poecillia latipinna*	
List of Crustaceans		
Callinectes sappidus	*Geocarcinidiae*	*Uca pugnax*
Cardiosoma	*Paguridae*	*Xiphocaris elongate*
Cyclopidae	*Palaemon pandaliformis*	
Cyrinus carpio	*Machrobrachium faustinum*	
List of Aquatic Flora		
Macroscopic Vegetation	*Filementous Green Algae*	*Phytoplankton*
Ceratophyllum	*Oedogonium*	*Amphiprora*
Chara	*Spirogyra*	*Cryptomonas*
Lemna	*Ulothrix*	*Cyclotella*
Lotus		*Nitzschia*
Nymphaea		*Oscillatoria*
Pistia		
Ruppia		
List of Insects and Amphibians		
Insects	*Amphibians*	
Gerris	*Bufo marinus*	
	Eleutherodactylus martinicensis	

Source: National Biodiversity Strategy and Action Plan, Technical Report: Marine Resources, 1998.

Appendix 3: Shrimp Biodiversity

3a: List of Shrimp in Fresh Water Catchments

Atya innocous	*Macrobrachium*
Macrobrachium crenulatum	*heterochirus*
Macrobrachium faustinum	*Palaemon aztecus subtilis*
Macrobrachium acanthurus	*Palaemon pandaliformis*
Macrobrachium carcinus	*Xiphocaris elongata*

Source: National Biodiversity Strategy and Action Plan, Technical Report: Marine Resources, 1998.

3b: Shrimp in Permanent Water Catchments

Location	Substrate Type	Connection to the Sea	Shrimp Species
Green Pond	muddy	none	*Macrobrachium crenulatum* *Macrobrachium faustinum*
Bawdens	muddy	none	*Macrobrachium carcinus* *Macrobrachium crenulatum* *Macrobrachium faustinum* *Atya innocous* *Xiphocaris elongata*
Hillaby	muddy	none	*Macrobrachium carcinus* *Macrobrachium crenulatum* *Atya innocous* *Xiphocaris elongata*
Bathsheba	sandy/silty	permanent	*Macrobrachium carcinus* *Macrobrachium crenulatum* *Macrobrachium faustinum* *Macrobrachium heterochirus* *Atya innocous* *Xiphocaris elongata*
Codrington College	rocky	permanent	*Macrobrachium carcinus* *Macrobrachium crenulatum* *Macrobrachium faustinum* *Macrobrachium heterochirus* *Atya innocous* *Xiphocaris elongata*
Consett Bay	muddy/silty	permanent	*Macrobrachium carcinus* *Macrobrachium crenulatum* *Macrobrachium faustinum* *Macrobrachium heterochirus* *Atya innocous* *Xiphocaris elongata*
Three Houses	silty	permanent	*Macrobrachium carcinus* *Macrobrachium crenulatum* *Macrobrachium faustinum* *Macrobrachium heterochirus* *Atya innocous* *Xiphocaris elongata*
Culpepper	silty	permanent	*Macrobrachium carcinus* *Macrobrachium crenulatum* *Macrobrachium faustinum*

Source: National Biodiversity Strategy and Action Plan, Technical Report: Marine Resources, 1998.

Appendix 4: Species Found in the Rocky Intertidal

4a: Rocky Cliffs

List of Algae		
Bostrychia tenella	*Polysiphonia howei*	
Cyanophyta	Sargassum	
Chlorophyta	*Lithothamniun sp*	
Enteromorpha lingulata		
List of Cnidarians		
Bunodactis stelloides	*Bunodosoma kukenthali*	*Phymanthus crucifer*
Bunodosoma cavernata	*Palythoa variabilis*	*Zoanthus pulchellus*
List of Crustaceans		
Calcinus tibicen	*Eriphia gonagra*	*Lithotrya dorsalis*
Clibanarius tricolor	*Ligia gracilis*	
List of Mollusks		
Acanthopleura granulata	*Litiorina ziczac*	*Tectarius tuberculatus*
Acmaea jamaicensis	*Nerita versicolor*	*Tertraclita squamosa*
Chiton marmoratus	*Nerita peloronta*	*Thais floridana*
Fissurella barbadensis	*Nerita tessellata*	*Thais patula*
Leucozonia ocellata	*Spiroglyphus irregularis*	
List of Other Species		
Annelids	*Phragmatopoma californica, Spriobranchus giganteus*	
Bryozoan	unidentified	
Coral	*Siderastrea radians*	
Echinoderms	*Echinometre lucunter*	
	Holothuria glaberrima	
Fish	Small cling fish unidentified	
Sponges	unidentified	

Source: National Biodiversity Strategy and Action Plan, Technical Report: Marine Resources, 1998.

4b: Pebble Beaches

List of Mollusks		
Chiton tuberculatus	*Nitidella ocellata*	*Tectarius muricatus*
Melampus coffeus	*Nitidella laevigata*	*Tectarius tuberculatus*
Nerita tessellate	*Planaxis lineatus*	*Tegula excavata*
Nerita versicolor	*Planaxis nucleit*	*Thais floridana*
List of Other Species		
Cnidarians	*Bunodosoma cavernata* *Bunodosoma kukenthali* *Bunodosoma stelloides*	
Crustacaeans	*Clibanarius tricolor*	
Echinoderms	*Holothuria glaberrima*	
Fish	*Gobiesox sp.*	

Source: National Biodiversity Strategy and Action Plan, Technical Report: Marine Resources, 1998.

4c: Low-Lying Platforms

List of Crustaceans		
Calcinus tibicen	*Lithotrya dorsalis porcellanid crab*	
Clibanarius tricolor	*Tetraclita squamosa*	
List of Mollusks		
Acmaea jamaicensis	*Littorina maleagris*	*Petaloconchus*
Fissurella barbadensis	*Nerita tessellate*	*Thais floridana*
Isognomon listeri	*Neritina pupa*	*Thais deltoidea*
List of Other Species		
Algae	*Coralline algae* *Ulva lactuca*	
Cnidarian	*Zoanthus pulchellus*	
Annelids	*Spirobranchus giganteus* *Spiroglyphus irregularis*	
Echinoderms	*Diadema antillarum* *Echinometra lucunter* *Tripneustes esculenus*	

Source: National Biodiversity Strategy and Action Plan, Technical Report: Marine Resources, 1998.

4d: Fish Found in Tidepools

True Residents	Partial Residents
Ahlia egmontis	*Abudefduf spp*
Apogon maculatus	*Acanthurus bahianus*
Arcos rubiginosus	*Allanetta harringtonensis*
Barbulifer antennatusa	*Antennarius multiocellatus*
Bathygobius curacao	*Canthigaster rostrata*
Cerdale floridana	*Caranx latus*
Echidna catenata	*Chaetodon striatus*
Enchelychore spp	*Epinephelus adscensionis*
Ginsburgellus novemlineatus	*Haemulon aurolineatum*
Gobiosoma hildbrandi	*Halichoeres maculipinna*
Gymnothorax spp.	*Halichoeres bivittatus*
Hypsoblennius exstochilus	*Halichoeres radiatus*
Labriosomus nigricinctus	*Halichoeres pictus*
Labriosomus nuchipinnis	*Holocentrus ascensionis*
Labriosomus bucciferus	*Holocentrus bullisi*
Labriosomus gobio	*Holocentrus rufus*
Labriosomus guppyi	*Holocentrus vexillarius*
Lythrypnus sp.	*Mugil liza*
Malacoctenus aurolineatus	*Opistognathus maxillosus*
Malacoctenus erdmani	*Pomacentrus dorsopunicans*
Malacoctenus triangulatus	*Pomacanthus paru*
Malacoctenus gilli	*Pseudupeneus maculatus*
Moringua edwardsi	*Rypticus saponaceus*
Myrichthys acuminatus	*Scorpaenodes caribbaeus*
Myrophis sp.	*Sparisoma spp.*
Ogilbia spp.	*Sphoeroides spengleri*
Ophioblennius atlanticus	*Stromateidae*
Paraclinus nigripinnis	*Syngnathus dunckeri*
Paraclinus cingulatus	*Thalassoma bifasciatum*
Scorpaena plumieri	
Starksia sluteri	
Starksia sp.	
Stathmonotus stahli	
Stegastes partitus	

Source: National Biodiversity Strategy and Action Plan, Technical Report: Marine Resources, 1998.

Appendix 5: List of Fish Species

5a: Most Frequently Caught Fish in Shallow-shelf Reef Fishery

Goatfish	*Mulloidichthys martinicus*	
Groupers	*Cephalopholis fulva*	*Epinephelus adscensionis*
Grunts	*Haemulon chrysargyreum*	*Haemulon flavolineatum*
Parrotfishes	*Sparisoma aurofrenatum*	*Sparisoma viride*
Squirrelfishes	*Holocentrus ascensionis*	*Myripristis jocobus*
	Holocentrus rufus	
Surgeonfishes	*Acanthurus bahianus*	*Acanthurus coeruleus*

Source: National Biodiversity Strategy and Action Plan, Technical Report: Marine Resources, 1998.

5b: The By-catch of the Shallow-shelf Reef Fishery

Angelfish/rock beauty	*Holocanthus ciliaris*	*Pomocanthus paru*
	Holocanthus tricolor	
Bigeye	*Priacanthus cruentatus*	
Butterflyfish	*Chaetodon capistratus*	*Chaetodon striatus*
Boxfish	*Rhinesomus triqueter*	
Conger eel	*Conger triporiceps*	
Croaker	*Equetus punctatus*	*Pogonias cromis*
Crustacea	*Lepdotus sp.*	*Panulirus guttatus*
	Panulirus argus	*Scyllaridae sp.*
Filefish	*Aluterus schoepfi*	*Cantherhinus pullus*
Gastropoda	*Octopus sp*	
Goatfish	*Pseudopeneus maculatus*	
Groupers	*Dermatolepis inermis*	*Hypoplectus puella*
	Epinephalus cruentatus	*Mycteroperca bonaci*
	Epinephalus flavolimbatus	*Mycteroperca interstitialis*
	Epinephalus guttatus	*Paranthias furcifer*
Grunts	*Haemulon album*	*Haemulon sciurus*
	Haemulon aurolineatum	
Moray	*Lycodontid funebris*	*Lycodontis vicinus*
	Lycodontis moringa	
Parrotfish	*Searus coeruleus*	*Searus vetula*
	Searus guacamaia	*Sparisoma rubripenne*
	Searus taeniopterus	
Damselfish	*Abudefduf saxatilis*	*Microsapathodon chrysurus*
Porcupinefish	*Diodon hystrix*	
Sea chub	*Kyphosus sectatrix*	
Soapfish	*Rypticus saponaceus*	
Snappers	*Lutjanus buccanella*	*Lutjanus vivanus*
	Lutjanus jocu	*Ocyurus chrysurus*
	Lutjanus mohogoni	*Rhomboplites aurorubens*
	Lutjanus synagris	
Surgeonfish	*Acanthurus chirurgus*	
Tilefish	*Malacanthus plumieri*	
Triggerfish	*Balistes capriscus*	*Canthidermis sufflamen*
	Balistes vetula	*Melichthys niger*
Wrasses	*Bodianus rufus*	*Haliochoeres radiatus*
	Clepticus parrai	

Source: National Biodiversity Strategy and Action Plan, Technical Report: Marine Resources, 1998.

5c: Lobsters Caught in Lobster Fishery Fishery

Target Species	*Panulirus argus*	*Panulirus guttatus*
By-catch	*Panulirus laevicauda*	*Slipper lobster*

Source: National Biodiversity Strategy and Action Plan, Technical Report: Marine Resources, 1998.

5d: List of Turtles Caught

Target Species	*Eretmochelys imbricata*	*Chelonia mydas*
By-catch	*Dennochelys coriacea*	*Caretta caretta*

Source: National Biodiversity Strategy and Action Plan, Technical Report: Marine Resources, 1998.

5e. Fish Caught in Deep-slope and Bank-reef Fisheries

Target Species	*Etelis oculatus*	*Lutjanus vivanus*	*Rhomboplites aurorubens*
By-catch	*Caranx lugubris*	*Seriola dumerili*	*Serranidae sp.*

Source: National Biodiversity Strategy and Action Plan, Technical Report: Marine Resources, 1998.

5f: Fish Caught in Coastal Pelagic Fishery

Anchovies	*Anchoa hepsetus*	*Anchoa lyolepis*
Ballyhoo	*Hemiramphas spp.*	2 species unidentified
Baracuda	*Sphynaena spp.*	
Gaffishs	3 species not identified	
Herrings	*Harengula humeralis* *Harengula jaguana*	*Jenkinsia lamprotaenia*
Jacks	*Caranx latus* *Caranx rubber*	*Caranx ruber* *Seriola dumerili*
Robins or scads	*Decapterus spp.*	Species unidentified
Silversides	*Atherinidae spp.*	

Source: National Biodiversity Strategy and Action Plan, Technical Report: Marine Resources, 1998.

5g: Fish Caught in Offshore Pelagic Fishery

Target Species	Caribbean stocks	*Acanthocybium solandri* *Coryphaena hippurus*	*Scomberomorus spp* *Hunnus atlanticus*
	Western Atlantic stocks	*Katsuwonus pelamus* *Istiophorus albicans* *Makaira nigricans* *Thunnus obesus*	*Tetrapturus pfluegeri* *Thunnus albacares* *Tetrapturus albidus* *Xiphias gladius*
By-catch	*Elasmobranchii spp*		

Source: National Biodiversity Strategy and Action Plan, Technical Report: Marine Resources, 1998.

Annex 1: Socio Economics

1a: Population by Sex and Age Group
Census Years 1970, 1980, and 1990

Age Group	1970			1980			1990		
	Both Sexes	Male	Female	Both Sexes	Male	Female	Both Sexes	Male	Female
0-4	25.7	13.0	12.7	21.2	10.7	10.5	19.6	9.9	9.7
5-9	31.2	15.7	15.5	25.5	12.8	12.7	21.3	10.7	10.6
10-14	30.2	15.0	15.2	25.8	12.9	12.9	21.7	11.0	10.7
15-19	25.7	12.8	12.9	27.8	14.0	13.8	23.8	12.0	11.8
20-24	19.5	9.9	9.6	25.7	12.7	13.0	22.5	11.3	11.2
25-29	12.0	5.7	6.3	20.9	10.2	10.7	24.1	11.8	12.2
30-34	10.6	4.8	5.8	16.1	7.9	8.2	23.1	11.1	12.0
35-39	10.1	4.3	5.8	11.0	5.1	5.9	21.4	9.3	12.1
40-44	10.7	4.5	6.2	9.9	4.5	5.4	15.5	7.6	7.9
45-49	9.9	4.3	5.6	9.0	3.9	5.1	11.0	5.1	5.9
50-54	10.9	4.8	6.1	9.8	4.2	5.6	10.1	4.6	5.5
55-59	10.0	4.5	5.5	8.7	3.8	4.9	8.8	3.9	4.9
60-64	9.2	4.2	5.0	9.0	4.0	5.1	8.5	3.7	4.8
70-74	10.4	2.4	8.0	17.4	6.6	10.8	8.2	3.5	4.7
75-79							6.5	2.7	3.8
80+							7.7	2.7	5.0
Not Stated	2.4	1.5	0.9	1.8	1.0	0.8	-	-	-
TOTAL	237.7	112.0	125.7	247.5	118.2	130.3	262.8	124.7	136.0

Source: Ministry of Finance and Economic Affairs: Barbados Economic and Social Report, 1999.

1b: Population, Rates of Birth, Death and Infant Mortality 1978-1999

Year	Resident Population at December 31	Birth Rate	Death Rate	Rate of natural increase	Infant mortality	Rate of population on growth
	('000 persons)	(Per 1000 pop.)	(Per 1000 pop.)	(Per 1000 pop.)	(Per 1000 Births)	%
1978	248.2	17.4	8.4	9.0	27.0	0.3
1979	248.8	17.2	8.6	8.6	24.0	0.2
1980	249.4	16.6	8.1	8.5	24.5	0.2
1981	250.5	17.6	7.4	10.2	16.0	0.4
1982	251.2	17.8	8.0	9.8	13.5	0.2
1983	251.8	17.9	8.2	9.7	24.5	0.4
1984	255.8	16.7	7.8	8.9	18.4	0.3
1985	257.0	16.7	8.3	8.4	17.8	0.4
1986	258.0	15.7	8.4	7.3	19.0	0.4
1987	258.8	14.8	8.5	6.3	22.2	0.3
1988	259.4	14.5	8.6	5.8	19.5	0.2
1989	260.3	15.5	8.8	6.7	18.2	0.2
1990	260.8	16.5	8.2	8.0	15.5	0.5
1991	262.5	16.2	8.7	7.5	15.3	0.4
1992	263.1	15.6	9.0	6.8	13.8	0.2
1993	263.9	14.3	9.1	5.2	9.8	0.3
1994	264.3	13.4	8.9	4.5	8.5	0.2
1995	264.4	13.1	9.4	3.7	13.2	0.4
1996	266.6	13.3	9.1	4.2	14.2	0.1
1997	266.1	14.3	8.7	5.6	13.2	0.6
1998	266.8	13.6	9.3	4.3	7.8	0.4
1999P	267.4	14.5	9.0	5.5	10.0	0.2

Source: Ministry of Finance and Economic Affairs: Barbados Economic and Social Report, 1999.

1c: Selected Tourism Indicators

Year	*Share of GDP (%)	Total Expenditure($M)	Average Length of Stays (nights)	Arrivals	
				Stay-over Visitors	Cruise Passengers
1978	11.6	271.5	9.1	316883	125988
1979	12.0	369.7	9.9	370916	110073
1980	11.7	473.7	9.8	369915	156461
1981	12.1	523.7	9.6	352555	135782
1982	10.2	502.2	8.3	303778	110743
1983	9.8	503.2	7.7	328325	102519
1984	10.0	560.7	7.1	367625	99168
1985	10.3	618.1	6.3	359135	112222
1986	10.2	647.3	6.5	369770	145335
1987	10.8	757.2	6.5	421859	228778
1988	11.8	918.5	6.7	451485	291053
1989	11.9	1055.6	7.1	461259	337100
1990	9.8	978.0	6.8	432092	362611
1991	5.8	919.5	6.9	394222	372140
1992	11.8	925.0	6.9	385472	399702
1993	13.0	1055.9	7.0	395979	428611
1994	14.0	1196.0	7.1	425630	459503
1995	14.5	1223.6	7.6	442107	484670
1996	13.9	1288.6	6.9	447083	509975
1997	13.8	1314.4	6.6	472290	517888
1998R	12.3	1405.7	5.9	512397	506610
1999P	11.2	1354.3	n.a	517870	432854

Source: Barbados Economic and Social Report and Barbados Statistical Service; *GDP at Factor cost

Annex 2: Land Resources

Soil Erosion in The Scotland District (tons/ha/year) (24 m³ plots)

BARE PLOTS				
Year	Clays	Loams	Muds	Sands
1985-1986	436.1	89.56	26.86	9.51
1986-1987	760.07	359.65	94.01	97.20
1897-1988	223.13	175.24	39.24	22.28
1988-1989	158.6	158.2	130.51	46.12
1989-1990	20.05	101.46	3.3	2.43
GRASSED PLOTS				
1985-1986	67.19	33.63	0.06	0.01
1986-1987	7.45	2.2	0.58	2.35
1897-1988	10.18	0.84	0.05	0.53
1988-1989	42.63	1.63	0.67	1.56
1989-1990	3.19	0.18	0.26	1.05

Source: Soil conservation Unit, Ministry of Agriculture, 1992.

Annex 3: Minerals and Energy Resources

3a: Index of Industrial Production 1984 - 1999 Average 1982 = 100

Year	Total All Industries	Mining and Quarrying	Electricity and Gas	Total Manufacturing
Weights	1000	53	102	845
1984	108.2	161.6	121.7	103.2
1985	104.6	174.0	130.2	97.2
1986	110.1	163.2	137.1	103.4
1987	104.7	151.0	142.7	97.2
1988	111.1	141.3	154.9	103.9
1989	115.0	132.9	159.3	108.6
1990	119.4	136.7	161.1	113.3
1991	116.4	130.4	165.1	109.7
1992	108.7	119.8	167.3	100.9
1993	105.7	119.8	168.1	97.3
1994	111.5	123.5	174.6	103.1
1995	119.9	124.1	186.5	111.6
1996	120.7	124.2	193.6	111.7
1997	125.5	128.9	201.0	116.2
1998	134.3	175.6	218.8	121.5
1999P	204.5	204.5	230.5	119.4

Source: Ministry of Finance and Economic Affairs: Barbados Economic and Social Report 1999

3b: Domestic Crude Oil and Gas Production 1978 - 1999

Year	Domestic Crude Oil (Barrels)	% of Total Crude Oil Supply	Gas Production
1978	271647	26.6	9600
1979	283472	30.5	15600
1980	305400	31.6	17500
1981	211400	16.7	9900
1982	258500	23.1	10300
1983	379600	36.9	21300
1984	634900	51.9	25300
1985	679200	55.7	33500
1986	559200	43.2	34500
1987	496800	36.5	29500
1988	427100	30.0	35000
1989	389289	25.0	31700
1990	454424	31.0	32900
1991	454514	37.7	30300
1992	478804	39.5	30600
1993	454664	43.5	27900
1994	453427	34.4	28900
1995	460300	27.8	29300
1996	362915	23.9	28914
1997	327806	20.2	28332
1998	585457	0.0*	37466
1999	710666	0.0*	46967

Source: Ministry of Finance and Economic Affairs: Barbados Economic and Social Report 1999

3c: Solar Water Heater Installations

Year	Number of Units	Capacity ('000l)	Area (m^2)	Cumulative Units
1974	12	2.5		12
1975	21	4.4		33
1976	46	7.8		207
1978	217	44.9		424
1979	545	126.7		969
1980	879	208.5		1848
1981	1143	336.2	3770	2991
1982	1251	374.1	4195	4242
1983	1210	285.4	3200	5452
1984	1415	350.9	3934	6867
1985	1329	343.3	3849	8196
1986	1578	400.5	4491	9774
1987	1715	417.1	4225	11489
1988	2445			13934
1989	2857			16791
1990	2579			19370
1991	2250			21620
1992	1768			23388

Source: Energy Division, Ministry of Environment, Energy and Natural Resources

3d: Energy Consumption 1978 - 1998 (Barrels of Oil Equivalent)

Year	Gasoline	Kerosene	Diesel	Gas Oil	Fuel Oil	LPG	Natural Gas	TOTAL
Conversion	1.12	1.04	1.00	1.00	0.97	1.49	0.17	
1978	297	58	253	17	529	81	21	1254.3
1979	311	57	269	15	609	77	25	1363.0
1980	309	47	312	8	633	74	33	1416.3
1981	310	40	310	4	591	80	35	1367.9
1982	305	38	297	2	665	79	36	1421.6
1983	309	36	290	0	597	74	56	1362.0
1984	317	35	266	0	691	77	62	1446.9
1985	327	34	262	0	817	76	62	1577.4
1986	349	31	270	0	902	81	64	1697.4
1987	382	27	264	0	910	82	58	1722.7
1988	416	25	282	0	898	79	98	1797.1
1989	427	24	307	0	1,017	74	93	1941.2
1990	440	23	380	0	1,014	74	87	2018.5
1991	447	23	355	0	1,001	74	89	1988.4
1992	448	23	281	0	916	74	88	1829.5
1993	436	27	284	0	951	76	89	1863.3
1994	460	31	369	0	1,000	74	86	2019.1
1995	464	18	319	0	1,045	71	91	2007.8
1996	486	19	356	0	1,097	73	77	2108.4
1997	516	23	387	0	1,068	71	73	2139.3
1998								2303.3

Source: National Indicators Programme, Ministry of Environment, Energy and Natural Resources

Annex 4: Water Resources

4a: Water Consumption and Number of Consumers 1978 - 1999

Year	Consumption (Million Cubic Metres)			Number of Consumers		
	Metered	Non-Metered	TOTAL	Metered	Non-Metered	TOTAL
1978	12.8	26.9	39.7	12000	51000	63000
1979	7.8	31.0	38.8	12752	52893	74858
1984	9.5	32.7	42.2	16295	60534	76829
1985	9.7	32.6	42.4	17062	16738	78800
1986	10.2	33.6	43.8	18008	62994	81002
1987	10.6	34.1	44.7	18963	60783	79746
1988	10.6	34.8	45.4	18876	60394	79270
1989	18.0	22.2	40.2	20519	61317	81836
1990	14.0	34.5	48.5	21731	62303	84034
1991	14.4	30.1	44.5	22960	60833	83792
1994	18.7	34.6	53.3	28182	66436	94618
1995	10.6	29.6	53.6	28096	62734	90830
1996	14.0	44.0	58.8	27589	57124	84713
1997	13.0	46.0	59.0	30308	58617	88925
1998	15.0	42.0	57.0	47536	47211	94747
1999	25.0	28.0	53.0	78195	17172	95367

Source: Ministry of Finance and Economic Affairs: Barbados Economic and Social Report, 1999.

4b: Available Water Resources

Source	1978 STUDY				1996 STUDY	
	Average Rainfall Conditions (60")		1 in 15 Design Drought Year		Average Rainfall Conditions (56")	
	m^3/day	(Mgd)	m^3/day	(Mgd)	m^3/day	(Mgd)
Groundwater	205,773	(45.27)	137,183	(30.18)	202.591	(44.57)
Surfacewater	32,682	(7.19)	13,136	(2.89)	15,909	(3.5)
Springwater	8,182	(1.80)	5,909	(1.3)	5,455	(1.2)
Wastewater*					30,018	(6.60)
Runoff	2,409	(0.53)	0.0	(0.0)	1,455	(0.32)
Total	249,046	(54.79)	156,227	(34.37)	225,410	(49.59)

Mgd = Imperial million gallons per day m^3 = Cubic metres/day

* = From Bridgetown, South and West Coast sewerage systems. Not considered in 1978 Study.

Source: Barbados Water Authority, 1996 and Klohn-Crippen Associates, 1997.

4c: Water Usage (1996) and Projected Water Demand for 2016

Use by Category	Consumption 1996			Demand 2016	
	m^3/day	(Mgd)	%	m^3/day	(Mgd)
Domestic (metered & unmetered)	48,681	(10.71)	22.00	51,337	(11.29)
Industrial and Commercial	16,955	(3.73)	7.66	17,460	(3.84)
Hotels and Ships	5,200	(1.14)	2.34	10,821	(2.38)
Agriculture	52,091	(11.46)	23.54	63,545	(13.98)
Golf-course Irrigation	2,458	(0.54)	1.11	14,182	(3.12)
Unaccounted-for-water	95,973	(21.11)	43.35	30,282	(6.66)
Total Consumption	221,358	(48.69)	100.00	187,627	(41.27)

Source: Barbados Water Authority, 1996

Annex 5: Coastal and Marine Resources

5a: Fishing Productivity at Speightstown and Oistins,1961-1989 (Kg of Catch per Trip)

Year	OISTINS			SPEIGHTSTOWN			TOTAL		
	Trips	Total	Catch/Trip	Trips	Total	Catch/Trip	Trips	Total	Catch/Trip
1961	814	27687	34.0	4538	188997	41.6	5352	216684	40.5
1962	1868	66931	35.8	3434	120198	35.0	5302	187229	35.3
1963	1391	48799	35.1	3356	146091	43.5	4747	194890	41.1
1964	858	33333	38.8	1223	20660	16.9	2081	53993	25.9
1965	1130	46849	41.5	1061	16094	24.6	2191	72943	33.3
1966	1557	65717	42.2	1660	76053	45.8	3217	141770	44.1
1967	1728	92551	53.6	1447	89312	61.7	3175	181863	57.3
1968	1881	97280	51.7	1365	60854	44.6	2944	186738	63.4
1972	1984	92124	47.3	1084	74475	68.7	3032	166599	54.9
1973	1673	78310	46.8	802	59820	74.6	2475	138130	55.8
1974	1514	86151	56.9	815	63799	78.3	2329	149950	64.4
1975	2279	160307	70.3	1342	112603	83.9	3621	272910	75.4
1976	2931	186012	63.5	1154	116144	100.6	4085	302156	74.0
1977	2848	183995	64.6	823	54677	66.4	3671	238672	65.0
1978	3161	179331	56.7	993	64800	65.3	4154	244131	58.8
1979	3088	194693	63.0	1229	108928	88.6	4317	303621	70.3
1980	3431	252246	73.5	1683	170312	101.2	5114	422558	82.6
1981	3813	322482	84.6	1402	140788	100.4	5215	463270	88.8
1982	3640	335385	92.1	1432	139606	97.5	5072	474991	93.6
1983	5726	575250	100.5	1434	153398	107.0	7160	728648	101.8
1984	6852	831393	121.3	2237	192851	86.2	9089	1024244	112.7
1985	6421	593265	92.4	1794	108275	60.4	8215	701540	85.4
1986	4804	431728	89.9	1538	114218	74.3	6342	545946	86.1
1987	4312	509052	118.1	850	73370	86.3	5162	582422	112.8
1988	3627	528115	145.6	627	65520	104.5	4254	593635	139.5
1989	2956	232743	78.7	508	37873	74.6	3464	270616	78.1

Source: Mahon *et al.*, 1990.

5b: Recorded Fish Landings 1989-1999

	Species (00 metric tonnes)						
	FlyingFish	Dolphin(mahi mahi)	Kingfish	Tunas	Bill-fishes	Snappers	Others
1989	615.8	2981.1	30.9	42.8	53.5	42.2	40.9
1990	1289.3	687.9	38.8	67.5	77.5	37.1	32.3
1991	1092.6	715.2	45.3	54.3	44.0	32.0	47.3
1992	1460.6	1470.5	51.3	112.1	84.5	33.0	57.3
1993	1986.6	513.2	54.5	100.1	58.9	19.0	55.0
1994	1640.2	499.3	35.8	156.2	95.9	25.5	61.3
1995	1497.6	635.6	39.1	194.0	120.7	37.0	74.0
1996	1702.1	707.8	41.0	160.4	106.3	33.2	73.4
1997	1305.4	600.8	39.3	150.9	117.8	21.4	43.4
1998	2201.1	406.1	39.5	147.0	97.5	28.6	41.9
1999	1627.0	613.7	30.9	151.4	73.2	18.9	23.6
TOTAL	16418.0	7139.2	46.5	1336.6	929.8	328.0	0550.1

Source: Fisheries Division, Ministry of Agriculture and Rural Development

Annex 6: Atmosphere and Climate

Carbon Dioxide Emissions by Source, 1970-1997 (000 metric tonnes)

Year	Total CO_2 Emissions	Gas Fuels	Liquid Fuels	Solid Fuels	Cement Production	Per Capita CO_2*
1970	114	2	112	0	0	0.48
1971	132	2	131	0	0	0.55
1972	136	1	135	0	0	0.56
1973	131	2	129	0	0	0.54
1974	135	1	134	0	0	0.55
1975	154	1	153	0	0	0.63
1976	145	2	142	0	0	0.59
1977	161	2	158	0	0	0.65
1978	172	5	167	0	0	0.69
1979	164	6	157	0	0	0.66
1980	184	7	177	0	0	0.74
1981	187	4	183	0	0	0.75
1982	176	5	172	0	0	0.70
1983	187	6	182	0	0	0.75
1984	204	10	173	0	20.4	0.81
1985	230	13	188	0	29.6	0.91
1986	250	14	209	0	27.0	0.98
1987	257	12	218	0	27.9	1.01
1988	258	14	219	0	25.0	1.01
1989	270	15	226	0	29.2	1.06
1990	294	15	251	0	27.2	1.14
1991	329	12	290	0	27.2	1.27
1992	267	11	232	0	23.8	1.03
1993	304	14	282	0	8.4	1.17
1994	204	12	182	0	10.6	0.78
1995	226	14	202	0	10.2	0.85
1996	232	15	202	0	14.6	0.87
1997	245	12	209	0	23.5	0.92
1998	429	19	374	0	35.2	1.60

Source: Carbon Dioxide Information Analysis Center (CDIAC), Oak Ridge National Laboratory, USA. July 2001.
*Reported in metric tonnes of carbon