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Small island developing states, sustainability and the Caribbean Sea

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SMALL ISLAND DEVELOPING STATES, SUSTAINABILITY AND THE CARIBBEAN SEA

by

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ABSTRACT

Asha Singh

Small Island Developing States, Sustainability and the Caribbean Sea

This study encompasses twenty-seven SIDS and the Caribbean Sea. In order to determine the pressure on the sea from anthropogenic activities both terrestrial and marine, four major components were investigated. These are (a) how land use activities on the islands are affecting the Sea (b) the effects of coastal and marine based activities on this marine area (c) the influences of natural events on the Caribbean Sea and the SIDS (d) how the region is responding to minimise the pressures on the sea via policies and programmes.

In the first component, the DPSIR in combination with GIS was applied to three islands to demonstrate the causal links between economic activities and its effects on the Caribbean Sea. The activities on these islands have resulted in loss of reef covers, reduction and loss of commercial fish species and reduction in water quality. The second component was investigated by using spatial analysis to compose a vulnerability assessment of the Caribbean Sea. This was derived from mapping anthropogenic activities and habitats within the sea. The assessment demonstrated varying levels of vulnerability throughout the sea. This finding reinforces the need to manage the sea as a large marine ecosystem. The third component demonstrated that events such as hurricanes, tsunamis and effects of climate change are affecting the quality of the ecosystems in the Caribbean Sea and increasing the vulnerability of island communities. Data analysed for a 44 year period show that the highest number of successive hurricanes that made landfall in the Caribbean SIDS was in the 1990s. The fourth component was an analysis of the existing legal and institutional mechanisms that are being used in the region to respond to the issues in the marine environment. The analysis revealed that most of the current responses are within geo- political borders which have been less effective in dealing with the issues.

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AUTHOR'S DECLARATION

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award without prior agreement of the graduate committee.

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GLOSSARY

Benthos	the communities of aquatic life which dwell in or on the bottom sediments of a water body
Chlorophyll A	this is a pigment in plants which give their green colour and is used in satellite imaging as an indicator of the amount of microscopic algae growing in water
Ciguatera	is a fish poison caused by dinoflagette *Gambierdiscus toxicus.*
Digitizing	is the process of converting features on a paper map into digital format.
Eutrophication	is a process whereby water bodies; receive excess nutrients that stimulate excessive plant growth (algae, periphyton attached algae). This enhanced plant growth, often called an algal bloom, reduces dissolved oxygen in the water when dead plant material decomposes and can cause other organisms to die.
Pelagic	refers to fish and animals that live in the open sea, away from the sea bottom and coastal or inland bodies of water
Rasters	contain data organised into bands. Each band consist of an array of cells with the optional attributes for each cell
Septic Tanks	a large percentage of homes within the WCR dispose of wastewater using on-site systems. An on-site system for wastewater treatment and sewerage disposal located immediately adjacent to a house or residential complex.
Septentrional Fault Zone	is the major left-lateral strike-slip fault separating the North America and Caribbean plates in northern Hispaniola (Haiti and Dominican Republic)
Shapefiles	a vector data storage format for storing the location, shape and attributes of geographic features
Zoo archaeology	is the analysis of animal remains (e.g., bone, shell) from sites to reconstruct the cultural life of people and the interrelationships between people, animals, and the environment.

LIST OF ACRONYMS

CARICOM	Caribbean Community Secretariat
CARICOMP	Caribbean Coastal Marine Productivity Programme
CARIPOL	Caribbean Oil Pollution Programme
CDERA	Caribbean Disaster Emergency Relief Agency
CEHI	Caribbean Environmental Health Institute
CIDA	Canadian International Development Agency
DAWASCO	Dominica Water and Sewerage Company
DFID	United Kingdom Department for International Development
GEF	Global Environmental Facility
IOC	Indian Ocean Commission
IWCAM	Integrated Watershed and Coastal Zone Management
OECS/NRMU	Organisation of Eastern Caribbean States Natural Resources Management Unit
PAHO	Pan American Health Organisation
SIDS	Small Island Developing States
SOPAC	South Asian Applied Geosciences Commission
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNEP	United Nations Environmental Programme
USAID	United States of America International Development

LIST OF INITIALISM

CTO	Caribbean Tourism Organisation
CDB	Caribbean Development Bank
FAO	Food and Agriculture Organisation
IUCN	International Union for Conservation of Nature and Natural Resources
OECD	Organisation of Economic Cooperation and Development
UNFCC	United Nation Framework for Climate Change

CHAPTER ONE

1.0 Introduction

The rise of global environmental awareness and the recognition of many Caribbean islands as Small Islands Developing States[1] (SIDS), have fostered a growing concern of their vulnerability to economic, social and environmental changes. Primarily, the current economic activities of many SIDS are placing a heavy reliance on the resources of the marine environment, mainly the Caribbean Sea. This reliance coupled with the islands developmental patterns are exerting pressures and accelerating the decline in the environmental quality of the sea (UNEP, 1994; GESAMP, 2001). Lack of adequate environmental management is also exacerbating the decline of environmental quality of the Caribbean Sea. Therefore, the emphasis of this thesis is to study the current socio-economic and environmental interactions and inter –relationships of the SIDS and the Caribbean Sea. This will demonstrate the pressures on the Caribbean Sea and provide recommendations to which an effective management regime can be adopted to address these pressures.

Human reliance on the environmental resources is not a new phenomenon, rather it existed throughout the settlement history of the Caribbean. Prior to the arrival of settlers, the natural vegetation of the SIDS was comprised of various plant communities, assemblages and associations. These groups included tropical rainforest, seasonal rainforest, dry forest, savannah forest, thorny woodland scrub, and mangroves (Beard, 1946; 1949). Some islands had a mixture of these groups, owing to the presence of other characteristics such as topography and wind pattern. The combination of these features produced a range of landscapes in the Caribbean from dry desert-like islands such as Aruba, Bonaire and

[1] There is no internationally accepted definition of a small island developing State. However, UN (UN-OHRLLS,2005) classified all the islands in the Caribbean as SIDS. In the context of this study, all the islands under study are called SIDS. They are vulnerable to external events with small and often undiversified economic activities and dependent on the surrounding marine habitats to aid economic prosperity.

Curaçao to lush tropical islands such as Dominica and St Lucia (refer to Figure 1.1 for location of the islands).

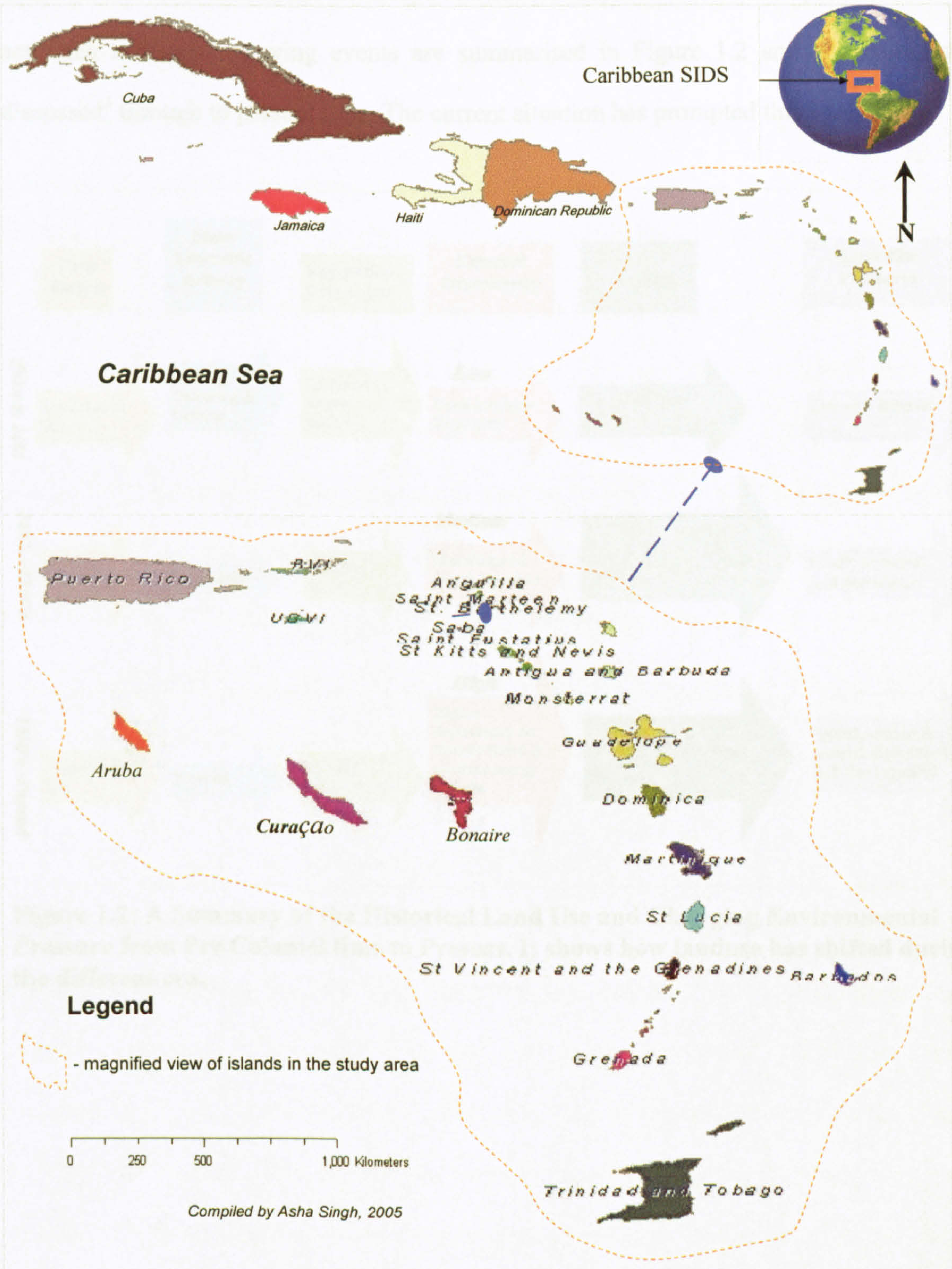


Figure 1.1: A Map showing the SIDS in the Caribbean. Compiled using data from ESRI[2], 2002

[2] Environmental Systems Research Institute

The arrival of settlers to the islands transformed these natural landscapes. The transformations occurred in three distinctive phases, which are characterised by different settlement eras such as pre colonial, colonial and post colonial. The activities in the different eras have altered the landscape and caused major environmental pressures. These activities and accompanying events are summarised in Figure 1.2 and chronologically discussed[3] through to present time. The current situation has prompted this study.

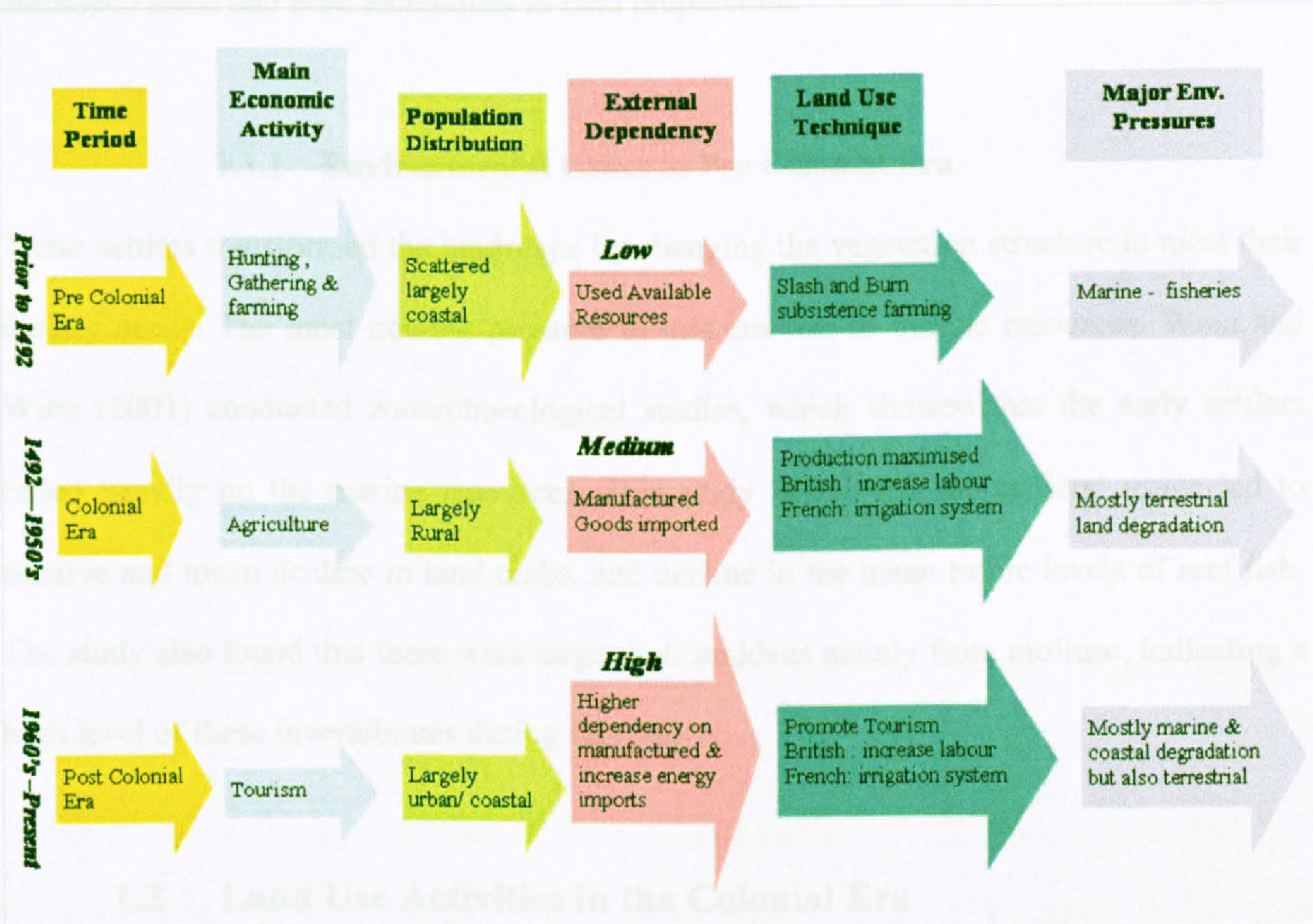


Figure 1.2: A Summary of the Historical Land Use and Changing Environmental Pressure from Pre Colonial time to Present. It shows how landuse has shifted during the different era.

[3] There are numerous activities which took place during these different eras, however, only the events that establish the changes in the landscape and environmental impacts in the SIDS are discussed.

1.1 Land Use Activities in the Pre Colonial Era

The earliest settlers[4] arrived from the Amazonian region of mainland South America around 2,500 BC (West and Augelli, 1989). They lived mainly on the coast and were hunters and gatherers (Walbank *et. al.*, 1978). Archaeological records proved that other tribes of earlier settlers arrived in subsequent years. These other arrivals were mainly Caribs and Arawaks. They cultivated mainly root crops (West and Augelli, 1989) and employed slash and burn techniques in land preparation.

1.1.1 Environmental Issues in Pre Colonial Era

These settlers transformed the landscape by changing the vegetation structure to meet their dietary needs. The most notable pressure in this era was to marine resources. Wing and Wing (2001) conducted zooarchaeological studies, which showed that the early settlers relied heavily on the marine resources. This study found that the settlers' usage led to relative and mean decline in land crabs, and decline in the mean tropic levels of reef fish. The study also found that there were large shell middens mainly from mollusc, indicating a high level of these invertebrates during this period.

1.2 Land Use Activities in the Colonial Era

The colonial era, which began in 1492 was marked by the arrival of the Spaniards led by Christopher Columbus. The Spaniards main aim was to explore for gold, precious stones and other minerals. Throughout their presence in the Caribbean, mineral extraction remained their main focus (Andrews, 1978). The lack of minerals in most of the islands prompted the Spaniards to move onto the continent in pursuit of gold. However, they made claims to all the islands and over time they settled mostly on the islands of Cuba, Puerto Rico and Hispaniola (present day Dominican Republic and Haiti). They conducted land clearances on other islands in order to build forts and storage facilities. These forts and

[4] These settlers are the indigenous people who consisted of many tribes. The Siboney tribe is believed to be the first indigenous people into the Caribbean. See Ragozinski, (2000)

storage facilities were used to provide security and supplies for the Spanish fleet in preparation for voyages to Europe (Ragozinski, 2000). In their travels to Europe, they brought and cultivated plants such as sugar cane *(Saccharum officinarum* L.), barley (*Leporinum spp.* L.), grapes (*Vitis spp* L.) and wheat (*Triticum turgidum* L). They also introduced animals such as pigs (*Sus domesticus* L.), horses (*Equus caballus* L.), sheep (*Ovis aries* L.) and cattle (*Bos spp* L.) to the Caribbean. The introduction of flora and fauna commence a large-scale transformation of the islands ecosystems.

Agricultural production was not a priority for the Spanish during the development of their early settlements. However, as their settlements grew in later years they began cultivation of sugarcane mainly in Hispaniola. They began exporting sugar to Europe in early 1522 (Rogozinski, 2000). The Spanish monopolised the economy and trade in the region until the early 1600s.

In the 1620s, the Dutch settled on unoccupied islands in the Caribbean along with the French and British. The Dutch (Dutch West Indian Company) developed a vibrant shipping fleet which enabled them to monopolise the shipping industry during this period. They transported processed sugar to Europe and supplied enslaved Africans to the colonial authorities (Golinga, 1971). The enslaved people provided the labour needed to cultivate the British and French held islands. At the abolition of slavery in 1870, a total of 4, 059,900 people[5] were shipped to the Caribbean Islands (Rogozinski, 2000).

The British, French and Dutch commenced tobacco production in their occupied islands. The British in St Kitts and Barbados, the French did the same in Martinique and Guadeloupe and the Dutch in St Eustatius. In the 1640s, the French and the British began

[5] The distribution were: British Islands – 1,666 800, French Islands - 1 521 000, Spanish Islands – 766 900, Danish Islands – 57,200 and Dutch Islands – 50,000

shifting sugar cultivation to other islands. Later in the century, it became the most profitable crop for the then British Barbados colony (Beckles, 1990). Its success fuelled a monoculture of sugar cane cultivation across the islands at different times under various colonial authorities. This demand was driven by the increased usage of sugar in Europe and high world market prices.

In 1713 through the Treaty of Utrecht, the various colonial authorities were given sovereignty of islands. The Spanish controlled Cuba, Puerto Rico and Dominican Republic, while the French was given control of Martinique, Guadeloupe and Haiti. The Dutch exerted control over Saba, St Eustatius, Aruba, Bonaire, and Curaçao, while the British controlled Barbados, St Kitts, Antigua, Montserrat, Nevis, British Virgin Islands (BVI) and Jamaica. This division has influenced the language, economy, culture and political alliances which still exist in the 21st century.

The French and the British invested heavily in the agricultural activities of their respective colonies and became major exporters of sugar. The British conducted monoculture sugar production (Andrews, 1984), while the French conducted mix cropping with sugar cane cultivation being its major crop. In the 1700s, islands such as Haiti and Barbados were among the richest countries in the world in terms of colonial wealth (Sokoloff and Engerman, 2000).

The French and British did not confine themselves to the islands assigned to them in the 1713 Utrecht Treaty, rather they augmented their sugar production to other islands. France expanded its agricultural efforts by developing sugar cane, coffee and cocoa plantations in Grenada. The British settled in Anguilla but the island was not favourable for agriculture. This aided the British to expand their industries to include salt production and fisheries.

Also during this period, the Dutch established salt ponds in their islands and used the islands of Aruba, Bonaire and Curaçao as shipping ports.

Price fluctuation on the world markets and competition caused sugar production and agricultural activities to fluctuate during the colonial era. In 1900, the Americans began buying islands in the Caribbean (e.g. US Virgin Islands). The Americans invested money and technology in plantations in Cuba, Dominican Republic and Puerto Rico. The British and French continued cultivating sugar cane in their respective islands until the late 1950s.

1.2.1 Environmental Issues in the Colonial Era

In the colonial era, productivity was of paramount importance thus little emphasis was paid to land degradation except when it affected outputs. In this era, agricultural activities dominated the landscapes of these islands. The removal of forest for the establishment of plantation caused soil degradation and reduced soil fertility. This impact on soil fertility was felt heavily in islands like Barbados. Soil fertility was so severely damaged in the 1760s, that in 1769, the colonial powers attempted to import soil into Barbados from Dutch Guiana in mainland South America (Deloughrey, 2004). Overall, during the 18th century the poor soil fertility forced plantation owners to begin using organic fertilizer to enhance productivity.

Fisheries were also subjected to pressure mainly from overfishing. Jackson (1997), found that the coastal ecosystems were severely degraded prior to the 1950s. This study also showed that many marine vertebrates such as, hawksbill turtle (*Eretmochelys imbricata*), manatee (*Trichechus spp.*) and now extinct monk seal (*Monachus tropicalis*) were already decimated in many islands around the 1800s.

1.3 Land Use Activities in the Post Colonial Era

By the 1960s, all of the islands had gained independence from their respective colonial authorities. The majority of the islands continued to promote agriculture as their major economic activity and continued to export large quantities of agricultural products to Europe. Their trade deals with Europe and America enabled them to maintain agricultural based economies. Other non-agricultural islands, such as the less fertile Dutch islands complemented their shipping business with oil transhipment and refining which became vibrant industrial sectors. As time progressed, other economic sectors developed in the region, such as tourism and industries. Even with the development of these sectors, agriculture still dominated the economies of many islands in the Caribbean.

By the 1980s, the agriculture sector suffered from trade losses and an influx of cheaper agricultural products from other regions, which resulted in an economic crisis. This propelled the Governments in the islands to fully embrace the already existing[6] tourism market. The islands began shifting from agricultural based economies to tourism based economies. Once again, the islands became host to large influx of people, this time as tourists. The coastal and marine assets formed the basis for the tourism industry. By the 1990s, tourism became one of the major economic sectors[7] in the islands. In 2002, nineteen of twenty-seven islands received their highest proportion of GDP from this sector[8]. Currently, tourism is a growing sector divided into mainly cruise and stay-over (air) visitors. The number of visitors has increased throughout the 1990s as shown in Figure 1.3. The core of the tourism sector is centred on the coastal areas - hotels, beaches, diving, snorkelling and yachting among others.

[6] This tourism market began in the 1950s when air travel became affordable and in the 1980s it became the fastest growing economic sector in many of the islands.
[7] See Chapter 3 for economic data and island profiles
[8] ibid

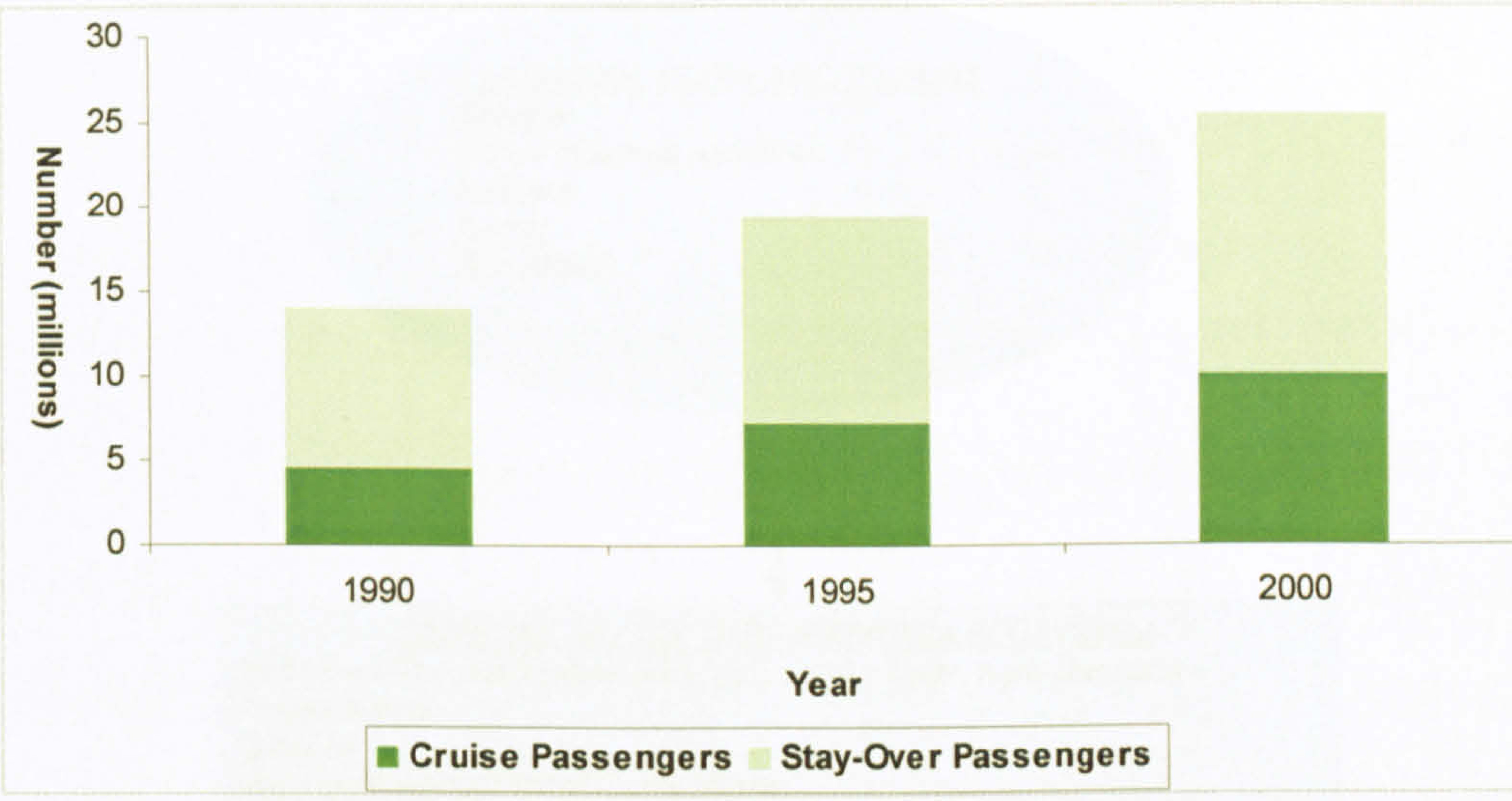


Figure 1.3: Total Arrivals to the SIDS for the Corresponding Years. Note the total number of tourist to the SIDS has nearly doubled in 2000 when compared to 1990. Compiled using data from CTO (2002), WTO, (2005) and individual islands National Statistics and Tourism Offices

In addition to tourism, the Caribbean islands currently have four other distinct economic sectors (industrial, agriculture, energy, fisheries), of which most of the activities occupy the coastal regions of the islands. In addition, large coastal populations within the urban areas dominate the current coastal land use in the islands.

1.3.1 Environmental Issues in the Post Colonial Era

In post colonial Caribbean, land degradation in the agricultural sector continued with the demands for produce being met with the increase usage of inorganic fertilizers. During this period, little emphasis was given to marine management.

However, as economic reliance shifted to tourism, the coastal development increased tremendously. Currently, these high coastal activities in the SIDS are placing tremendous pressures on the coastal and marine environment particularly, the Caribbean Sea. These pressures and concomitant environmental changes are summarised in Figure 1.4 and discussed in Chapter Two.

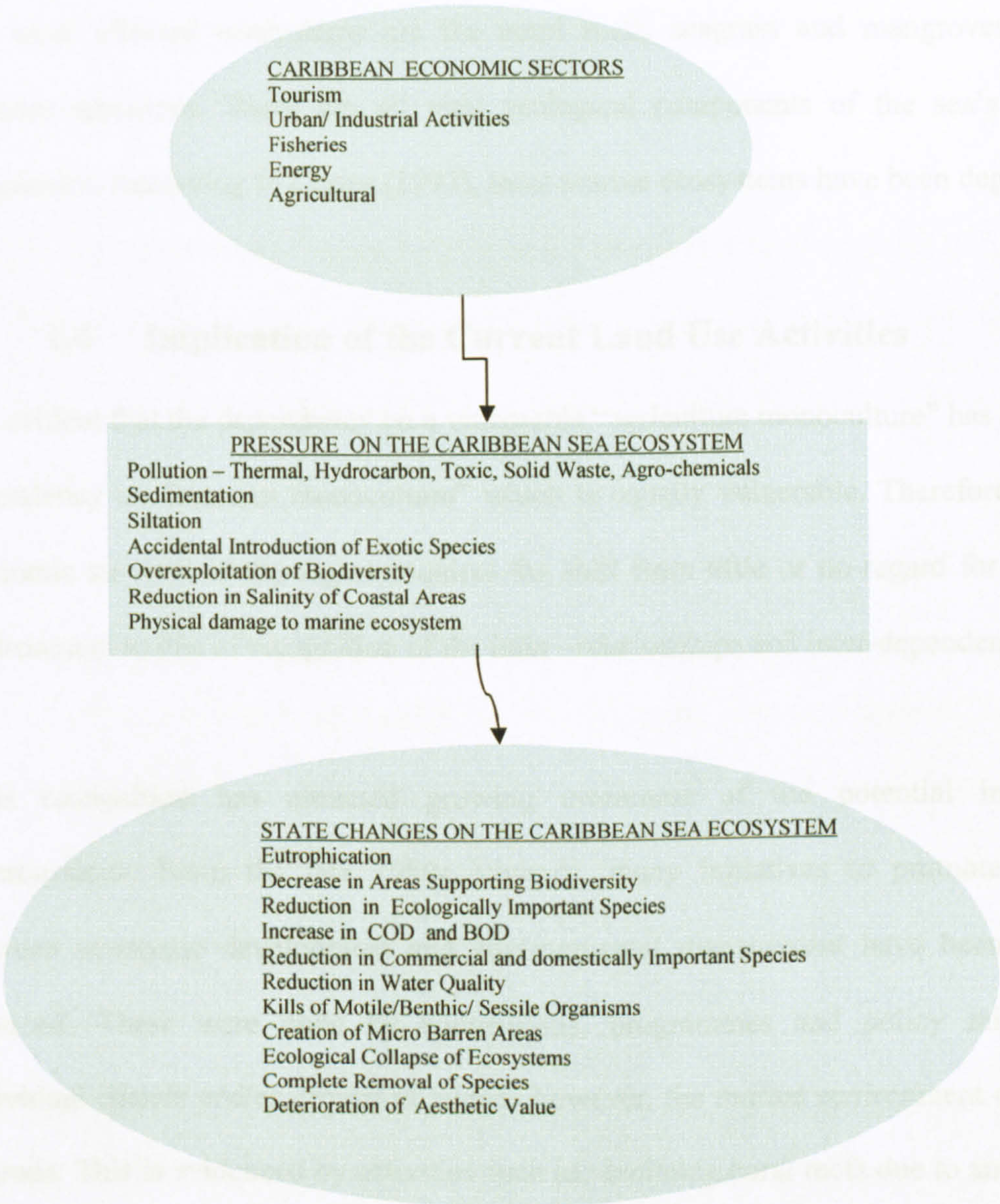


Figure 1.4: Representation of the Issues Affecting the Marine Environment in the Caribbean Sea. It shows that the economic activities in the islands are causing pressures on the marine environment. These pressures result in changes to the state of the Caribbean Sea

The most affected ecosystems are the coral reefs, seagrass and mangroves[9] also the fisheries resources. These are all vital ecological components of the sea's biological complexity. According to Cortes (1993), most marine ecosystems have been degraded.

1.4 Implication of the Current Land Use Activities

It is evident that the dependency on a vulnerable "agriculture monoculture" has switched to dependency on "tourism monoculture" which is equally vulnerable. Therefore, sustained economic survival of the region requires the shift from little or no regard for the marine environment to one of recognition of the inter –relationships and inter-dependence.

This recognition has attracted growing awareness of the potential impacts and repercussions. From the late 1980s onwards, many initiatives to promote a balance between economic development and environmental management have been taken and enforced. These were done by conventions, programmes and policy initiatives for individual islands and/or groups of islands however, the marine environment continues to degrade. This is evidenced by activities such as, declining coral reefs due to anthropogenic stress and the decline of water quality among others[10].

It is recognised that there are various barriers, which are contributing to the continued marine degradation. These include but are not limited to the following:

- Ineffective local laws and legislation
- Little commitment to international obligations[11],
- Lack of integrated cooperation among the many States,
- Fragmented data collection,
- Lack of monitoring

[9] See Chapter Two for description of the ecosystems
[10] See Chapter Two for specific examples of coral reef decline
[11] See Chapter Seven for the status of the region's policies

- Little consideration for the collective need to recognise the sea as one system

Beyond the bureaucratic barriers, there is a lack of effective research to quantify the pressures/stress on the sea[12]. Most islands have not effectively developed techniques to incorporate their surrounding marine ecosystems into their management plans. Currently, the Caribbean Sea is prone to damage from land use decisions.

1.5 Aim of the Study

The aim of this study is to respond to the emerging environmental problems in the Caribbean Sea, through the development of a holistic approach to illustrate multiple impacts from terrestrial (SIDS) and marine activities.

1.6 Justification for this Study

This study will advance Caribbean science, which focuses on the relationship between SIDS and the Caribbean Sea. Research and information of this nature is currently lacking. In addition, the results derived from this study will provide information, spatial and economic data that can be used to support further research, policies and decision-making regarding SIDS and the Caribbean Sea.

Currently, the effectiveness of existing regional initiatives and programmes by international organisations, Governments and NGOs are hampered by inadequate data compilation and analyses at the sea's ecosystem level. This study will contribute to resolving this deficit and enable a more sustainable policy approach based on better knowledge of the overall marine ecosystem. This study will not be restricted to any

[12] See Chapter Four for proposed method

political jurisdictions which is a recurring difficulty in existing programmes[13]. It will encompass the geographic borders of the Caribbean Sea.

1.7 Objectives of the Study

1. To compile and analyse spatial and economic data for each island to determine their levels of economic activities and overall contribution to environmental problems of the sea.
2. To apply the DPSIR framework (Driver-Pressure-State Changes-Impact-Response) on three islands to demonstrate the causal links between economic activities and environmental issues in the marine environment.
3. To analyse the influences of natural events on the SIDS and the Caribbean Sea.
4. To demonstrate and determine the vulnerability of the Caribbean Sea to anthropogenic activities by spatial analysis.
5. To analyse the current policies responses in the region which are aimed at minimising marine degradation.
6. To develop an Integrative and Adaptive Management Strategy for the Caribbean Sea base on the findings of this study.

1.8 General Limitations of this Study

1.8.1 Geographic Information Systems

According to Johnston (1998), GIS is defined as "an integrated system of computer hardware and software for entering, storing, retrieving, transforming, measuring, combining, subsetting and displaying spatial data that have been digitised and registered to a common coordinate system." GIS is increasingly being used as a tool to deal with the spatial complexity in decision making. This complexity arises from the numerous conflicting objectives and dissimilarity in focus of involved stakeholders (Bartlett, 1993)

[13] See Chapter Seven for discussion on political influences in existing policies

which is often spatially related. The major criticism of GIS is its inability to handle dynamic spatial models (Burrough and Mc Donnel, 1998; Pullar, 2005).

Specific to this study, GIS is used as an analytical tool to indicate the pressures on the marine environment. A large-scale database comprising various attributes relevant to the Caribbean Sea has been built which is useful for policy making. In addition, some methods (Chapters Four and Six) are proposed to show how GIS can be used as an analytical tool to address environmental and policy related issues in the region. However, incorporation of GIS into decision making is not straightforward, and its usefulness will depend on the objective of the specific policy. This study demonstrates the usefulness of GIS as a tool in identifying and analysing problems and how incorporating the results into policy decisions at island and regional levels can assist in addressing some of the region's environmental issues. The major strengths and limitations in using GIS are explained below.

1.8.1.1 Limitations of the GIS in this Study

- The GIS in this study offers no temporal data.
- Spatial objects are products of available data. Therefore there are limitations in the application of GIS in this study with regard to data quality and quantity.
- There are limitations in establishing causal links between land use activities and pressures on the marine environment. The application of GIS/DPSIR provides indicators of possible pressure but in order for casual links to be verified, water quality data are required and in this study such data are largely unavailable.

1.8.1.2 Strengths of GIS in this Study

- GIS offers realistic cartographic modelling which improves the description and understanding of the physical environment in the Caribbean region, and the natural environment in relation to anthropogenic activities.

- It provides object-oriented database models which are used to understand complex spatial issues and to provide geographical analytical needs at both island (e.g Dominica) and regional (e.g Caribbean Sea) levels.

1.8.2 Data Accuracy

Embarking on such broad –based research in the Caribbean region requires a large core of data which is either non existent in a common format or not readily available. To ensure that the collected data are an accurate representation of the issues, utmost consideration was given to maintaining data quality and integrity and where appropriate the collected data were triangulated. One of the triangulation methods used was comparison and verification with other sources. For example data gathered from the Food and Agriculture Organisation (FAO) database were crosschecked with statistical and other relevant agencies in the islands. In some cases there was only a single data source for some parameters, for example energy statistics. Such data may have inherent inaccuracy which cannot be verified.

In some cases, data to assess the pressures are not available for all the countries. In order to overcome this shortcoming, other forms of data had to be used as proxies. For example urban population statistics for Bonaire, Curaçao, St Eustatius, Saba and St Marteen are combined and represented as Netherlands Antilles. Such method of data collection are not beneficial to show the individual island pressure. Therefore, to show the consumption pattern for each island a proxy value was calculated based on Aruba's urban population.

Another issue in this study is the unavailability of some types of data for all the islands. For example, the use of hotels as a indication of tourism pressure would have been ideal. However, the lack of spatial data on hotels for all the islands made it impossible to use this parameter. In order to overcome this information limitation, cruise passengers arrivals which are more readily available for most of the islands were used instead. The same issue existed for the vulnerability assessment conducted in Chapter Six. This assessment could have been further enhanced by using shipping intensities rather than just shipping routes. The absence of shipping data by ports of call made it impossible to compile a shipping intensity map of the Caribbean Sea for this study.

These data issues are unavoidable limitations which must be considered in this study. Such inherent problem reinforces the need for resources to be allocated to data gathering. In addition, this study also shows how researchers and even policy makers can overcome the issue of inadequate data in addressing environmental issues.

1.8.3 Qualitative Data Gathering

This study also relied on qualitative data in the form of interviews which were open ended and semi structured. Therefore, the account given may be based on personal opinions. To minimise these potential bias, care was taken to ensure that the conclusions drawn from the interviews were based on credible and reliable information. In most cases, the interviews were crosschecked with other sources in the islands (refer to Chapter Four for more on the methodology). A total of twenty eight people were interviewed in the three islands (see Chapter Four).

1.9 Thesis Structure

In addition to Chapter One, this thesis is composed of a further seven chapters.

- *Chapter Two* introduces the study area and provides background information, including a review of the physical oceanography, island geomorphology and current issues affecting the Caribbean Sea.

- *Chapter Three* presents an overview of all the islands and incorporates analyses of their economic trends and implications on the marine environment of the study area (islands profiles are presented in Appendix One).

- *Chapter Four* deals with the application of the DPSIR framework in combination with GIS to demonstrate the linkage between economic activities and environmental pressures in the marine environment and assesses the implications of these linkages. In this chapter, existing land use information is utilised as a proxy for identifying pressures on the marine environment from land based activities.

- *Chapter Five* discusses the influences of external factors on the study area by investigating naturally occurring phenomena. These events are hurricanes, tsunamis and the effects of climate change.

- *Chapter Six* demonstrates an applied method for assessing the vulnerability of the Caribbean Sea to anthropogenic activities. This assessment includes mostly offshore and coastal activities.

- *Chapter Seven* investigates the existing policies related to the environmental issues in the Caribbean and discusses the possible reasons for their ineffectiveness to curb degradation in the marine environment.

- *Chapter Eight* discusses sustainability in the context of SIDS and the Caribbean Sea and proposes recommendations for management of the Sea. The scope for future work is also discussed in this chapter.

CHAPTER TWO

2.0 AN OVERVIEW TO THE STUDY AREA: PHYSICAL AND ENVIRONMENTAL PROPERTIES

2.1 Introduction

The focus of this chapter will be to provide an overview of the study area. This includes the physical and environmental attributes also the environmental issues that are affecting the Caribbean Sea.

2.2 Methodology

2.2.1 Data Collection

Data for spatial and statistical analyses were collected from different sources as shown in Table 2.1 which were analysed to highlight various issues in the Caribbean Sea.

Table 2.1: Data used to show various characteristics in the Study Area

Data	Source	Format
Spatial Data		
Islands	ESRI, (2002)	Digital provided but was manipulated for this study
Seagrass	UNEP/WCMC, (2003;2004)	
Coral reef		
Ports	Various sources including World Seaport, 2003 and Fairplay, 1999 databases	Spatial data compiled
Study Area	Compiled	
Oil spills	Office of Response and Restoration, (1992)	
Statistical Data		
Mangrove distribution	FAO, (2003)	Statistical data compiled
Beach debris	Coastal Cleanup, (2005)	

2.2.2 Data Analysis

2.2.2.1 Spatial

The spatial data shown in Table 2.1 were mapped and inputted into ARC/GIS 8.3, for analysis. Figure 2.1 shows the method used in GIS to produce maps showing the various themes which are used in this chapter.

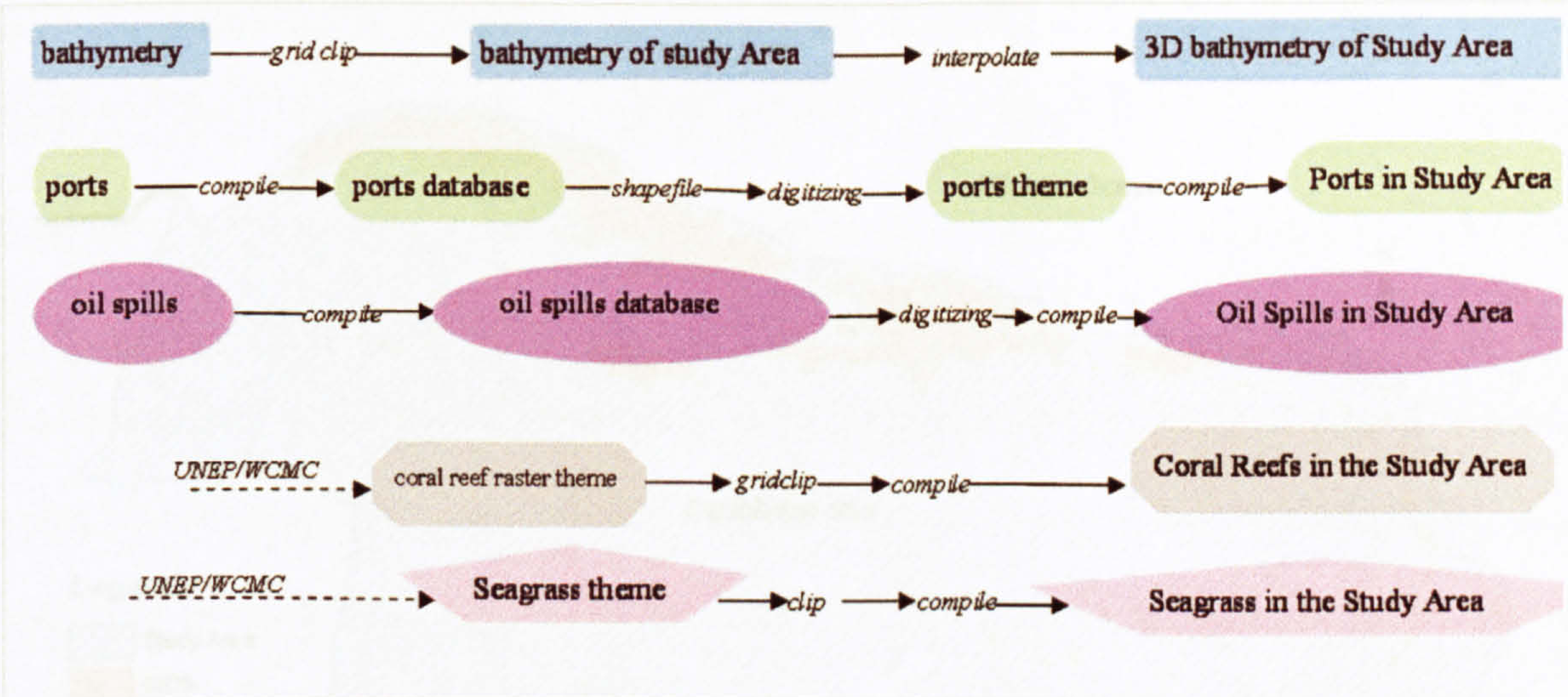


Figure 2.1: Diagrammatic Representation of analysis conducted in ARC/GIS to produce spatial information for this study

2.2.2.2 Statistical

Mangrove data were compiled into a database and the percentage changes were calculated for 1980 and 2000, to demonstrate the area of mangroves lost during this 20-year period (1980-2000). The beach debris compiled were analysed to illustrate the number of beach debris per kilometre of coast for the islands.

2.3 Geographic Location of the Study Area

The Caribbean Sea is located between 9-22°N and 89-60°W and is the second largest sea in the world (Richards and Bohnsack, 1990). It is semi-enclosed by South and Central America (Latin America) and an archipelago of twenty-four island states. A few other islands are scattered within the sea. The study area comprises of a total of 27 island states and the Caribbean Sea as shown in Figure 2.2.

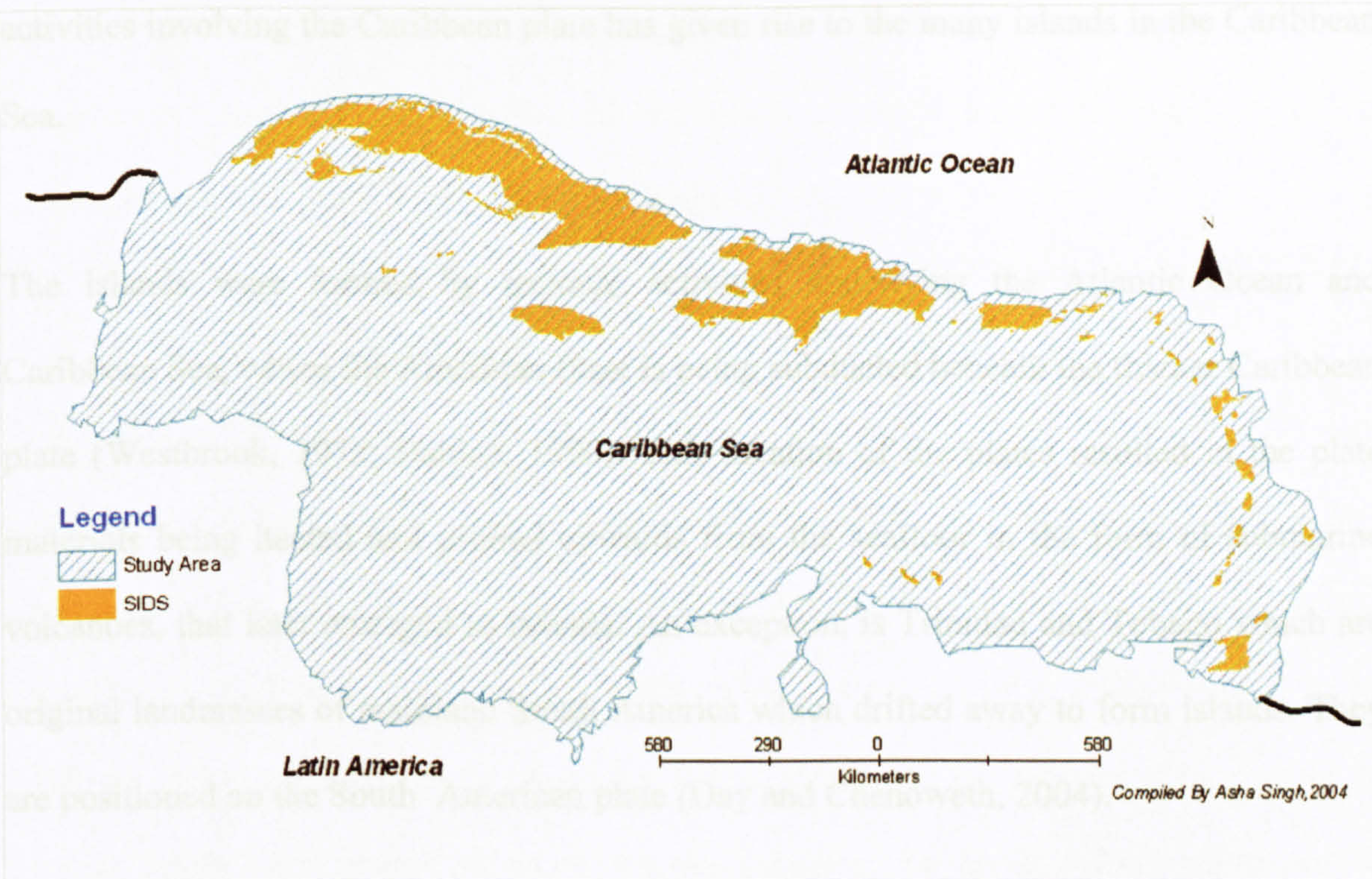


Figure 2.2: A Map showing the Study Area. Compiled using digital information from ESRI, (2002) and data generated for this study.

2.4 Geomorphic and Oceanographic Properties

In this section, the general geomorphic and oceanographic properties will be discussed briefly. These properties include the formation of the islands, bathymetry and the current movement of the water in the Sea.

2.4.1 Formation of the Islands in the Caribbean Sea

There has been continuous debate by many researchers regarding the location and formation of the Caribbean plate. Schubert (1935) and Meyerhoff and Meyerhoff, (1972) suggested that the Caribbean plate was formed in situ (in the Caribbean Sea) and has had little movement since. However, many recent researchers (Burke *et. al.*, 1984; Burke, 1988; Pindell, 1990; Pindell and Barrett, 1990; Montgomery *et. al.*, 1994; Kerr *et. al.*, 1999) have concluded that the Caribbean plate was formed in the Pacific and was transported to its present location by significant eastward plate movement. These theories of the location are still suppositions and have not been resolved. However, tectonic activities involving the Caribbean plate has given rise to the many islands in the Caribbean Sea.

The islands were formed by tectonic activities underlying the Atlantic Ocean and Caribbean Sea, where the American Plate is being subducted beneath the thicker Caribbean plate (Westbrook, 1975; Dahlen, 1990). This location of the plates resulted in the plate materials being heated and pushed upwards from the seafloor in the form of submarine volcanoes, that later emerged as islands. An exception, is Trinidad and Tobago which are original landmasses of mainland South America which drifted away to form islands. They are positioned on the South American plate (Day and Chenoweth, 2004).

2.4.2 Island Geomorphology

All the islands formed in the Caribbean Sea have various geomorphological features, climates and individual assets. They vary in size and range from 13 Km^2 (Saba) to 110, 860 Km^2 (Cuba). Some islands display characteristic of a typical volcanic islands, such as the crater lakes of Grenada, or the naturally occurring hot springs in Nevis. Others, such as the large rugged island of Dominica, is made up of a convergence of several volcanic islands (Rudder, 2000). However, Barbados, found on the easternmost edge of the Caribbean is predominantly a coral limestone island - 85% (Brewster and Mwansa, 2001), but it also shows signs of volcanic activity driven by subduction. This is displayed in the uniquely rugged features of its Scotland District. This area of Barbados has sedimentary rocks that were folded and compressed by the tectonic activities (Carson and Tam, 1977).

Some islands still have present day volcanic hazards because of their geographic location in relation to the tectonic plate. Saba in the North to Grenada in the South represents a chain of volcanoes that has built up along the boundary between the Caribbean and the American plates known as the Active Arc (Roobol *et. al.*, 1997). To date, seismic activities still occur on some islands, such as Montserrat. In contrast, Anguilla, St Marteen, St Barts, Antigua and Barbuda and Guadeloupe represent an older extinct volcanic arc called Limestone Caribee (Martin- Kaye, 1969; Roobol *et. al.*, 1997)

2.4.3 Bathymetry

This Caribbean Sea covers an area of 2,515 900 sq km (NOAA, 2003; Encarta, 2004) with many basins/troughs, which were formed in the cenozoic era (Bachmman, 2001). The Cayman trough is the deepest vertical depression in the sea, with various estimated depths. Bachmann (2001) estimated it to be 7,680m while Ten Brink *et al.*, estimated it to be 7,000 m. However, a 3D model of the sea's bathymetry was built by the author using an existing raster base image which shows the trough to be about 6,700m deep and is illustrated in Figure 2.3. These differences in anomalies maybe attributed to our limited knowledge of the seafloor bathymetry. Also this is an active earthquake area where active spreading is occurring (Leroy *et. al.*, 1996; Ten Brink *et. al.*, 2002).

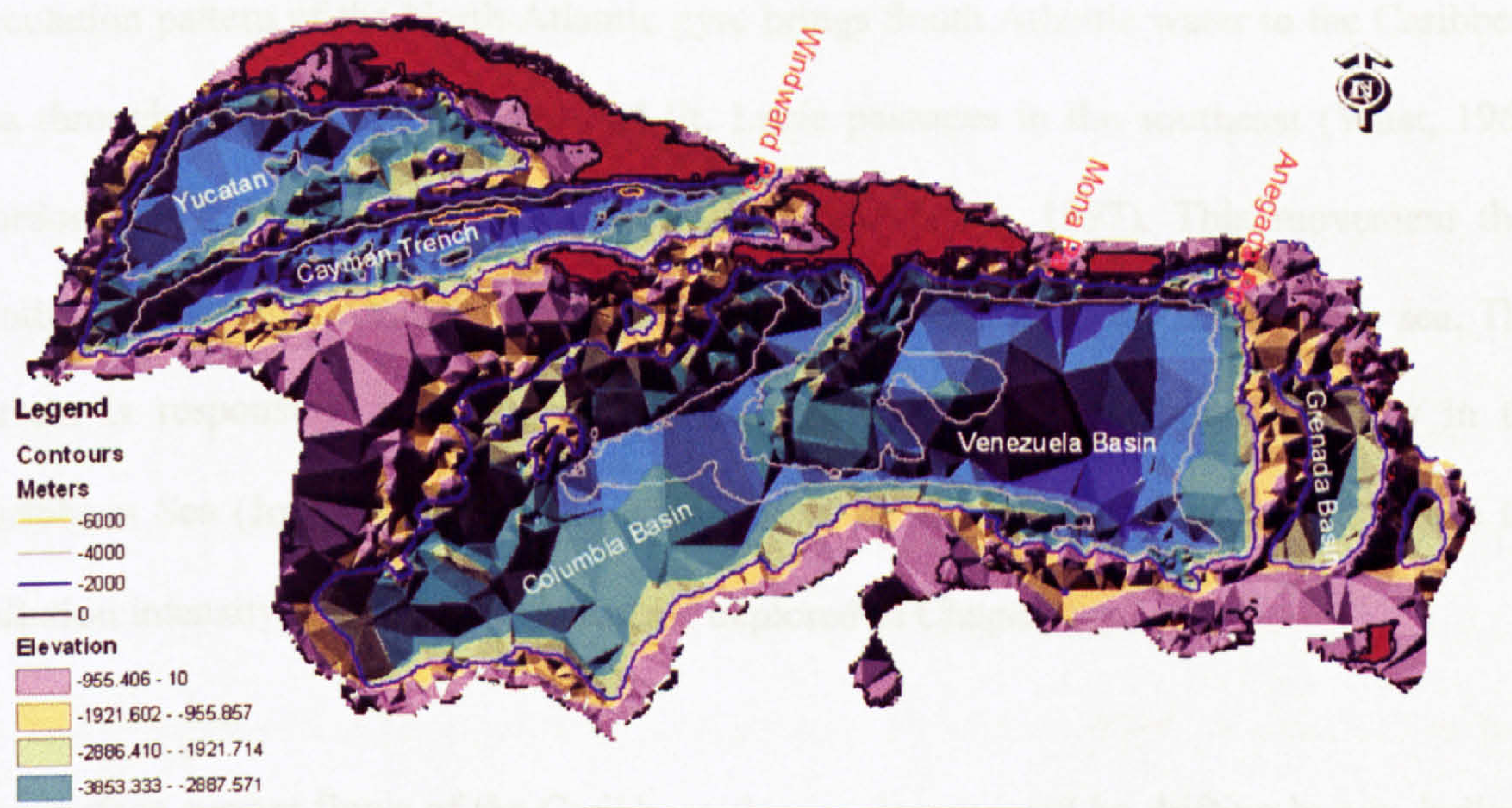


Figure 2.3: A 3D Map of the Caribbean Sea showing the Bathymetry and Ocean Passages. Compiled using data from ESRI, (2002).There are three passages in the sea and five basins

In addition to the Cayman trough, there are four additional basins that make up the bathymetry of the Caribbean Sea - Yucatan, Columbia, Venezuela and Grenada. All of the basins range between 914 to 975 m deep with the exception of a small area northwest of Grenada, which has an approximated depth of 1,249 m as shown in Figure 2.3. There are also many passages in the sea as depicted in Figure 2.3. The Anegada passage reaches a depth of approximately 594-701m and serves as one of the principal shipping lanes in the Caribbean Sea.

2.4.4 Current Movement in the Caribbean Sea

Water masses in the Caribbean, originate in both the North Atlantic and South Atlantic Ocean (Wilson and Johns, 1997; Murphy *et. al.*, 1999; Andrade and Barton, 2000; Gyory *et. al.*, 2002; Johns *et. al.*, 2002).

Researchers have investigated the current movement through the examination of temperature, salinity and dissolved oxygen signatures. These criteria reveal that the circulation pattern of the North Atlantic gyre brings South Atlantic water to the Caribbean Sea through Grenada, St. Vincent and St. Lucia passages in the southeast (Wust, 1964; Gordon, 1967; Mazeika *et. al.*, 1980; Wilson and Johns, 1997). This movement then continues westward as the Caribbean current which is located to the south of the sea. This current is responsible for the main surface circulation and the strongest flow in the Caribbean Sea (Johns *et. al.*, 2002). This pattern of movement is likely to influence the pollution intensity in the sea and is further explored in Chapter Six.

The surface current flows of the Caribbean Sea, as documented by drifting buoys, indicate a relatively slow current speed (0.2 ms^{-1}) in the easterly Grenada Basin (Kinder, 1983; Kinder *et. al.*, 1985; Molinari *et. al.*, 1985), and a moderate to relatively stable current speeds of 0.5 ms^{-1} in the Central basins, which includes the Venezuelan Basin (Kinder *et.*

al., 1985). Hernandez-Guerra and Joyce, (2000) revealed from a study conducted in the vicinity of Puerto Rico that the Caribbean surface water in the upper 50m of the water column has salinity values of less than 35.5 psu and a potential temperature of 28°C. These studies seem to suggest that the water column is relatively stable. Similar findings were presented by Richards and Bohnsack, (1990 page 44) in which they mentioned that "the surface water of the Sea is thermally stable and stratified with little seasonal variation in the surface water temperature, which has a range from 25.5°C in winter to 28°C in the summer."

The highly stratified nature of the water in the Caribbean Sea makes it one of the most oligotrophic seas in the world. According to Gordon (1967) and Gyory *et. al.* (2002) the Caribbean Sea is highly stratified in the upper 1,200m, weakly stratified between 1,200-2,000m and almost uniform below 2,000m. Thus, the sea is relatively nutrient deficient (nitrates and phosphates) except for isolated areas of upwelling (NOAA, 2003). These are mainly coastal upwelling occurring on the northern coast of South America (Richards and Bohnsack, 1990). Studies conducted in 1995 by NOAA using SeaWifs global primary productivity index, revealed that the Caribbean Sea has a productivity index of less than 150 g C/m^2-yr, falling into the 111 Class of low productivity. In addition, studies conducted in 2002 by the University of Puerto Rico, using SeaWifs chlorophyll A images in an area close to Puerto Rico, indicated that the primary productivity ranges from 200-4000 mg C/m^2/day (Sastra and Armstrong, 2002). The low productivity of the sea is primarily caused by the short supply of nitrogen (N) and phosphorous (P) as a result of limited amounts of inorganic nutrients in the water. This low level of productivity leads to long food chains that are vulnerable to over-exploitation of the sea biological resources and subsequent recovery can be slow. The limited continental shelf of the islands supports most of the Caribbean's sea biodiversity in the form of coral reefs and sea grass areas, which in turn supports many species of marine life.

2.5 Habitats in the Study Area

There are three major marine habitats/ecosystems in the study area and these are coral reefs, seagrass and mangroves. When compared to the Indo Pacific region, the diversity[14] and distribution in the Caribbean is lower as shown in Figure 2.4. Higher diversity in the Indo Pacific region can be attributed to it being an older area than the Caribbean Sea, in terms of the geologic time scale. The period for speciation has therefore, been much longer (UNEP/CEP, 2003). In total, the Caribbean has approximately 10 % of the world's coral (ICRAN, 2001). The diversity of seagrass and coral reef is lower in the Caribbean region than it is in the Indo-Pacific. However, the Caribbean has the highest number of regionally endemic genera in the world (UNEP/CEP, 2003).

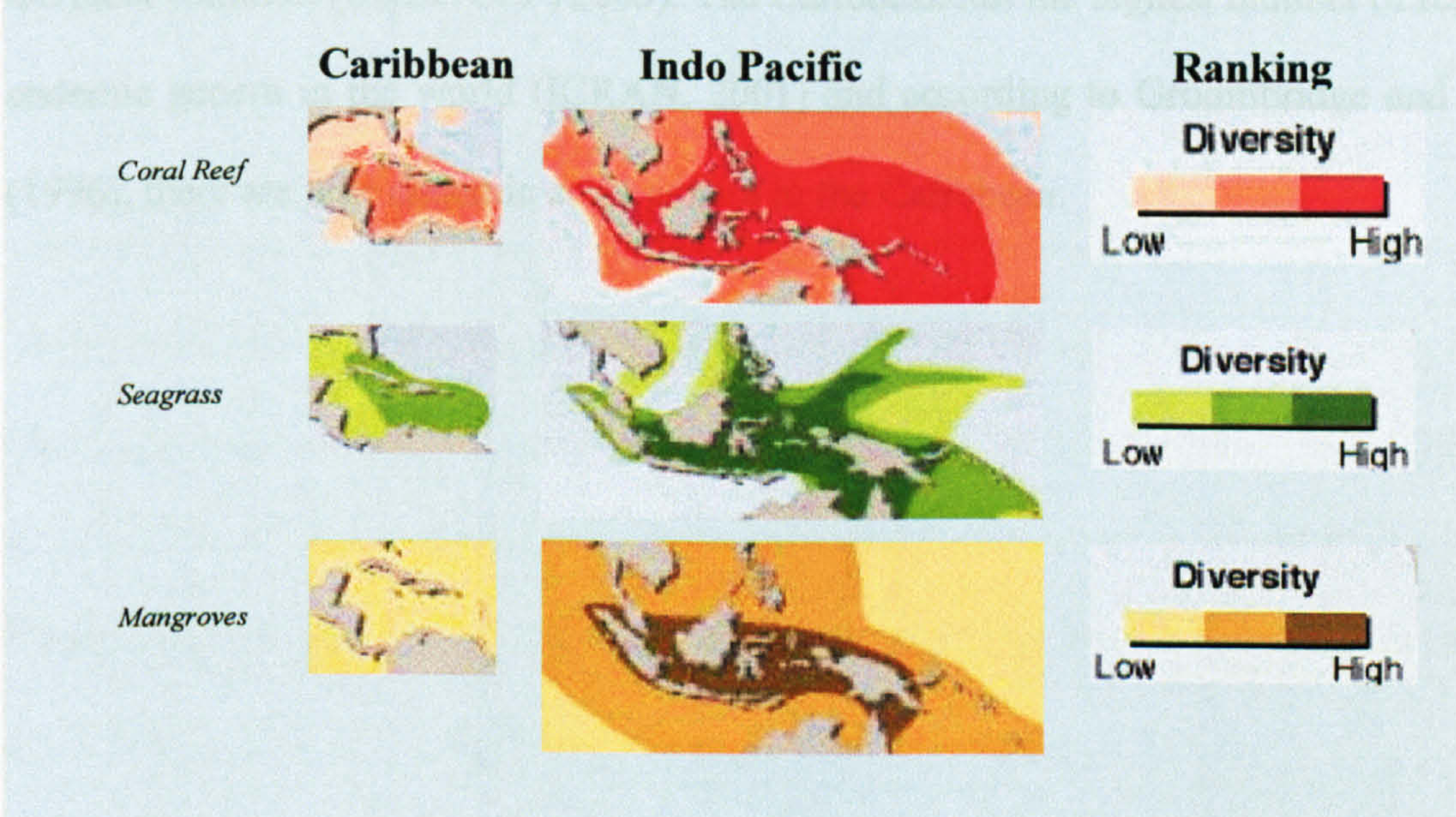


Figure 2.4: A Comparative Illustration of Habitat Diversity in the Indo Pacific and Caribbean Regions. Modified from original images by UNEP-WCMC, (2001), taken from UNEP, (2002a). The diversity for coral reef in the Caribbean is ranked medium, seagrass is both low and medium and mangroves is low. The Indo Pacific is high for the three habitats/ecosystems

[14] diversity represented by the number and abundance of these ecosystems.

Despite the comparatively low diversity in the region, these habitats are important to maintaining biological diversity and indirectly provide economic sustenance to the region and are discussed within the regional context.

2.5.1 Coral Reefs

A spatial map showing the coral reefs distribution shown in Figure 2.5 demonstrates that coral reefs are found throughout the Sea, though they are limited in size and vary in abundance on an island basis. In the Caribbean, there are more than one thousand species of corals (Gjerde and Davidson, 1988; Edmunds *et. al.*, 1990) including many species of hard and soft corals (CARICOMP, 2002). The stock of soft gorgonian corals is more abundant in the Caribbean Sea than other parts of the world also the fringing reefs being the most common (UNEP/CEP, 2003). The Caribbean has the highest number of regionally endemic genera in the world (ICRAN, 2001) and according to Groombridge and Jenkins (1996), there are nine endemic coral genera in the Caribbean.

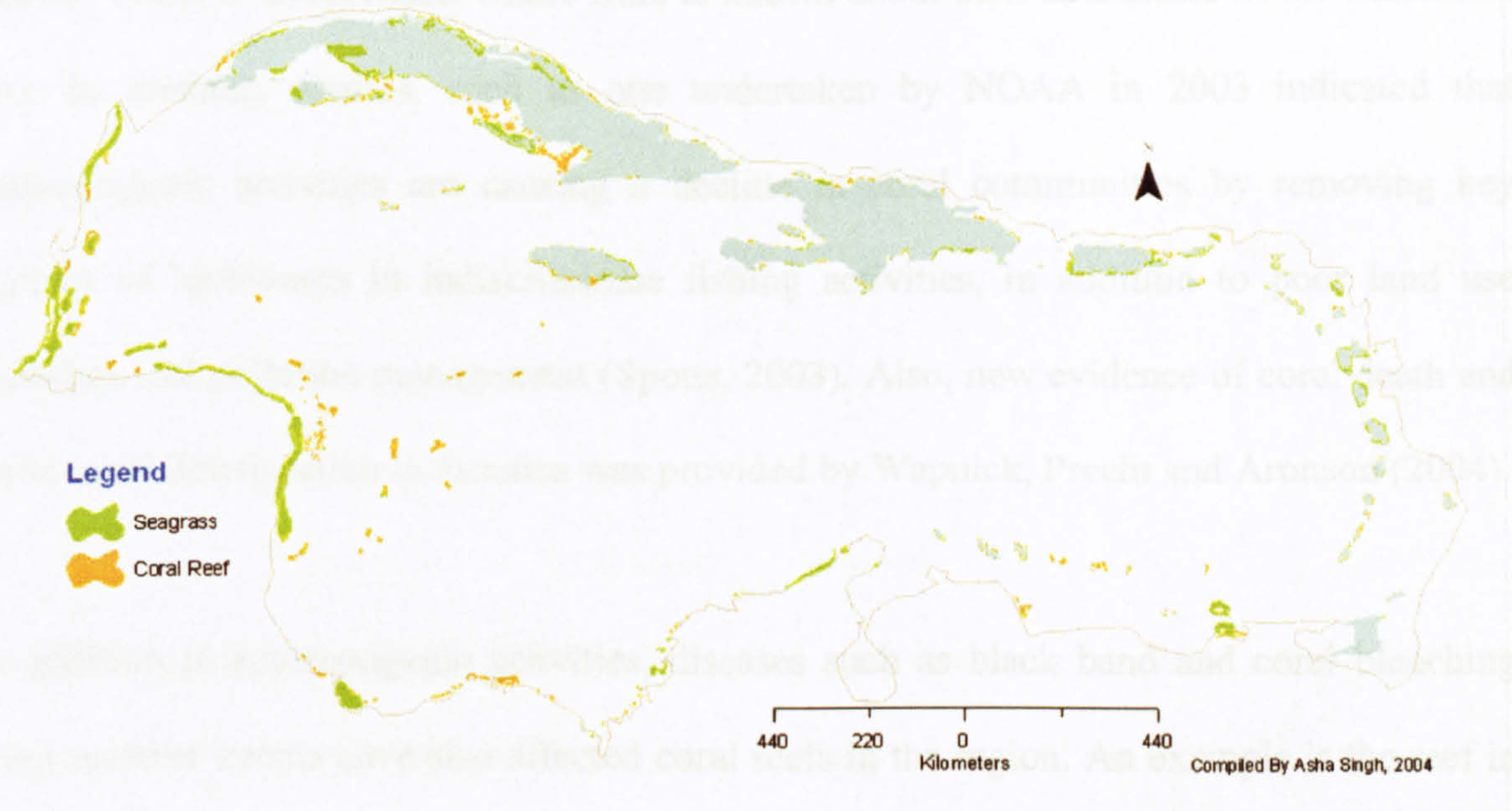


Figure 2.5: A Map of the Coral Reefs and Seagrass Distribution in the Caribbean Sea. Compiled using data from UNEP/WCMC, (2002). Both the coral reef and seagrass habitats are found throughout the sea, with the highest abundance in the coastal areas of the islands

The reefs in the Caribbean contain a diverse array of biodiversity including many species of reef fish, mollusc and crustaceans. This array of biodiversity in the reefs is important to the tourism industry (diving snorkelling) and near shore fisheries (Munro, 1983). However, over the years these resources have been subjected to a number of negative impacts from human-induced activities (UNEP, 1994), which include both land and marine based activities as well as natural disasters[15].

Many studies have been conducted on coral reefs in the Caribbean owing it its importance in the biological chain, and while some studies have suggested that coral reefs are in crisis (Bouchon *et. al.*, 2004; Burke and Maidens, 2004a; Jones *et. al.*, 2004), others suggested otherwise. Studies by Ginsburg from the University of Miami (Carlson, 2003) and Singh from Woods Hole Oceanographic Institution (Cooke, 2004) have suggested that the coral reefs are healthier than previously thought. However, these healthy reefs are among those

[15] See Chapter Seven for Natural Disasters in the Caribbean.

that are found in deep water, where little is known about their abundance in the Caribbean Sea. In contrast, studies, such as one undertaken by NOAA in 2003 indicated that anthropogenic activities are causing a decline in coral communities by removing key species of herbivores in indiscriminate fishing activities, in addition to poor land use practices and pollution management (Spotts, 2003). Also, new evidence of coral death and rapid coral deterioration in Jamaica was provided by Wapnick, Precht and Aronson (2004).

In addition to anthropogenic activities, diseases such as black band and coral bleaching from weather events have also affected coral reefs in the region. An example is the reef in Discovery Bay in Jamaica, which displayed reduced growth after a coral bleaching event in 1987. This was measured using the reef building coral species *Montastrea annularis* (Goreau and Mc Farlane, 1990).

2.5.2 Seagrass

The Seagrass beds as shown in Figure 2.5 are found in most of the islands, although the species diversity may be low in some areas/islands. The most common species are the *Thalassia testudinum* -Turtle Grass, *Syringodium filiforme* - Manatee Grass and *Halodule wrightii*- Shoal Grass (Duarte, 1999; CARICOMP, 2002). There are two endemic species of Seagrass in the Caribbean, these are *Halophila emgelmannii* and *Halophila johnsonii* (Groombridge and Jenkins, 1996). Interspersed between the seagrass beds are benthically rooted algae species such as *Avrainvillea, Udotea, Penicillus, Halimeda, Amphiroa,* and *Caulerpa*. Seagrass habitats play host to various species, such as the West Indian Manatee (*Trichechus manatus*) which feeds on the grass. Like the coral reefs, these habitats have also been overtly subjected to stress from human activities.

2.5.3 Mangroves

The mangal system represents another stressed habitat in the Caribbean. Though comparatively small on an international scale, they play a vital role in coastal stability. Mangroves serve as fish breeding and nursery grounds (Ogden and Gladfelter, 1983), avifauna habitat, silt trap and nutrient exporter (Odum and Heald, 1972). According to Rutzler and Feller (1996), the species which can be found in the region include *Rhizophora mangale* (Red Mangrove), *Laguncularia racemosa* (White Mangrove), *Avicennia germinans* (Black Mangrove) and *Conocarpus erecta* (Buttonwood). Mangrove abundance ranges from a few scattered scrub patches to a more diverse riverine or fringing mangal system. This system is faced with the threat of tourism development (UNEP, 1989) and landfill usage in many islands. For example, in St Lucia it has been estimated, that over 50% of mangrove wetlands were lost to development of the hospitality sector, such as hotels (Bushnell *et. al.*, 2001). In addition, solid waste build-up and excess siltation in mangroves are further issues that negatively affect the marine system. This has been exemplified in St Lucia by the now defunct "Ciceron" landfill, which was a mangrove habitat (Geraldine Lendor, *pers. comm.)*. In Guadeloupe, the largest public landfill covers approximately thirty hectares and was built on a mangrove habitat (DDE, 1995a). This is a recurring trend in most of the islands where this habitat type occurs. As shown in Table 2.2, most of the islands have progressively lost mangrove area. In countries like Dominica, over 75% of mangrove areas were lost between 1980 and 2000. Barbados also showed a high percent loss with 59% while Cuba recoded the lowest loss of mangroves with less than 1 %. These recorded loss of mangroves seem to suggest that development in coastal belt in the islands are increasing, which are replacing these habitats.

Table 2.2: The Distribution and Status of Mangroves in the Caribbean SIDS. Compiled using data from FAO (2003). All the islands except USVI and Aruba have loss mangroves area. Cuba has the largest area of mangroves in the SIDS while Dominica has the smallest in year 2000

Country	1980 (ha)	1990 (ha)	2000 (ha)	Calculated % Change 1980 & 2000	Status
Antigua & Barbuda	1,570	1,200	900	-43	Decline
Barbados	30	16	10	-67	
Cuba	530,500	529,800	529,000	-0.3	
Dominica	40	13	9	-77	
Dominican Republic	33,800	26,300	18,700	-45	
Grenada	295	262	230	-22	
Haiti	17,800	15,000	10,000	-44	
Jamaica	23,000	10,800	9,300	-59	
Netherlands Antilles	1,140	1,138	1,130	-0.9	
St. Kitts & Nevis	84	80	75	-11	
St. Vincent & Grenadines	60	52	45	-25	
Trinidad & Tobago	9,000	7,200	6,600	-29	
St. Lucia	200	190	180	-5	
US Virgin Islands	978	978	978		Constant
Aruba	420	420	420		

In conclusion, threats to the ecosystems (seagrass, coral reef and mangroves) vary in magnitude depending on the scale of the inland activities, pressure and the proximity in relation to the ecosystems at risk (Rodriguez, 1981). This will be demonstrated further in Chapter Four. Overall, it is evident that there is loss or decline in the quality of productive areas in terms of coral reef, mangrove and sea grass areas in the Caribbean Sea.

2.6 Anthropogenic Pressures Affecting the Study Area

This section presents a description of the pressures, which were highlighted in Chapter One. These include siltation and effluent discharges among others. These issues are a general reflection of the pressures on the marine environment, which are a result of land and maritime based activities.

2.6.1 Siltation

Siltation of nearshore areas is a major problem facing the Caribbean archipelago. High levels of sediment are deposited in bays via river systems which themselves have been degraded due to poor landuse practices such as tree cover removal in Haiti (Ministère De L'Environnement, 2001). Deforestation along riverbanks and slopes, and uncontrolled and poorly controlled construction in coastal areas are common occurrences. Pumice and silt from the quarry operations in islands such as Grenada and Jamaica have contributed to the smothering of nearby reefs, thereby causing major disturbances in the habitats (Department of Economic Affairs, 2001; NRCA, 2001). Farming steep gradients (for example, coffee cultivation in Jamaica) is also a cause of increased sediment loads in the nearby coastal zone.

2.6.2 Effluent

Effluents including those from domestic and ship sewage, industrial and agro processing and urban drainage water, are discharged into the sea (UNEP, 1994, 1997; GESAMP, 2001; UNEP, 2004a). These discharges pose a major threat to the ecosystems in the region. The treatment and disposal of waste is a major concern in the Caribbean because of the lack of adequate treatment facilities (Vlugman, 1992). Though some treatment facilities exist in the region as shown in Table 2.3, most are unable to deal with the amount and types of waste generated or in most countries, these facilities are inadequate. This is evident from a study conducted in 1992 by CEHI/PAHO, which showed that in excess of 70% of the treatment plants in the Caribbean are non-operational, most being old and defunct. Where these facilities are absent or non-functional, the collected effluent is discharged directly into the sea untreated e.g. the Castries Sewerage Plant in St Lucia (Errol Frederick *pers. comm.*). In some cases primary treatment is carried out prior to the discharge e.g. DOWASCO in Dominica (George Martin, *pers. comm.*). None of the islands applies tertiary treatment to the collected sewage. Guadeloupe has twenty public sewerage treatment plants in total, with only nine using satisfactory techniques, while four are inadequate and the remaining seven are ineffective (IFRECOR, 2000). Notably majority of the population in all the islands are not connected to a sewerage system, but rather their sewage is disposed into septic tanks. Pit latrines are also widely used. The effluent from these two disposal systems often enters the nearby marine areas via surface drains.

Table 2.3: Status of Sewerage Treatment Facilities in the SIDS. Compiled using data from UNEP, (1998), IFECOR, (2000) and other sources in the Islands. STW = sewerage treatment work, NI = no information.

Country	Number of Plants (STW)	Country	Number of Plants (STW)	Country	Number of Plants (STW)
	Level of Service		Level of Service		Level of Service
Aruba	2	Guadeloupe	20	British Virgin Islands	1
	-Most pop. are serviced		-some are inadequate -7 ineffective (IFECOR,2000)		
Curaçao	4	Montserrat	1	USVI	NI
	-Some hotels have independent sys. -sewerage are still drained viable pipes		NI		NI
Bonaire	1	Antigua & Barbuda	No central system	Puerto Rico	NI
	NI		Most hotels have independent sys. App. 16		NI
Trinidad & Tobago	Approx. 116	St. Kitts - Nevis	No central sys.	Dominican Republic	NI
	Most of population serviced		Mostly for hotels and hospitals		25% of urban population (in 1979)
Grenada	1	Saba	None	Haiti	1
	Service St. George		NI		
St. Vincent	1	St Eustatius	None	Cuba	NI
	for City of Kingstown		NI		34.2 % of pop. Served by sewerage
Barbados	2	St Marteen	I	Cayman Islands	NI
	Serve 10% - of Bridgetown, 1 -South Coast		NI		NI
St. Lucia	2	St Martin	NI	Jamaica	109
	20% of population		NI		21 serve Kingston area; not enough capacity
Martinique	NI	Anguilla	NI	Dominica	1
	NI		NI		City of Roseau,

Many hotels throughout the Caribbean have privately owned treatment plants, with subsequent disposal of the partially treated effluent into the neighbouring waters (Pattullo, 1996; UNEP, 1997). It is an accepted fact by many governing bodies that there is a need for proper disposal facilities thus more emphasis is being placed on building treatment plants in the islands. However, currently the available capacity is still not adequate to service the waste generated by the population (Table 2.3). The coastal water quality is still a major concern in many islands (PAHO, 1998), because these treatment systems are not available to all households. This is evident in islands such as Dominica (Joseph Martin *pers. comm.*).

Agro-industries generate large quantities of wastewater, mostly from cleaning or sanitising equipment, which drains into nearby rivers and streams via sewerage and drainage. This eventually reaches the sea. Though limited information exists on the composition and effects of wastewater, it is a known fact that these waters contain traces of various chemicals of different proportions and compositions (UNEP, 1989) which are likely to be harmful to marine life. Other agro-chemicals are discussed in Section 2.6.4 (pg. 38).

Industrial effluents are a particular problem in industrial islands such as Trinidad and Jamaica and to a lesser extent Martinique, Guadeloupe, Aruba and Curaçao. Many of the existing industries do not conduct adequate treatment prior to the disposal of effluents which cause pollution to coastal areas (UNEP, 1989).

Thermal effluent emanating from electricity generating plants and from some factories, has resulted in increased temperature and chemical output of the receiving marine environment. In most cases, the site location of these plants is in the coastal areas of the islands and there has been reports of adverse effects such as dead fish zones in Dominica (Drigo, 2001). The micro barren marine area adjacent to an electricity generating plant at

Spring Gardens in Barbados is an example of the adverse effects these sites can have on the marine environment (personal observation).

Leacheates from disposal activities are also a problem to the marine environment. For example, during the rainy season in Guadeloupe, leacheates from dump sites enter into nearby marine areas (IFRECOR, 2000). In some islands, the landfills (which are located on the coast) are not well engineered, resulting in seepage into the marine environment, for example in Dominica (Jeno Jacobs, *pers. comm.).*

2.6.3 Solid Waste

Solid waste reaching the coast includes poorly degradable synthetic materials such as plastic (PET) bottles and bags used in the soft drink industry and stores. These materials have become particularly problematic in many islands such as St Lucia (Department of Economic Affairs 2001) and the region in general because there are no recycling facilities within the region. This problem is more evident after periods of heavy rainfall as plastic bottles and other debris can be observed clogging river mouths and nearshore areas in some islands (Henneman, 1988; Department of Economic Affairs, 2001). Plastic debris can be particularly dangerous to marine life because it can be ingested by various species (Balazs, 1984).

Many of the islands in the Caribbean participate in the annual collection of marine debris. Secondary data compiled showed that the amount of debris collected varied among islands. As shown in Table 2.4, Jamaica recorded the highest collection per area and Barbados the lowest. The data in Table 2.4 may be an indication of the waste management policy and attitudinal behaviour in the islands with regard to waste disposal. Corbin and Singh (1993), found that plastic was the most common type of beach debris on the coastal area in St Lucia accounting for over 59.3 % of total waste collected between 1992 and 1993.

Table 2.4: Coastal Debris collected in the SIDS for various years. Compiled using data from Coastal Cleanup, (2005). Jamaica has the largest amount of debris per kilometre of coast

Island	Year	Area Covered (km)	Trash (items)	Calculated Trash/Km
Jamaica	2004	18.7	34,333	**1,836**
Guadeloupe	2003	1.4	103	**787.8**
Trinidad &Tobago	2004	8.2	6,257	**763**
Dominica	2004	66	45,290	**686.2**
Haiti	2003	0.5	324	**648**
Martinique	2002	0.75	414	**552**
Puerto Rico	2004	102	48,291	**473**
Cuba	2004	2.4	1,000	**416.6**
Antigua & Barbuda	2004	8	3,000	**375**
Grenada	2003	2.4	800	**333.3**
St Lucia	2004	36	7,027	**195.2**
BVI	2004	19.1	3,275	**171.5**
St Kitts & Nevis	2004	21.3	2,840	**133.3**
Barbados	2004	1.6	210	**131.2**

Legislation has been enacted to address the issue of solid waste and Solid Waste Management Units have been established in many islands. However, inadequate landfill sites, or in some cases careless dumping along riverbanks and coastal areas, as well as the lack of formal recycling facilities continues to present problems for coastal and marine management authorities throughout the region.

2.6.4 Agro Chemical Pollution and Eutrophication

Another problematic issue is the use of agricultural fertilizer, pesticides and insecticides in the agricultural sector, which is causing marine pollution in the region. Pesticide runoffs into streams is responsible for fish kills in inland St Lucia (Bushnell *et. al.*, 2001). Eutrophication is believed to have negative impacts on the coastal areas of the Caribbean and is noted as a serious risk (UNEP, 1994). For example, in 1993 a large fish kill off the coast of Trinidad (Point Lisas) was linked to harmful algal blooms (Institute of Marine Affairs, 2005). Studies, conducted in Jamaica's Kingston Harbour showed contamination by insecticides of the marine area (Mansingh and Wilson, 1995).

Acidic waste (vinasse) from sugar cane refining and alcohol distillation conducted primarily in Cuba, Barbados, Guadeloupe and Trinidad also poses a threat to the marine environment. In Guadeloupe for example, vinasse generated from the distilleries is disposed directly into open channels or rivers flowing into the sea without any form of treatment (IFRECOR, 2000). It is estimated that the quantities of organic pollution entering the marine environment during the manufacturing period, are equivalent to 20 t/day domestic/oxidizable waste generated by the total population (177,000) of Guadeloupe (DRIRE (ed.), 1994). In 1988, Trinidad experienced a massive algal bloom which was caused by effluent discharge from a distillery and resulted in large fish kills (1mile area) in the Gulf of Paria, (UNEP, 1994).

Eutrophication emanating from areas in Jamaica is also well documented especially in Hunt's Bay. This is a shallow and poorly flushed estuarine bay that is both polluted in organics and metals (Andrews *et. al.*, 1998) causing it to be eutrophic (Ranston and Webber, 2003). Two rivers drain into the bay and are responsible for bringing a mix of sediments and pollution from upstream sources. Impacts from these pollution sources have intensified over the past decades as the population of Kingston has increased[16]. Immediately surrounding the bay are industries including breweries, distilleries, tanning and food processing plants, as well as Kingston's main landfill site and a sewage treatment plant (Andrews *et. al.*, 1998). Although the bay has always been poorly flushed, the construction of a causeway in the late 1960s severely aggravated the problem (UNEP, 2002b). Sedimentation from local development combined with excessive inputs of nutrients and organic materials have led to hypoxic bottom waters across much of the bay (UNEP, 2002b). This eutrophication has affected the mangrove productivity and reduce the spatial extent (Mc Donald *et. al.*, 2003).

[16] Refer to Appendix One, Jamaica Profile for Population Statistics

In addition, Kingston harbour has a traditional near shore fishery that is in direct threat from the sediment pollution from Hunt's Bay. In the event that the pollution sources entering Hunt's Bay are to cease, the layers of sediment that are present are so contaminated that they intrinsically represent a long term source of pollution (UNEP, 2002b).

2.6.5 Heavy Metals

Heavy metals in the marine environment may not be a major issue throughout the region but it is a problem that is affecting some islands marine area and the Caribbean Sea. Heavy metals were found in the vicinity of Kingston Harbour in the water column and suspended sediments (Knight *et. al.*, 1997). This heavy metal contamination may be caused by sediments being disturbed from dredging (Siung-Chang, 1997; Villasol *et. al.*, 1997). Studies conducted in other regions of the world have found that heavy metals enter the food chain via shellfish, oyster and other animals (Hardy *et. al.*, 1984). There is evidence to suggest that this may be increasing in the region. High levels of mercury and other contaminants were found in marine fish and coral reefs in the waters of areas of the Caribbean Sea (Shrestha and Morales, 1987; Shrestha *et. al.*, 1988; Guzman and Jimenez, 1992). Further, in the surrounding waters of Guadeloupe, high and abnormal concentrations of some heavy metals were found in sediments, marine organisms and within the water column (Lamour and Burgaud, 1993; DDE, 1995a, b; De Lapeyre, 1995; Doris, 1996). These heavy metals included lead -Pb, cadmium -Cd, vanadium -V, copper -Cu, zinc -Zn and tin -Sn (Bernard, 1994). The origins of these pollutants vary. The Lead originates from urban and industrial waste, cadmium and vanadium from sump oil and copper, tin and zinc are mostly from anti-fouling marine paints (IFRECOR, 2000).

2.6.6 Hydrocarbon Pollution

According to UNEP (1989) hydrocarbon pollution in the Caribbean Sea is one of the most significant threats to marine life. Among those causing pollution are land based and maritime activities as well as oil and gas extraction. In total, there are two hundred and fourteen ports found within or bordering the Caribbean Sea, shown in Figure 2.6. According to the UNEP (1994), marine pollution prevails in all major ports of the Caribbean. Shipping and maritime activities such as ballasting, operational oil, accidental oil spills and tank washing are the main contributors to marine pollution in the sea. This can be attributed to heavy traffic movement of petroleum through the sea, owing to large petroleum trade (Dillion, 1995). In addition, the strategic location of the Panama Canal fosters a high level of vessel movement. There are in excess of seven million barrels of oil being discharged annually into the marine areas from tank washing in the Caribbean Sea (Botello *et. al.*, 1997). Of the two hundred and fourteen ports in the Caribbean, sixty-two (28%) handles oil and oil products, however, only twenty-two (35%) have oil/slop or ballast reception facilities, as shown in Figure 2.6.

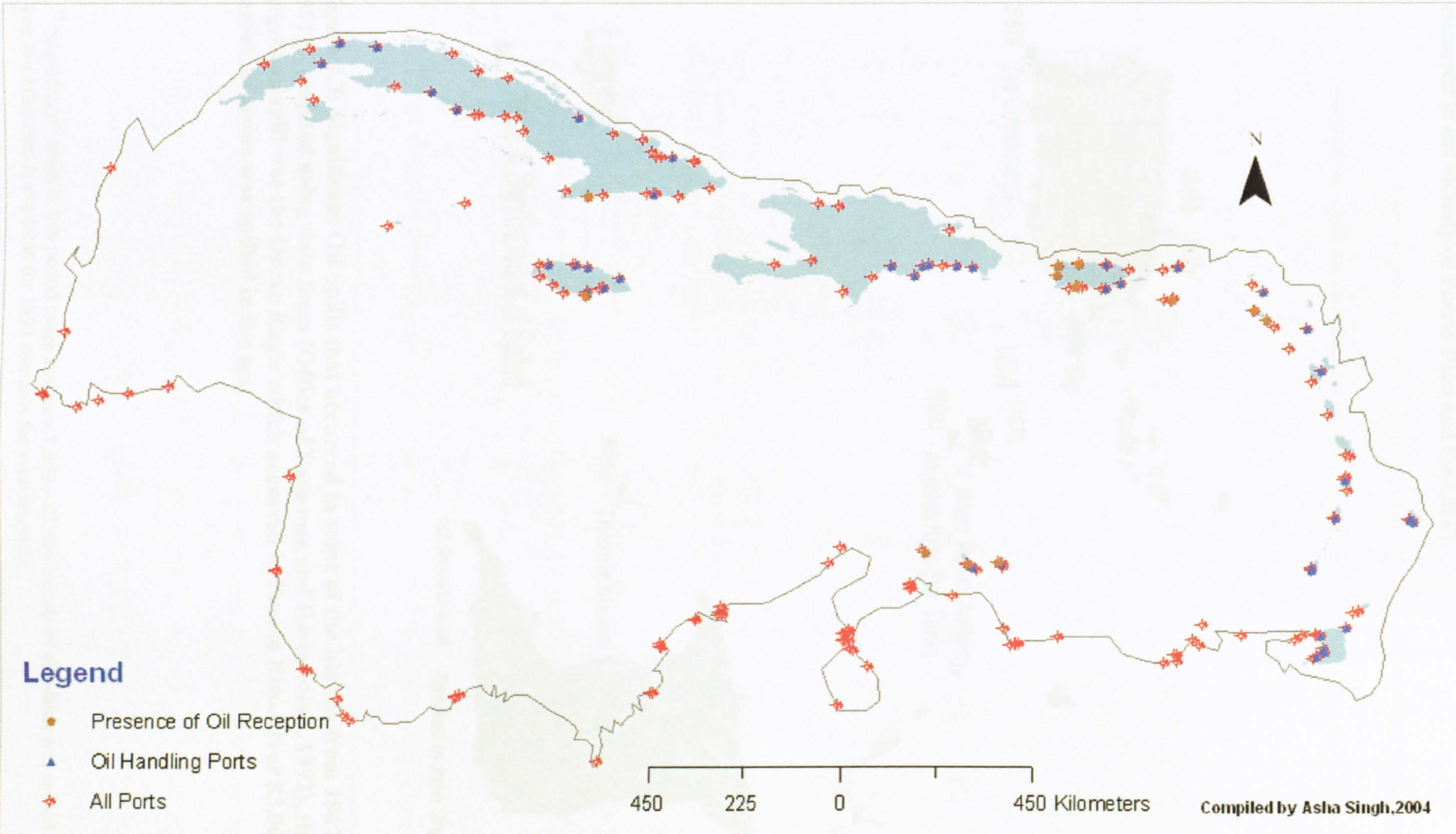


Figure 2.6: A Map of the Caribbean showing all the Ports, those that handle mainly petroleum related products and ports which have oil reception facilities. Compiled using information from World Seaport, (2003), Fairplay, (1999) and other literature.

Further data analyses showed that since 1960, over seven significant[17] incidences of oil spills have occurred in the Caribbean Sea, as shown in Figure 2.7. Most of the spills occurred in the vicinity of Puerto Rico and the USVI.

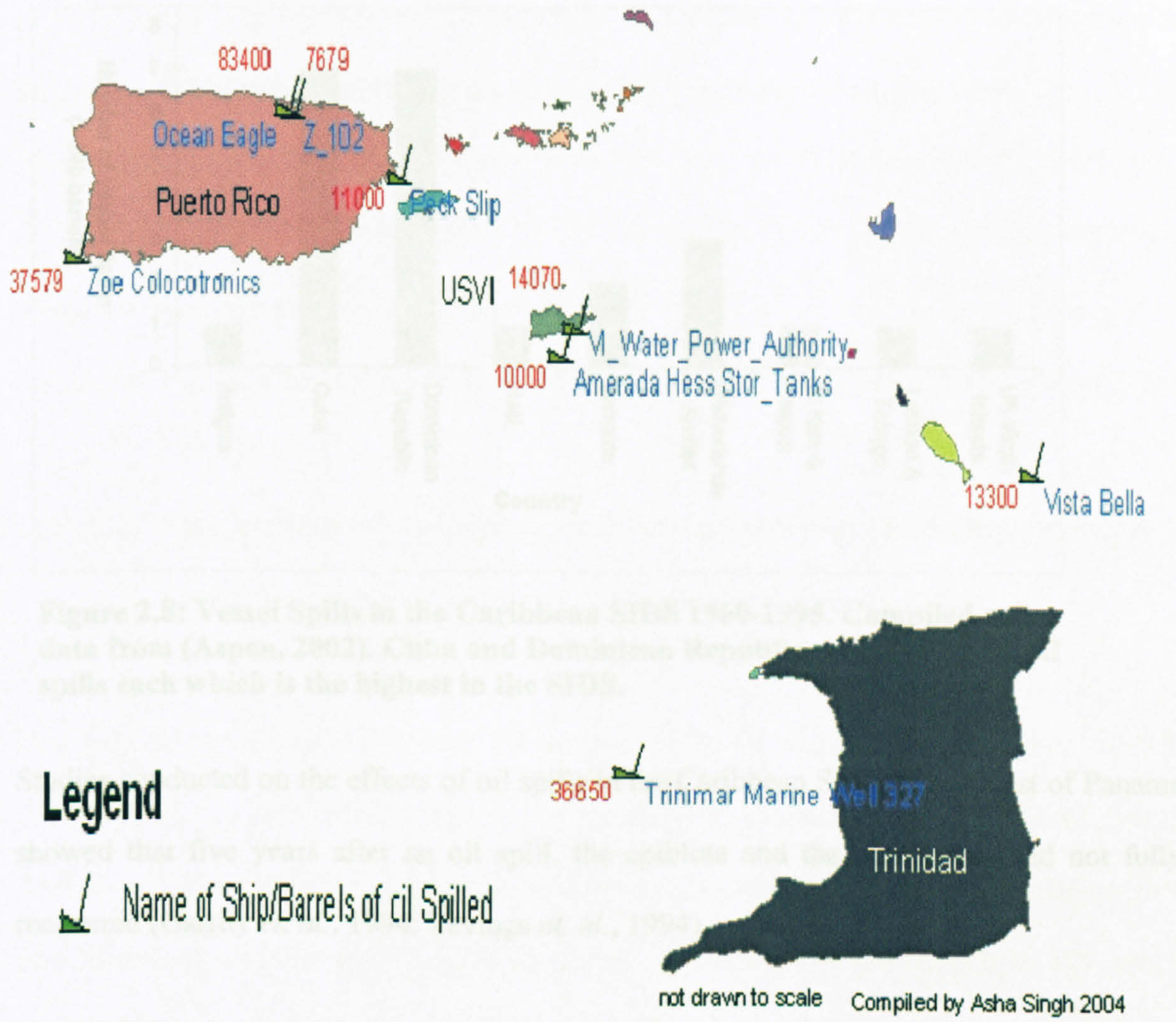


Figure 2.7: Significant Oil Spills that occurred in some of the islands from 1967 to 1991 (Compiled using data from (Office of Response and Restoration, 1992), the largest oil spill was the Ocean Eagle which occurred in Puerto Rico. Over 83,000 barrels of crude was spilled in the sea

[17] "significant" spills in this period range between 7,000 – 83,400 barrels of oil which was spilled into the sea. No other data is available for 1991 onwards for such amounts.

This amount does not include small unreported spills and those from operational cleaning of marine vessels. As shown in Figure 2.8, twenty-eight vessel spills in excess of 240 barrels (>10,000 gallons) occurred in the SIDS from 1960 to 1995, with Cuba and Dominican Republic recording the highest. During this period, 1,720 spills occurred worldwide with the US recording the highest.

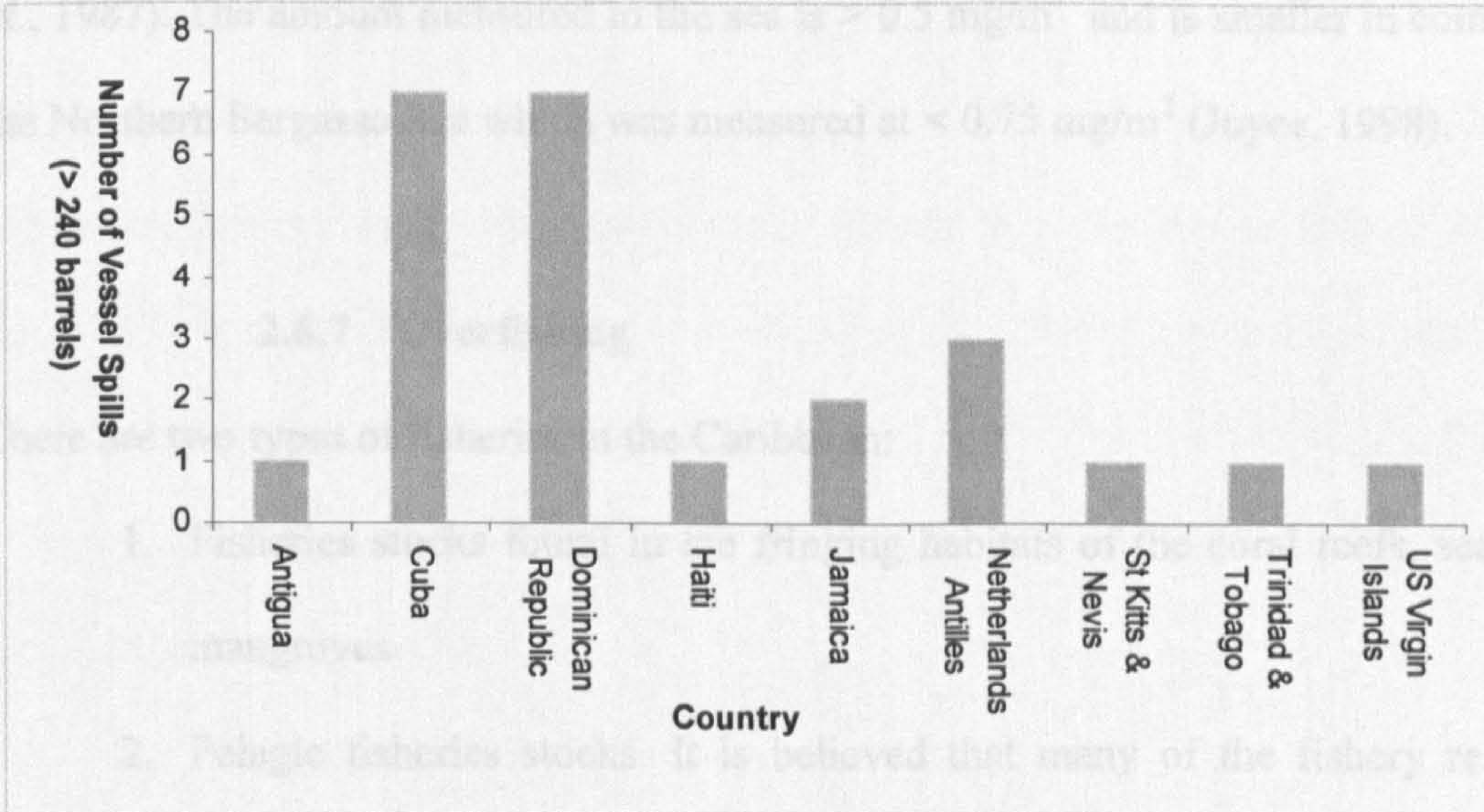


Figure 2.8: Vessel Spills in the Caribbean SIDS 1960-1995. Compiled using data from (Aspen, 2002). Cuba and Dominican Republic recorded seven oil spills each which is the highest in the SIDS.

Studies conducted on the effects of oil spills in the Caribbean Sea off the Coast of Panama showed that five years after an oil spill, the epibiota and the mangroves had not fully recovered (Garrity *et. al.*, 1994; Levings *et. al.*, 1994).

The UNEP estimated that in excess of 50% of the pollution is caused by ballasting and emptying of bilges in the Caribbean region (UNEP, 1994). To date there are no ballast programmes in existence in the Caribbean region. This is in contrast to the Caribbean Sea being ranked as one of the principal waterways in the world harbouring in excess of 50,000 ship calls per year (ACS, 2002), and is classified as having one of the most intensive maritime traffic in the world, according to UNEP (2005c).

There are increasing reports of oil slicks in coastal waters and along beaches in the Caribbean for example, in Jamaica (Wade *et. al.*, 1987) and Curaçao (Buth and Ras, 1992). High levels of Dispersed/Dissolved Petroleum Hydrocarbons (DDPH) were recorded at various cruise stations in the South Eastern part of the Caribbean Sea (Persad and Rajkumar, 1995), and in other areas of the sea (Harvey, 1987). In addition, reports of the presence of floating tar has also been documented for some areas of the sea (Richardson *et. al.*, 1987). The amount measured in the sea is > 0.5 mg/m^2 and is smaller in comparison to the Northern Sargasso Sea which was measured at < 0.75 mg/m^2 (Joyce, 1998).

2.6.7 Overfishing

There are two types of fisheries in the Caribbean:

1. Fisheries stocks found in the fringing habitats of the coral reefs, seagrass and mangroves.
2. Pelagic fisheries stocks. It is believed that many of the fishery resources is linked at a Caribbean wide level (Richards and Bohnsack, 1990).

The fisheries sector in the islands utilise a diversity of marine species, which include offshore pelagic, reef fishes, lobsters, conch, shrimps, continental shelf demersal fishes, deep slope and bank fishes and coastal pelagic groups. Many of these species along with a few migratory species such as swordfish are targeted in a few countries. Of lesser economic importance are marine mammals such as sea turtles, sea urchins and seaweeds (Chakalall *et. al.*, 1998).

Most islands have limited demersal fisheries resources due to small economic exclusive zones (Benbow and Burnett-Herkes, 1980; NOAA, 2003). In general, the fisheries in the Caribbean is limited to the coastal areas and other scattered habitats[18] owing to the low

[18] Refer to Chapter Six for Spatial Location of Major Habitats in the Sea

productivity of the sea (Section 2.4.4) and small EEZs. The local fishing industries have been relatively limited to artisanal or small-scale commercial activities for many decades (Laya and Weidner, 2001a). Cuba being the exception has developed a large-scale commercial fishery. However, its shipping fleet has declined since the 1980s due to the decrease in subsidies from Russia (Adams *et. al.*, 2000). Some islands are now placing emphasis on longline fisheries and in recent years, countries like Trinidad and St Vincent have being developing their fishing fleets.

Caribbean fisheries production has changed greatly in recent years. Fishing efforts have grown substantially in the 1980s but declined in the 1990s as shown in Figure 2.9. The FAO estimated that in 1985, the Caribbean Sea produced a catch of half million metric tonnes (FAO 1987), this estimated catch included the landings in the other jurisdictions of South and Central America.

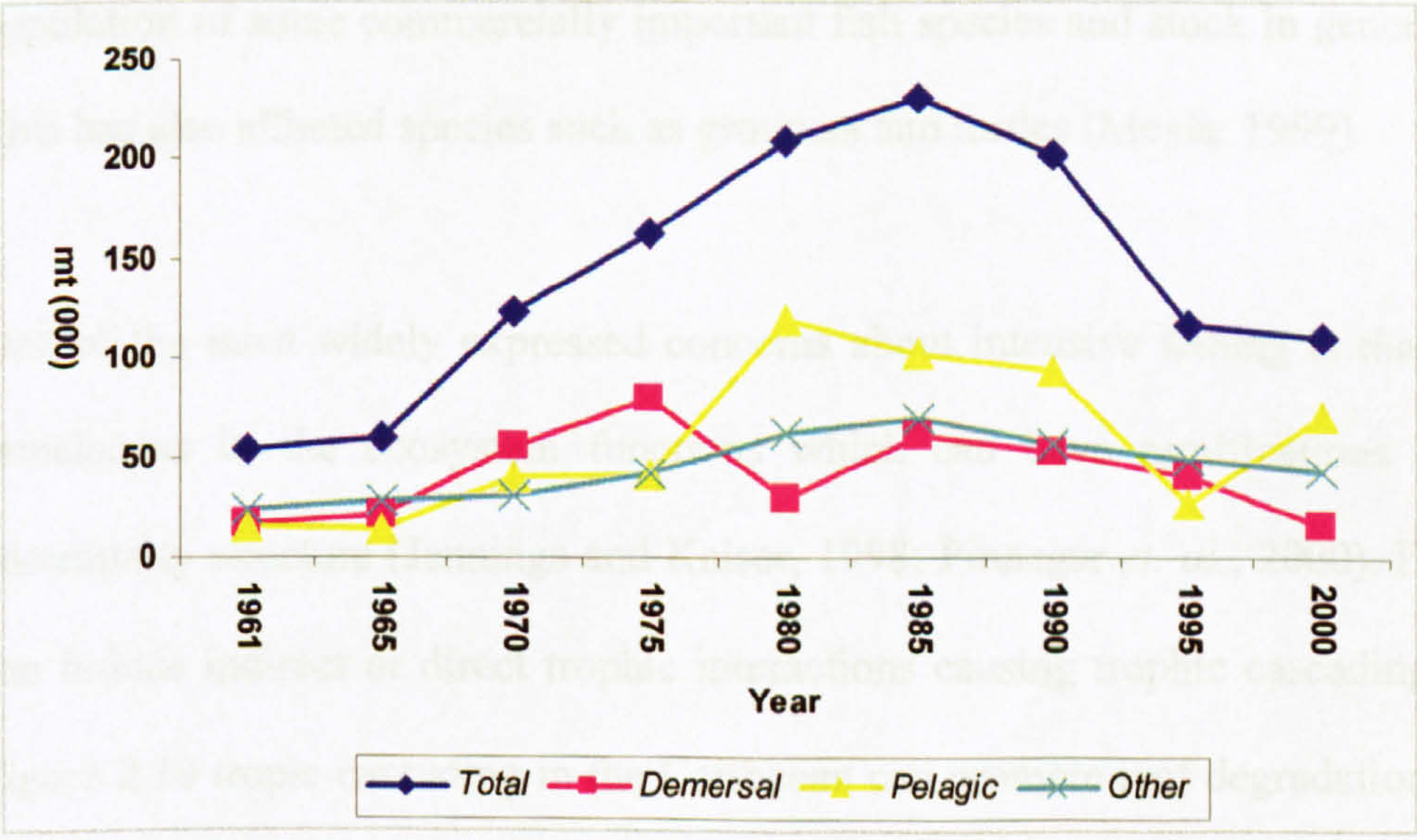


Figure 2.9: Fisheries Production in the Caribbean SIDS 1961-2000. Compiled using data from FAO, (2003).

Many studies conducted in the Caribbean have suggested that many species are overexploited such as Nassau groupers *Epinephelus striatus* (Callum, 2002), conch and lobster (Sturm, 1991). In addition, the pressure on the fisheries has been exacerbated by institutional failure and lack of management which are evident in many islands.

Poorly controlled fishing restrictions are affecting populations of species such as turtles and billfish (Laya and Weidner, 2001a). Islands such as St. Vincent, where whale watching is a marketed product of tourism local fishermen are permitted to hunt whales and other marine mammals (Laya and Weidner, 2001a). In most of the islands, nearshore resources such as the White Sea Urchins (*Diadema Spp.*) and various species of reef fishes are under considerable stress from predation and loss of habitats (Nicholson and Hartsuiker, 1983; UNEP, 1989; Aronson and Precht, 2001). There is a rise in demand for fish by the public, hotels and restaurants due to the thriving tourism sector (Pattullo, 1996). These demands have contributed to significant increases in exploitation and a significant fall in the population of some commercially important fish species and stock in general (Figure 2.9). This has also affected species such as groupers and turtles (Meyla, 1999).

One of the most widely expressed concerns about intensive fishing is that it can lead to imbalances in the ecosystem functions which can have ramifications on the overall community structure (Jennings and Kaiser, 1998; Pinnegar *et. al.*, 2000). Fishery removal can induce indirect or direct trophic interactions causing trophic cascading. As shown in Figure 2.10 tropic cascading in the Caribbean can promote reef degradation and epiphytes overgrowth. Figure 2.10 illustrates how cascade can occur when predators are being overfished. As the large predators decrease, the small pelagic increases. This increase resulted in the overgrazing of the zooplanktons and subsequent increase in the phytoplankton communities. The phytoplankton communities affect the reef due to overgrowth.

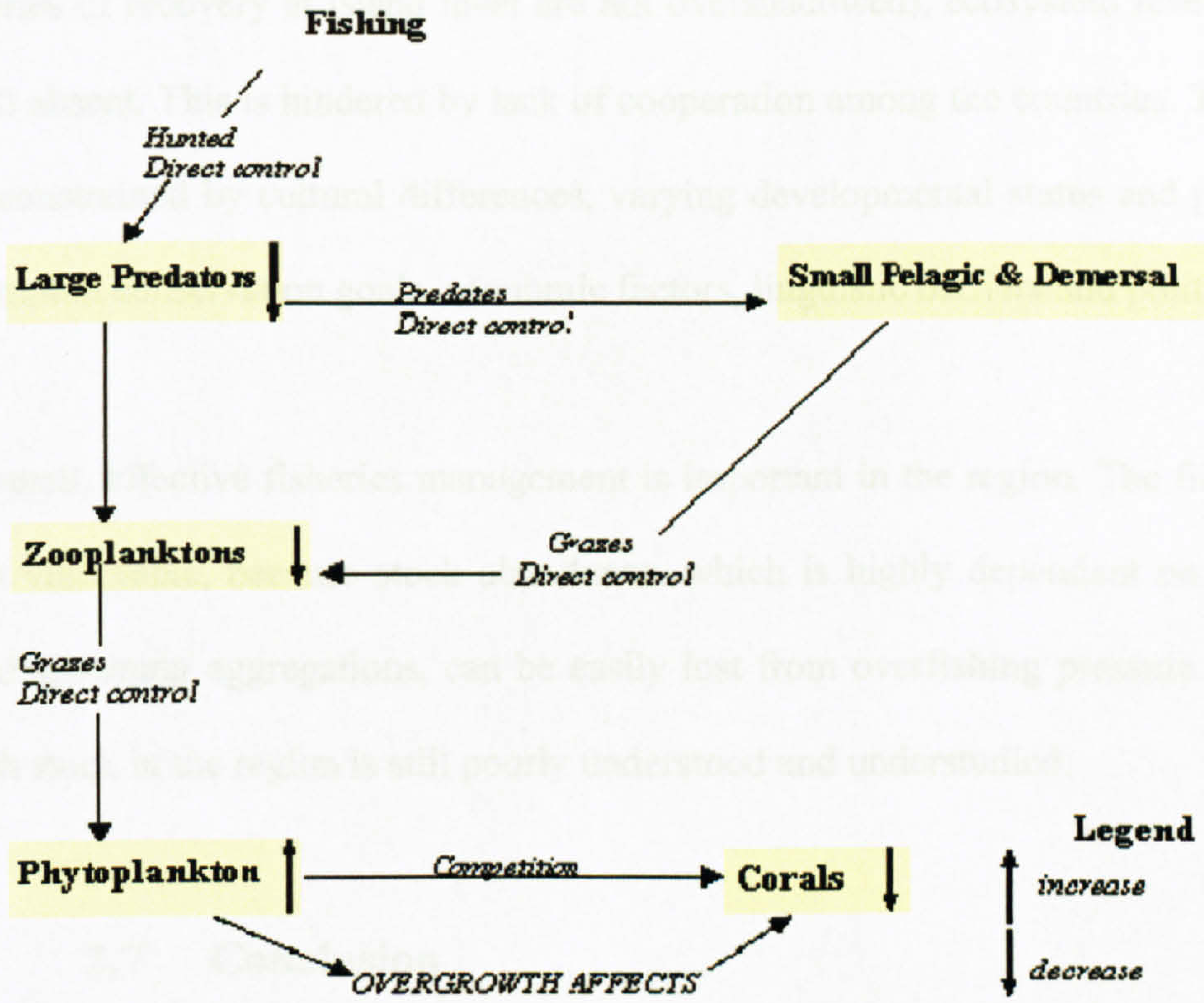


Figure 2.10: Conceptual Top-Down Control of Tropic Cascading in the Caribbean

In Jamaica, Lapointe *et. al.* (1997) found a strong correlation of cascading from overfishing in Discovery Bay which lead to increase macroalgae community and decline fringing coral reef. This was further demonstrated by Jennings and Kaiser (1998), who showed the effects of overfishing on the coral reef off the North Coast of Jamaica. Species protection can also induce trophic cascading. Stenneck (1998) noted that where large densities of predators are increased due to protection (e.g. in marine reserves), the prey population may decrease in a classic tropic cascade .

Overall, it is evident that the region's fisheries are under pressure, therefore a meaningful ecosystem management approach is vital to maintain a sustainable fisheries sector. Presently fisheries management in the region is still fragmented which has resulted in fisheries continued exploitation. Management is conducted in an ad-hoc manner and while some countries may have systems in place which has lead to recovery (these success stories of recovery at island level are not overshadowed), ecosystem level management is still absent. This is hindered by lack of cooperation among the countries. This co-operation is constrained by cultural differences, varying developmental status and priorities, lack of common conservation goals, economic factors, linguistic barriers and political differences.

Overall, effective fisheries management is important in the region. The fisheries resources are vulnerable, because stock abundance, which is highly dependent on habitat integrity and spawning aggregations, can be easily lost from overfishing pressure. Connectivity of fish stock in the region is still poorly understood and understudied.

2.7 Conclusion

This overview demonstrates that there are many pressures on the Caribbean Sea, which can have severe implications. Some of the issues discussed emanate mainly from the land based activities in the islands such as agro chemical pollution, while some issues such as hydrocarbon pollution are mainly from maritime traffic in the sea. Collectively, it is evident that these activities from both spatial locations are exerting enormous pressure on marine ecosystems and environment. High resource extraction in the fisheries sector is also affecting the sea's biodiversity.

Each island contributes to some or all of the problems in varying magnitude. The extent of each island contribution to these issues is driven by the islands economic, environmental and social status. Therefore, the focus of Chapter Three will be to investigate each island individually to determine their contribution to marine issues in the Caribbean Sea.

CHAPTER THREE

3.0 AN ENVIRONMENTAL AND ECONOMIC PROFILE ANALYSIS OF THE SIDS IN THE STUDY AREA

3.1 Introduction

Islands found in the Caribbean Sea are classified as Small Island Developing States (SIDS). These islands have common characteristics such as small landmasses, limited resources, vulnerable to anthropogenic activities and extreme natural disasters, fragile ecosystems and small undiversified economies. A closer examination of the individual islands' history, population dynamics and resources utilization and consumption patterns revealed that they are not homogenous. The islands differ in terms of the type and magnitude of environmental issues and economic and social development patterns. The examination of the economic and environmental profile of each island will foster further understanding of their role in the issues affecting the marine environment as discussed in the previous chapter. This will be explored in the following sections.

3.2 Description of the Islands

In Appendix One, a profile of each island is presented. The profile of each island contains a brief description of the physical characteristic and the economic, social and environmental issues related to the marine environment. The profiles also contain information regarding the various economic sectors (fisheries, energy, agriculture, urban, industrial and tourism) using literature and graphical charts for statistical representations of compiled data. The results of these profiles are summarised in Table 3.1. The information from these profiles is used as the basis for the system wide analysis developed in this chapter.

Table 3.1: Summary of the Economic Sectors and Environmental Issues in the Caribbean SIDS

COUNTRY	ECONOMIC ACTIVITIES	MAIN ECONOMIC SECTOR	LOCALISED COASTAL ISSUES
Aruba	Tourism, construction, oil refining, production of beverages and consumer goods	TOURISM	No information
Curacao	Oil refining, transhipment, container repairs, offshore banking, tourism	INDUSTRIAL (OIL REFINING)	Pollution (hydrocarbon) waste water, sewerage
Bonaire	Tourism, petroleum storage, rice refining and salt mining	TOURISM	Sedimentation, nutrient enrichment, sewerage
Trinidad and Tobago	Natural gas, tourism, manufacturing, energy (steel and iron carbide), agriculture, fisheries	ENERGY	Pollution (agrochemicals, hydrocarbon) sewerage, sedimentation
Grenada	Tourism, offshore financial industry, agriculture, fisheries	TOURISM	Pollution (solid waste, liquid waste, agrochemical, hydrocarbon) sedimentation, beach erosion,
St Vincent and the Grenadines	Agriculture, tourism, industrial (cement, furniture, sugar refining), offshore banking, ship registration, fisheries	AGRICULTURE	Pollution (solid waste, ship discharge, agrochemical) siltation, sewerage
Barbados	Offshore activities, agriculture, fisheries, tourism	TOURISM	Pollution (agrichemical, leacheate from landfill, wastewater)
St Lucia	Agriculture, offshore banking, tourism, manufacturing, fisheries	TOURISM	Pollution (agrichemical, hydrocarbon, industrial waste) sewerage, sedimentation
Martinique	Agriculture, fisheries, manufacturing, tourism, oil refining	TOURISM AND AGRICULTURE	No information
Dominica	Agriculture, eco tourism, manufacturing	TOURISM	Sedimentation, Pollution (industrial liquid waste)
Guadeloupe	Agriculture, tourism and manufacturing (light industry), fisheries	AGRICULTURE	Pollution (heavy metals, agrochemical, liquid waste, urban waste), sedimentation
Montserrat	Economy rebuilding and infrastructure reconstruction (volcano disaster),	No information	Sand mining on beaches
Antigua and Barbuda	Tourism, agriculture, industrial (light industry) manufacturing	TOURISM	Sewerage, sedimentation, huge coastal pressure
St Kitts and Nevis	Agriculture, tourism, manufacturing, offshore banking,	TOURISM	Pollution (hydrocarbon, agrochemical, solid waste), sweerage
Saba	Tourism, fisheries	TOURISM	Sedimentation, landfill leacheates
St Eustatius	Oil storage (transhipment), tourism, fisheries	TOURISM	Pollution (tourism related activities, hydrocarbon), sedimentation
St Marteen	Tourism, agriculture (local consumption), fisheries	TOURISM	Unplanned coastal settlement, sewerage, landfill leacheate
St Martin	Tourism	TOURISM	No information
Anguilla	Tourism, offshore banking, fisheries, industrial sector, agriculture	TOURISM	Sewerage, sedimentation, beach erosion
British Virgin Islands	Offshore company registration, tourism, agriculture, fisheries	TOURISM	Beach erosion, pollution (solid waste, liquid waste, industrial), sewerage
US Virgin islands	Tourism, manufacturing, petroleum refining, industrial	TOURISM	Pollution (Hydrocarbon) sedimentation, sewerage
Puerto Rico	Industrial, agriculture, construction, tourism	INDUSTRIAL	Pollution (industrial), sedimentation, beach modification
Dominican Republic	Agriculture, sugar refining, industrial, manufacturing, tourism	AGRICULTURE	Soil erosion, sedimentation, sewerage, Pollution (agrochemical, industrial), solid waste
Haiti	Agriculture, manufacturing, industrial, tourism	AGRICULTURE	Sedimentation, sewerage
Cuba	Agriculture, mining, fisheries, industrial, manufacturing, natural gas, tourism	TOURISM	Pollution (nutrient load, soild waste, hydrocarbon, heavy metal), sewerage, sedimentation
Cayman Islands	Offshore financial services, tourism	TOURISM	Pollution (urban, tourism), sewerage
Jamaica	Agriculture, tourism, fisheries, manufacturing, mining	TOURISM	Pollution (heavy metals, industrial, solid waste), sedimentation, sewerage.

(Note: This is a brief summary of each island, more detailed information is presented in Appendix One

3.3 Methodology

3.3.1 Types of Data

The study of the SIDS involved the use of two major data types, spatial and statistical data. Spatial data were used to produce maps for each island and to show the major features that influence the problems in the marine environment. These features include geographic location of capital city, shipping ports, refineries (if present), coral reef, sea grass ecosystems, and legally designated marine protected areas. Spatial data are used in this analysis of the islands to identify locations where the pressures on the marine environment are likely.

Statistical data (Economic Sectors) were used to analyse the economic sectors of each island. The activities in each sector that are most likely to have implications on the marine environment were used as indicators. For example, in the tourism sector, the frequency of cruises and the number of stay-over visitors and cruise passengers were used as indicators, as these have implications on the Caribbean Sea. An eleven-year period (1990-2000) was used for each indicator. The period 1990 to 2000 was chosen as a representative timescale of the current trends and future progression in the Caribbean area. In addition, documented data is more readily available for all the sectors, in this period. However, where deemed necessary other available datasets were consulted.

3.3.2 Data Collection

3.3.2.1 Spatial

To produce the spatial information, data were compiled from various sources as shown in Table 3.2.

Table 3.2: Metadata Information of Data used for Spatial Analysis. Refineries, cities, MPAs and ports are represented as points, the islands, coral reefs and seagrass as polygons

DATA THEME	SOURCE(S)	FORMAT	ATTRIBUTES
Islands	ESRI (2002)	Digital, but had to be customised for the each island	Compiled – names of islands, and total area
Refineries	Various literature including Dillion, (1995)	Digital data were compiled	Compiled – names of country and names of refineries
Legal Marine Protected Areas (MPAs)	Compiled database mainly from OAS, (1988) and Geoghegan *et. al* (2001)		Compiled – names of the MPAs, country location, class and total area (ha)
Coral Reef	UNEP/WCME, (2003)	Digital data provided but customised for this study	Recompiled from data created for analysis in Chapter Two
Seagrass	UNEP/WCMC, (2004)		
Cities	Various literature	Undefined city locations	Compiled – names of cities and islands
Ports	Various literature including World Seaport, (2003) and Fairplay, (1999)	Digital data compiled	Recompiled from data created for analysis in Chapter Two

3.3.2.2 Economic Sectors

Data were compiled to represent each economic sector in the SIDS. These are shown in Table 3.3.

Table 3.3: Economic Data used to represent the Sectors in the SIDS

SECTOR / YEAR / UNITS	INDICATOR	CODE	DATA SOURCE
POPULATION 1990-2000 (# of persons)	Total	TOT	FAO Statistical Database, (2004) and other Statistical Agencies
	Urban	URB	
	Rural	RUR	
FISHERIES 1990-2000 (Metric Tons)	Total Fisheries	TOF	FAO, (2004)
	Crustacean Mollusc, Cephalopods	CMC	
	Pelagic	PEL	
	Demersal	DEM	
AGRICULTURE 1990-2000 (Metric Tons)	Agricultural Area	AGL	FAO, (2004) and other Literature
	Fertilizer	FRT	
	Crop Production	CRP	
TOURISM 1990-2000 (# of persons)	Cruise Passengers	CRP	CTO, (2002) and other Statistical Agencies in the SIDS
	Cruise Ships	CRS	
ENERGY 1990-2000 (barrel/year)	Fossil Fuel Used	FFU	Energy Information Administration Database, (2003)
	Natural Gas Produced	NGP	
INDUSTRIAL 1990-2000 %	Industrial contribution as % of total GDP	IND	CDB, (2002) and other statistical Agencies

3.3.3 Data Analysis

3.3.3.1 Spatial

Data shown in Table 3.2 were mapped and inputted into ARC/GIS 8.3, which allowed for the manipulation and spatial analyses to be conducted. The procedures used in the spatial analyses are shown in Figure 3.1. The analyses show how coverages on various themes were derived by using examples.

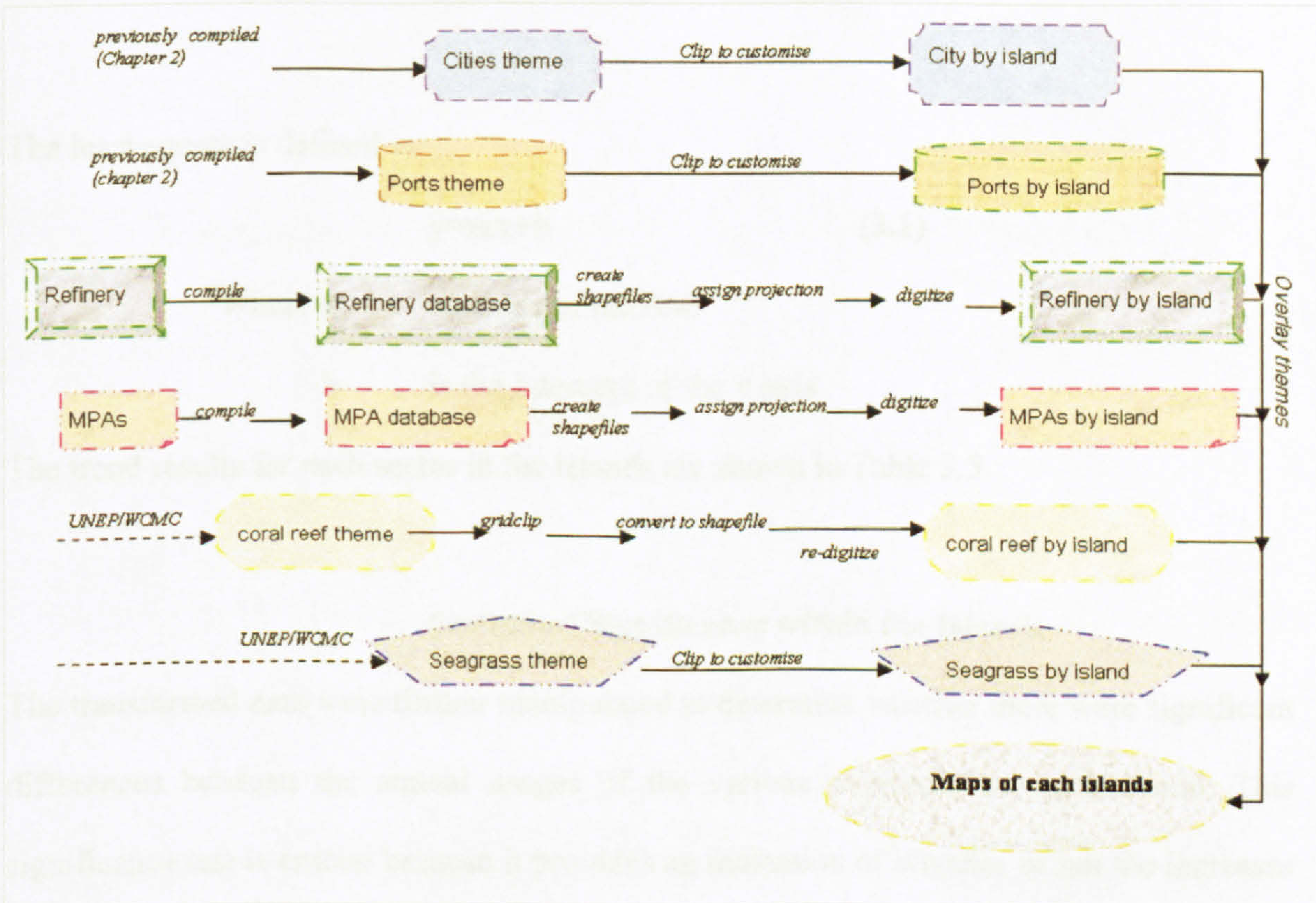


Figure 3.1: Simplified Diagrammatical Representation of GIS Data Manipulation This diagram shows some of the major procedure which were conducted to derived the maps.

The spatial data which were achieved from the analyses are presented as individual country maps, which form part of the islands' profiles presented in Appendix One. A comparative summary of the spatial data is presented in Table 3.4 and examples of spatial data.

3.3.3.2 Economic Sectors

(a) Comparison of Trends and Statistical Significance

Comparison of Trends within the Islands

The data shown in Table 3.3 were transformed into categories and inputted into Microsoft Excel and Minitab Statistical Software, where they were manipulated so that conclusions could be made for each island. Linear regression analysis using the least squares fit method (Zar, 2004) was used to ascertain the trends of the targeted variables for the period 1990 to 2000.

The least square is defined as:

$$y=mx+b \qquad (3.1)$$

Where m is slope of the line

b is the intercept of the y axis

The trend results for each sector in the islands are shown in Table 3.5.

Statistical Significance within the Islands

The transformed data were further manipulated to determine whether there were significant differences between the annual usages of the various resources for each island. This significance test is crucial because it provides an indication of whether or not the increases or decreases in the variables are very different among the years of the study period. To determine the significance, a number of procedures were followed which is diagrammatically represented in Figure 3.2, followed by an explanation of the tests employed.

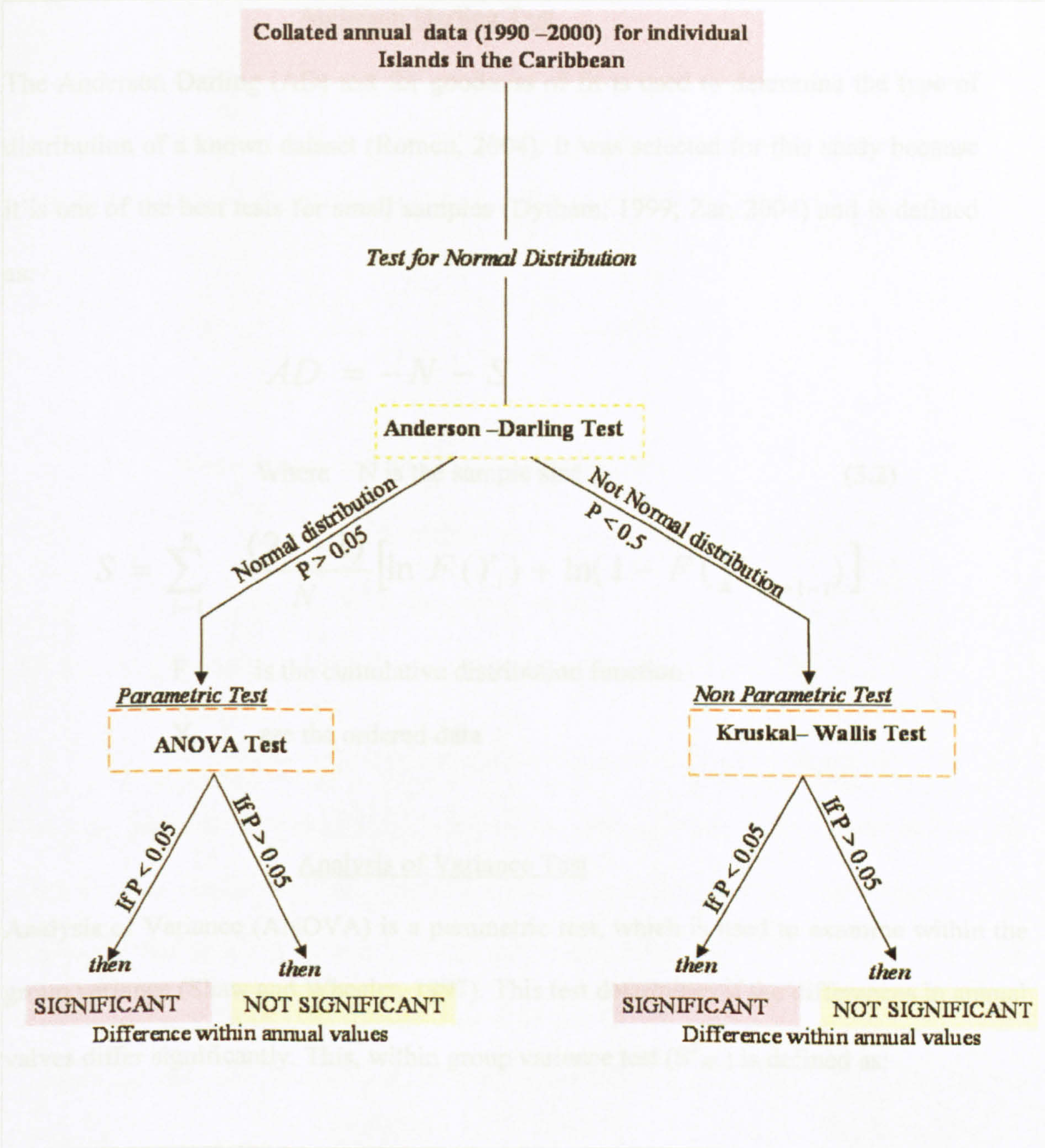


Figure 3.2: Decision Support Tree showing procedure used to test the Statistical Significance of annual resource usage for the various sectors in the islands. These statistical tests are explained in this chapter

Anderson Darling Test

The Anderson Darling (AD) test for goodness of fit is used to determine the type of distribution of a known dataset (Romeu, 2004). It was selected for this study because it is one of the best tests for small samples (Dytham, 1999; Zar, 2004) and is defined as:

$$AD = -N - S$$

Where N is the sample size **(3.2)**

$$S = \sum_{i-1}^{n} \frac{(2i-1)}{N} \left[\ln F(Y_i) + \ln(1 - F(Y_{N+1-i})\right]$$

F is the cumulative distribution function

Y_i are the ordered data

Analysis of Variance Test

Analysis of Variance (ANOVA) is a parametric test, which is used to examine within the group variance (Shaw and Wheeler, 1997). This test determines if the differences in annual valves differ significantly. This, within group variance test ($S^2{}_W$) is defined as:

$$s_w^2 = \frac{\sum_{j-1}^{k} \sum_{i-1}^{j} \left(X_{ij} - \bar{X}_j \right)^2}{n - k} \quad \textbf{(3.3)}$$

Where n is the total number of observation

k is the number of groups

$\bar{X}_j$ is the group mean

X_{ij} is the observations within each group

Kruskal Wallis Test

Kruskal Wallis (KW) is a non-parametric test which is applicable to 'not normally distributed' data (Shaw and Wheeler, 1997; Zar, 2004). This test uses interval data and is used for the 'not normally distributed' data in this study. KW is defined as:

$$KW = \left[\frac{12}{N_s(N_s+1)}\right]\left[\sum_{i=1}^{k}\frac{R_i^2}{n_i}\right] - 3(N_s+1) \qquad \textbf{(3.4)}$$

Where N_S is the total number of observation

n_i is the within the group data (annual values)

k is the number of groups

The results of the statistical significance tests are presented in Table 3.5.

(b) Inter – Island Comparison of Resource Utilisation

Data were analysed to determine and compare the average levels or the amount of resource usage between the islands. This type of analysis was used because it is informative of the measure of tendency (Shaw and Wheeler, 1997; Zar, 2004) and in this case, it can allow for comparison between the islands. The data for all the parameters (1990-2000) were analysed for resource comparison between the islands by calculating the mean for the following:

Population

1. Urban population

Fisheries

2. Marine production

Agriculture

3. Area under cultivation
4. Crop production by agriculture area
5. Fertilizer used by agriculture area

Energy

6. Fossil fuel consumption
7. Fossil fuel consumption per capita
8. Crude oil production

Industrial

9. GDP contribution by the industrial sector

Tourism

10. Number of cruise ship arrivals
11. Number of Passenger Arrivals

These values were then combined and presented graphically in Figures 3.5, 3.6, 3.7, 3.8, 3.9, 3.10, 3.11, 3.12, 3.13, 3.14, and Table 3.6 respectively.

(c) Comparison of Sectors in 1960 and 2000

To demonstrate the change of some economic sectors over time, the percentage changes between 1960 and 2000 were calculated for sectors where information is available. The results are shown in Tables 3.7, 3.8, 3.9 and 3.10.

(d) Grouping the Islands by Levels for the Economic Sectors

In order to determine the level of resource utilization, the islands were ranked by using parameters to represent each sector, which are:

Population	Mean Urban Population (1990-2000)
Fisheries	Mean Marine Fish Production (1990-2000)
Agriculture	Mean Agricultural Area (1990-2000)
Energy	Mean Fossil Fuel Usage (1990-2000)
Industrial	Mean Industrial Contribution (1990-2000)
Tourism	Mean cruise passenger arrival (1990-2000)
	Mean stay over visitors (1990, 1995, and 2000)

In order to rank the data into equal parts, the Percentile Ranked analysis (Zar, 2004) was applied to the derived mean of each of the above. The calculated percentiles were then assigned using the following ranking:

100 – 75% ⟶ High

74 – 26 % ⟶ Medium

25 – 0 % ⟶ Low

The derived calculations from the percentile ranking are shown in Appendix Two, and the results of the sectors are shown in Table 3.11

(e) Grouping the Islands by Spatially Normalised Sectoral Pressure

The above grouping has provided an indication of the scale of the economic sectors based on collective data for each island and is useful when comparing the levels. However, this assessment does not take into account the size of the islands; hence, the level of pressure exerted from certain sectors cannot be compared between islands and should be normalised. This is explored by using the economic data for the year 2000 and is done for the following sectors:

Cruise Tourism

Assuming that cruise passengers spend their time on the beaches and nearby coastal area, most of the pressure will be on the coastal area. The pressure (C) was calculated and defined as:

$$C = \frac{Q}{T} \times M \qquad \textbf{(3.5)}$$

Where Q is the total number of cruise tourist on given island

T is the coastline length (km)

M is the number of days per year (366)

Agriculture

The ratio of agricultural area to total land area can determine the scale of the spatial extent of the sector. The pressure of agriculture (A) on the island is defined by:

$$A = \frac{Ag}{Ta} \qquad \textbf{(3.6)}$$

Where Ag is the total area of agricultural land (sq. km)

Ta is the total land area (sq.km)

Fisheries

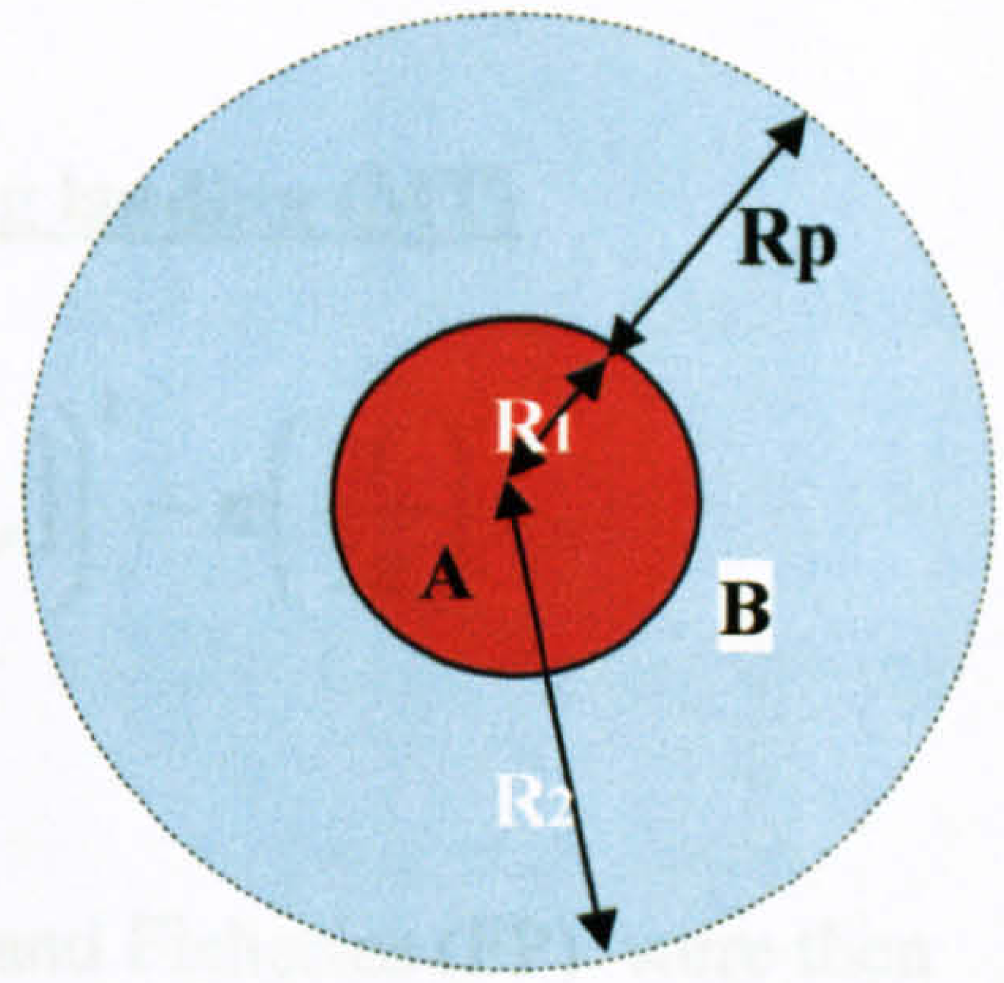
The calculation of the pressure exerted from fishing is challenging because the area of fishing and/or the exclusive fishing zones are not known. All the islands in the study area claimed 200NM, which in practice are impossible. In order to determine the approximate area of fishing in each island, analysis was conducted in GIS to determine whether the islands can claim 12, 24 or 200 NM, the maximum calculated spatial extent for each island is shown in Appendix Three. These values were then used to calculate the fishing pressure (FP), which is defined as:

$$FP = \frac{F}{Fa} \qquad \textbf{(3.7)}$$

Where F is the total fish landing (mt)

Fa fishing area (km)

To calculate **Fa**, the following assumptions were made



1. all the islands were assumed to be circular

2. the coastline lengths were used as perimeter values

3. the radius is calculated from the centre of the island

4. A is the island mass

5. B is the territorial waters that are allowed for each island from shoreline (fishing area)

The perimeter of the island (A): $\pi D = 2\pi R_1 = coastline \ (d)$ **(3.7.1)**

therefore $R_1 = \frac{d}{2\pi}$

The Perimeter of fishing area (B): $\pi D = 2\pi R_2$ **(3.7.2)**

where $R_2 = R_1 + Rp$ **(3.7.3)**

and Rp is the territorial claim (km)

substituting R_1 with $\frac{d}{2\pi}$ into (3.7.3)

therefore $R_2 = \left[\left(\frac{d}{2\pi}\right) + \left(R_p\right)\right]$ **(3.7.4)**

Therefore, Fishing Area (B) = total area – area A

where total area $= \pi \left[R_2\right]^2$

area A is the area of the islands $\pi \left[R_1\right]^2$

Fishing Area (B) = $\left[\pi(R_2)^2\right] - \left[\pi(R_1)^2\right]$ **(3.7.5)**

Substituting R_2 with $\left[\left(\frac{d}{2\pi}\right) + \left(R_p\right)\right]$; Substituting R_1 with $\frac{d}{2\pi}$

Fishing area (B) = **Fa** $= \pi\left(\left[\frac{d}{2\pi}\right] + \left[R_p\right]\right)^2 - \pi\left(\frac{d}{2\pi}\right)^2$ **(3.7.6)**

Therefore fishing pressure FP $= \frac{F}{Fa} = \frac{\text{total fishing landing (MT)}}{\pi\left(\left[\frac{d}{2\pi}\right]+\left[R_p\right]\right)^2 - \pi\left(\frac{d}{2\pi}\right)^2}$

The data values obtained for the tourism (C), agriculture (A) and Fisheries (FP) were then ranked into equal parts using the Percentile Ranked analysis (Zar, 2004). The calculated percentiles were then assigned a level based on the ranking shown previously (page 62). The derived levels of pressure are shown in Table 3.12 and the calculations are shown in Appendix Four.

(f) Coastal Pressure from Cruise Passengers

The same procedure used to calculate spatial pressure from cruise tourism (page 59) was used to calculate the coastal pressure for years 1990, 1995 and 2000. This was done to compare the change in spatial pressure from the cruise population in the 1990s. This is shown in Figure 3.15.

(g) Fishing Pressure vs. Affluence

Chapter Two highlighted the declining fisheries stock in the region. In an attempt to determine if consumption and level of development in the islands are contributing to this decline, three islands were used as a sample. A comparison was made by analysing the per capita consumption of seafood, per capita production of marine products and standard of living (measured by the Human Development Index -HDI)[19]. The three islands which were selected have different levels of HDI according to UNEP ranking (UNDP, 2005). These islands were Barbados (high HDI), Jamaica (medium HDI Index) and Haiti (low HDI). The per capita marine consumption and production were calculated for a five-year interval (1975-2000) and compared with the HDI for the corresponding year. The results for Barbados, Jamaica and Haiti are shown in Figures 3.16, 3.17 and 3.18 respectively.

[19] Human Development Index is used by international development agencies like UNEP. HDI ranks the level of development in a country. It is calculated by measuring standard of living, adult literacy and life expectancy at birth. The HDI method classifies countries as high, medium or low and was developed by UNDP.

3.4 RESULTS

3.4.1 Spatial

The maps in the island profile (Appendix One) show the spatial distribution of major habitats and other features, which are summarised in Table 3.4 and Figures 3.3 and 3.4.

Table 3.4: A Summary of the Spatial Analysis conducted for each island in the Study Area. A Map of each island showing the locations of these attributes is presented in Appendix One. LO = Location, TOT = Total, NI =no information

Islands	Cities (LO)	Ports (TOT)	Refinery (TOT)	MPA (TOT)	Reef	Seagrass
Aruba	CS	3	1	1	yes	yes
Curaçao	CS	4	1	1	yes	no
Bonaire	CS	6	0	2	yes	yes
Trinidad & Tobago	CS	11	1	7	yes	yes
Grenada	CS	3	0	1	yes	yes
St Vincent & Grenadines	CS	3	0	NI	yes	yes
Barbados	CS	44	0	1	yes	yes
St Lucia	CS	4	0	3	yes	yes
Martinique	CS	2	1	1	yes	yes
Dominica	CS	1	0	2	yes	yes
Guadeloupe	CS	2	0	NI	yes	yes
Montserrat	CS	1	0	1	no	yes
Antigua & Barbuda	CS	1	0	3	yes	yes
St Kitts & Nevis	CS	2	0	0	yes	yes
Saba	CS	1	0	1	yes	yes
St Eustatius	CS	1	0	0	yes	yes
St Marteen/St Martin	CS	1	0	NI	yes	yes
Anguilla	CS	1	0	4	yes	no
British Virgin Islands	CS	2	0	3	yes	yes
US Virgin Islands	CS	6	1	5	yes	yes
Puerto Rico	AO	15	2	3	yes	yes
Dominican Republic	CS	11	2	10	yes	yes
Haiti	CS	3	0	0	yes	yes
Cuba	AO	32	3	16	yes	yes
The Cayman Islands	CS	3	0	4	yes	yes
Jamaica	CS	15	1	4	yes	yes

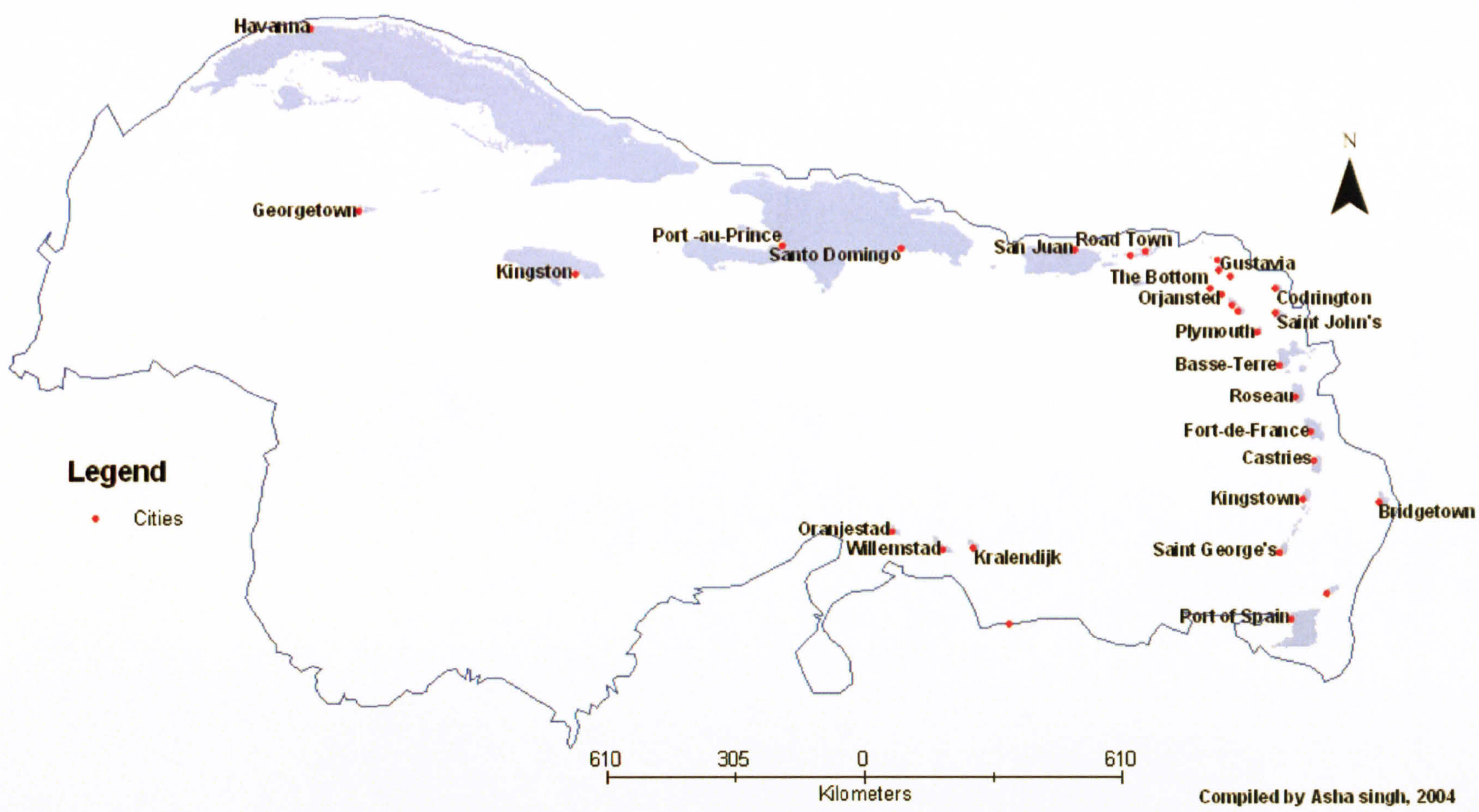


Figure 3.3: A Map showing the location of the Capital Cities in the SIDS. All the cities are coastal based and many are in close proximity to the Caribbean Sea. Compiled from various sources

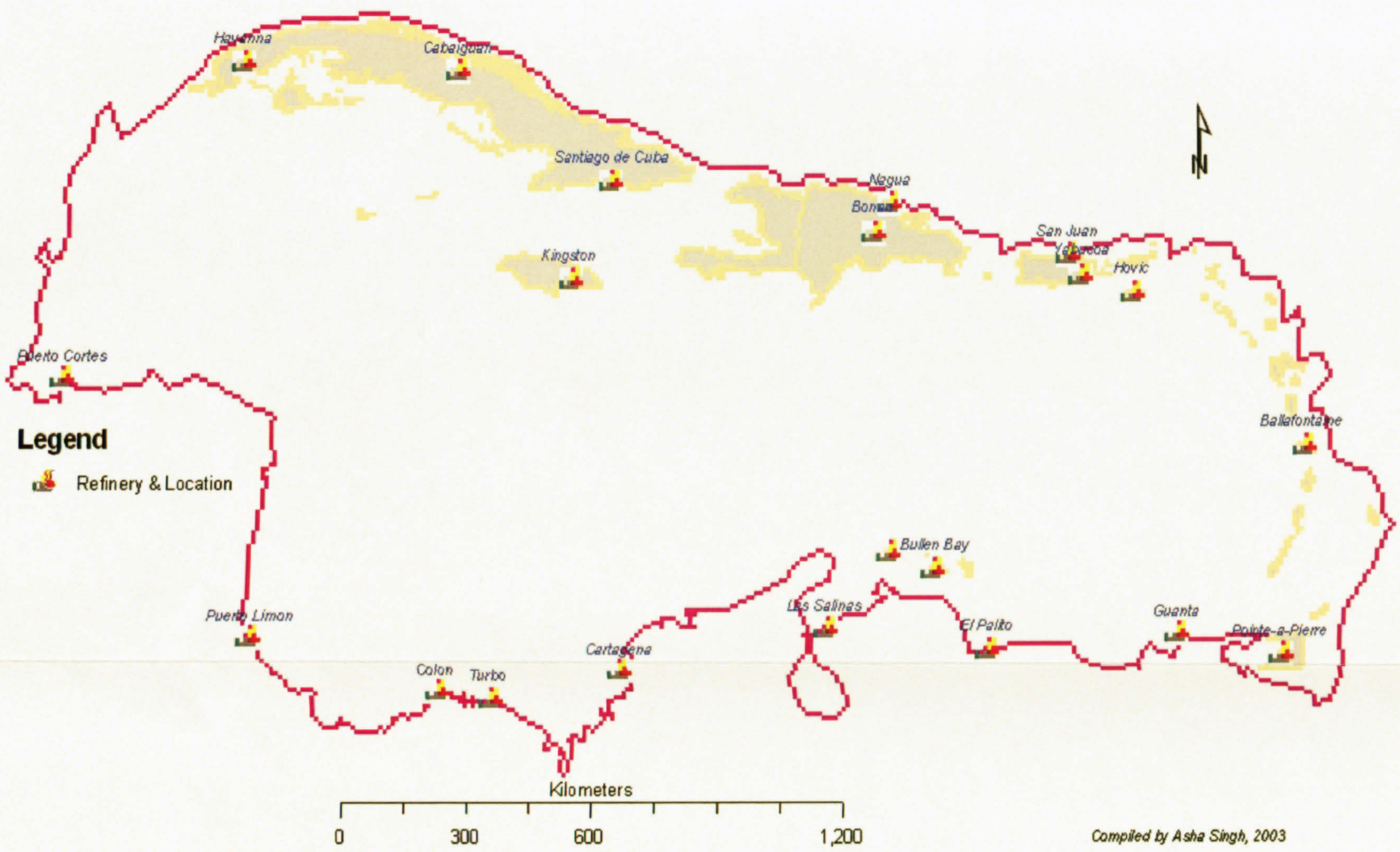


Figure 3.4: A Map showing the location of the refineries in the Caribbean. Most of the refineries are in southern area of the Sea in Latin American countries. Compiled using data from Dillion, (1995) and various other sources

3.4.2 Economic Sectors

(a) Comparison of Trends and Statistical Significance

The results of the inter-annual comparison of the trends and statistical significance in the islands showed differences in the islands. The results are further displayed in Table 3.5 and subsequently explained.

Table 3.5: Comparison of Trends and Statistical Significance within the Islands. TOT = total, URB = urban, RUR = rural, TOF = total fisheries, CMC = crustacean, mollusc, cephalopod, PEL = pelagic, DEM = demersal, AGL = agricultural area, FRT = fertilizer, CRP = crop production, CRP = cruise passengers, CRS = cruise ships, FFU = fossil fuel, NGP = natural gas produced, IND = industrial contribution as % of total GDP.

Island	POPULATION			FISHERIES				AGRICULTURE			TOURISM		ENERGY		INDSTRIAL
	TOT	URB	RUR	TOF	CMC	PEL	DEM	AGL	FRT	CRP	CUP	CRS	FFU	NGP	IND
Aruba	↗	↗	↗	↘	ND	↘	↗	→	↗	ND	↗	↗	↗	NR	* ↗
Curaçao	↘	ND	ND	ND	ND	ND	ND	ND	ND	ND	↗	↘	ND	NR	ND
Bonaire	↗	ND	ND	ND	ND	ND	ND	ND	ND	ND	↗	↘	ND	NR	ND
Trinidad & Tobago	↗	↗	↘	↗	↘	↘	↗	↗	↗	↘	↗	ND	↗	↘	* ↘
Grenada	↘	↗	↘	↘	↗	↗	↗	↘	ND	↘	↗	↘	↗	NR	* ↗
St Vincent & Grenadines	↗	↗	↘	↗	↘	↗	↘	→	↗	↘	↘	↗	↗	NR	* ↘
Barbados	↗	↗	↘	↗		↗	↘	→	↗	↘	↗	↘	↗	↗	* ↘
St Lucia	↗	↗	↗	↗	↗	↗	↗	↘	↘	↘	↗	↗	↗	NR	* ↘
Martinique	↗	↗	↘	↗	↗	↗	↗	↘	↘	↗	↘	↘	↗	NR	ND
Dominica	↗	↗	→	↗	↗	↗	ND	↘	↘	↘	↗	↗	↗	NR	* ↗
Guadeloupe	↗	↗	↘	↗	↗	↗	ND	↘	↗	↗	* ↗	↘	↗	NR	ND
Montserrat	↘	→	↘	↗		ND	ND	→	ND	↗	ND	ND	↗	NR	* ↘
Antigua & Barbuda	↗	↗	↗	↗	↗	ND	ND		ND	↘	↗	↘	↗	NR	* ↘
St Kitts & Nevis	↗	↘	↗	↗	↘	↗	↗	↘	↗	↗	↗	↘	↗	NR	* ↘
Saba	↗	ND	ND	ND	ND	ND	ND	ND	ND	ND	↗	↘	ND	NR	ND
St Eustatius	↗	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	↘	ND	NR	ND
St Marteen	↗	ND	ND	ND	ND	ND	ND	ND	ND	ND	↗	↘	ND	NR	ND
Anguilla	↗	↗	NR	↘	↘	ND	ND	ND	ND	ND	↗	ND	ND	NR	↗
B Virgin Island	↗	↗	↘	↘	↘	↗	↗	→	ND	↗	↗	↘	↗	NR	* ↘
US Virgin Island	↗	↗	↗	↘	↘	ND	↗	↘	↘	ND	↗	↘	↗	↗	ND
Puerto Rico	↗	↗	↘	↗	↗	↗	↗	↘	ND	↘	* ↗	↘	↗	NR	ND
Dominican Republic	↗	↗	↘	↘	↘	↘	↘	↗	↗	↘	* ↗	ND	↗	↗	ND
Haiti	↗	↗	↗	↗	↘	ND	ND	↘	↗	↘	ND	ND	↗	NR	ND
Cuba	↗	↗	↘	↘	↗	↘	↘	↘	↘	↘	ND	ND	↘	↗	ND
Cayman Island	↗	↗	NR	↗	ND	ND	ND	→	ND	↗	↗	↗	↗	NR	* ↗
Jamaica	↗	↗	↘	↘	↗	↗	ND	↗	↗	↘	↗	↗	↗	NR	↘

Explanation of Significant Test

Significant	There is a significant difference between the annual values ($P < 0.05$)
Not Significant	There is not a significant difference between the annual values ($P \geq 0.05$)

Other Explanation

* Analyses are based on less than 11 years dataset
ND No data
NR Not relevant

Explanation of Trends

↘ Shows a decreasing trend where m is a negative value e.g. $y = -2.7781x + 409340$

↗ Shows a increasing trend where m is a negative value e.g. $y = -2.7781x + 409340$

→ Shows no trend movement as values are constant

Note: The gradient of the arrows does not imply levels of increase or decrease
The annual values for each island in each group are presented in graphs in the CD provided

Population

All the islands have demonstrated total population increases except Montserrat, Grenada and Curaçao. In Montserrat, the data suggest a migration movement out of the island, which is likely to be as a direct consequence of the eruption of the volcano in 1996. Curaçao has a declining population. It is likely that economic decline in the refining industries (Appendix One Curaçao) may have contributed to this migration out of the island. Comparison of migration data from the Central Bureau of Statistics (2004b) showed that Curaçao has the highest migration rate within the Dutch dependent islands of the Caribbean. All the islands showed a significant difference in the population increases or decreases except Saba and St Eustatius. In these two countries, the population increases are not significant.

The urban population exhibits an increasing trend in all the islands except Montserrat and St Kitts and Nevis. This trend in St Kitts and Nevis may be as a result of the urban areas been replaced by tourism infrastructure. Many of the population maybe selling their leasehold and moving to the rural areas where agricultural areas are transformed to other development. In 2001, the Department of Environment reported that most of the sugar cane areas on the flat coastal areas are replaced by development projects without the guidance of land use plan (Department of Environment, 2001). This explains the ruralization of St Kitts and Nevis shown from the analysis of the data. This trend exhibited in St Kitts and Nevis is likely to reverberate throughout the islands as more economies move to larger tourism based development. In Grenada, the urban population has increased while the rural population has declined. This growth indicates that that the rural population is moving to the urban centres or migrating from Grenada.

Fisheries

Thirteen of the twenty-one islands where data are available showed an increasing trend in total marine fisheries production, although these increases may be very small. This indicates the increased extraction of the fish stock by the islands which may be due to increase in fishing efforts. Another reason could be the upgrading of fishing equipment such as, gears, boats and engines (Laya and Weidner, 2001a), which allows fishermen to fish beyond the traditional areas or more efficiently in nearby areas.

In terms of total recorded catch, Trinidad, Barbados, Martinique, Dominica, Guadeloupe, Antigua, Puerto Rico and Haiti showed significant annual increases. St Lucia, Montserrat, St Vincent and the Grenadines and the Cayman Islands also showed increases in total marine production. However, these annual increases are not significant. Cuba's total marine production has shown a declining trend, this decline between the years is statistically insignificant, hence indicating a still vibrant sector.

In terms of pelagic fisheries, Grenada, Barbados, St Lucia and Guadeloupe have shown an increasing trend and significant annual increases in this sector. In contrast, Trinidad and Tobago, Aruba, Dominican Republic and Cuba have shown a decreasing trend in the landings of pelagic fishes.

Trinidad and Tobago and Dominican Republic have shown significant decreases in the crustacean, mollusc and cephalopod (CMC) group. In contrast, Guadeloupe, Jamaica and Cuba showed a significant increase in this group (CMC). This significant increase may indicate that stocks in this group are highly fished in these countries. It is known that production emphasis in Cuba has shifted from high volume, low valued pelagic stocks to high valued nearshore fisheries (Adams, 1998). The significant decreases in Trinidad and Tobago and Dominican Republic may indicate a decline in the abundance of these species.

Overall, only St Lucia, Martinique, Dominica and Guadeloupe have shown increasing trends in all the fish sub groups and this may be an indication of growing fisheries sectors in these islands.

Agriculture

Land area, fertilizer usage and crop productions vary between the islands. All the islands have a decreasing trend in agricultural land (number of hectares) with the exception of Trinidad and Tobago, Dominican Republic and Jamaica. However, despite the increasing trend in agricultural land area in these three islands, the crop outputs are decreasing. Simultaneously, the amounts of fertilizer used have increased. This increasing trend in fertilizer usage and decreasing output may indicate decline in soil quality. This poor soil quality has been highlighted in Jamaica. Poor land management and soil loss were identified as important issues in that country (NRCA, 2001).

The increase in agricultural land area in islands like Dominican Republic and Jamaica may have been caused by the intrusion onto forested areas. It is known that Jamaica's forest is rapidly decreasing (Tole, 2001). According to Weis (2000), Jamaica has one of the highest rates of deforestation in the world. Grenada has progressively lost agricultural areas in the period studied (Appendix One). This decrease in Grenada could be a result of land being taken up by other sectors particularly tourism and larger urban population.

St Lucia, Dominica and Cuba indicate a decreasing trend in agricultural land, fertilizer use and crop production. This decrease may suggest an overall reduction in the agricultural sector in these three islands. Fertilizer usage has increased in Guadeloupe and St Kitts and Nevis, although the land areas have decreased. Crop production in Guadeloupe and St Kitts and Nevis exhibited increasing trends, which may be a reason for the increased fertilizer uptake (to boost crop production).

Although Haiti has shown a decreasing trend in agricultural land area and crop production, an increasing trend in fertilizer usage has been recorded. The increase fertilizer usage may be used to supplement the poor soil fertility. Poor soil and large scale degradation are cited as the main reason for decline in land productivity (Ministère De L'Environnement, 2001). Haiti is among the most deforested countries in the world (refer to Appendix One pg. 368 for more on Haiti's land degradation).

Tourism

There is an increasing trend in cruise passenger arrivals in all the islands except Martinique and St Vincent and Grenadines. The decrease in cruise passengers in St Vincent and the Grenadines may partly due to an implementation of a head tax of US$7.50 (part of an environmental levy) on cruise passengers visiting the island. This was implemented in the latter part of the 1990s. Many cruise companies boycotted this measure by removing St Vincent and the Grenadines as a destination. In 2001, the government lowered the head tax in an attempt to attract more cruise ships and to improve the competitiveness of the destination. The Caribbean Tourism Organisation proposed this head tax but many countries did not support this measure, mainly out of fear of reduced visitors arrival as seen in the case of St Vincent (refer to Appendix Five pg. 384 for interviews and excerpts on this issue).

Most of the islands show a decreasing trend in the number of cruise ships. This decrease could be due to larger ships being used in the cruise industry. Overall, the analyses conducted for the tourism sector have shown a growing sector further justifying that tourism is an important sector in the SIDS.

Energy

Barbados, St Lucia, Martinique, Dominica, Cayman Islands and US Virgin Islands have shown insignificant increases in fuel usages. However, all the other islands have exhibited a significant increase in the annual consumption for the data period.

Cuba is the only country, which has a declining trend in fossil fuel usage, and it is likely that the isolation of its economy (partly from US blockade and trade sanctions) is dictating the amount of fossil fuel imports. Grenada and Montserrat showed an increasing trend in fuel consumption despite a declining population trend. Particularly, Montserrat whose population was nearly halved by the volcanic eruption showed an increase in energy consumption. The reconstruction process that followed the volcano disaster is the possible cause for this continued increasing fuel usage.

(b) Inter –Island Comparison of Resource Utilisation

The results of the inter-island comparison by sectors are described below.

Population

Most of the islands have a higher proportion of their total population living in urban areas, as shown in Figure 3.5, and in some islands, the entire population is urban, as in the case of the Cayman Islands and Anguilla. Montserrat has the lowest urban population caused by the volcano eruption in 1998.

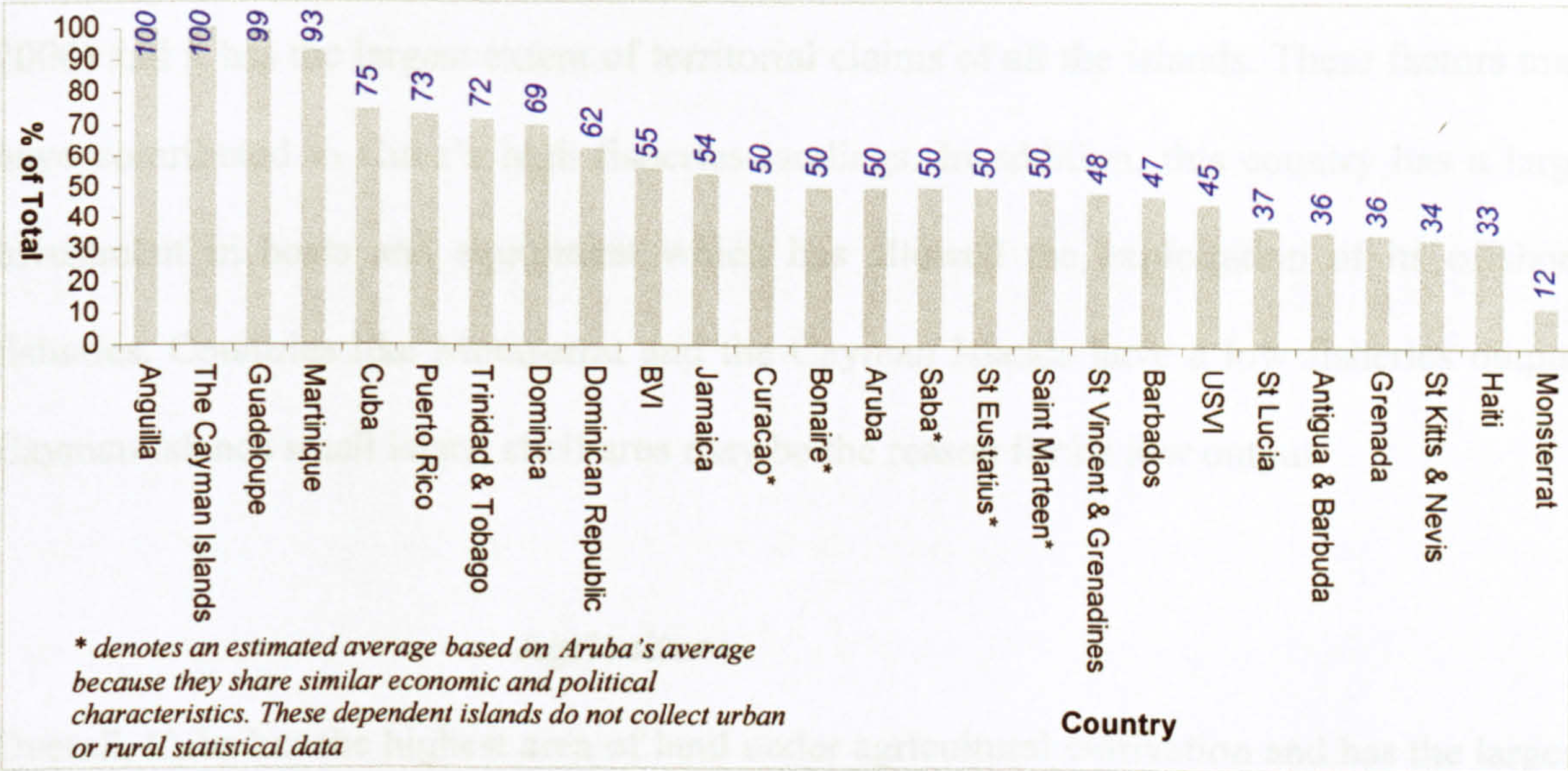


Figure 3.5: Average Urban Population 1990-2000. Compiled using data from FAO, 2004 and other statistical agencies

Fisheries

As shown in Figure 3.6 Cuba records the highest marine fish production. This is followed by Trinidad and Tobago and St Vincent and the Grenadines. Montserrat recorded the lowest of the islands.

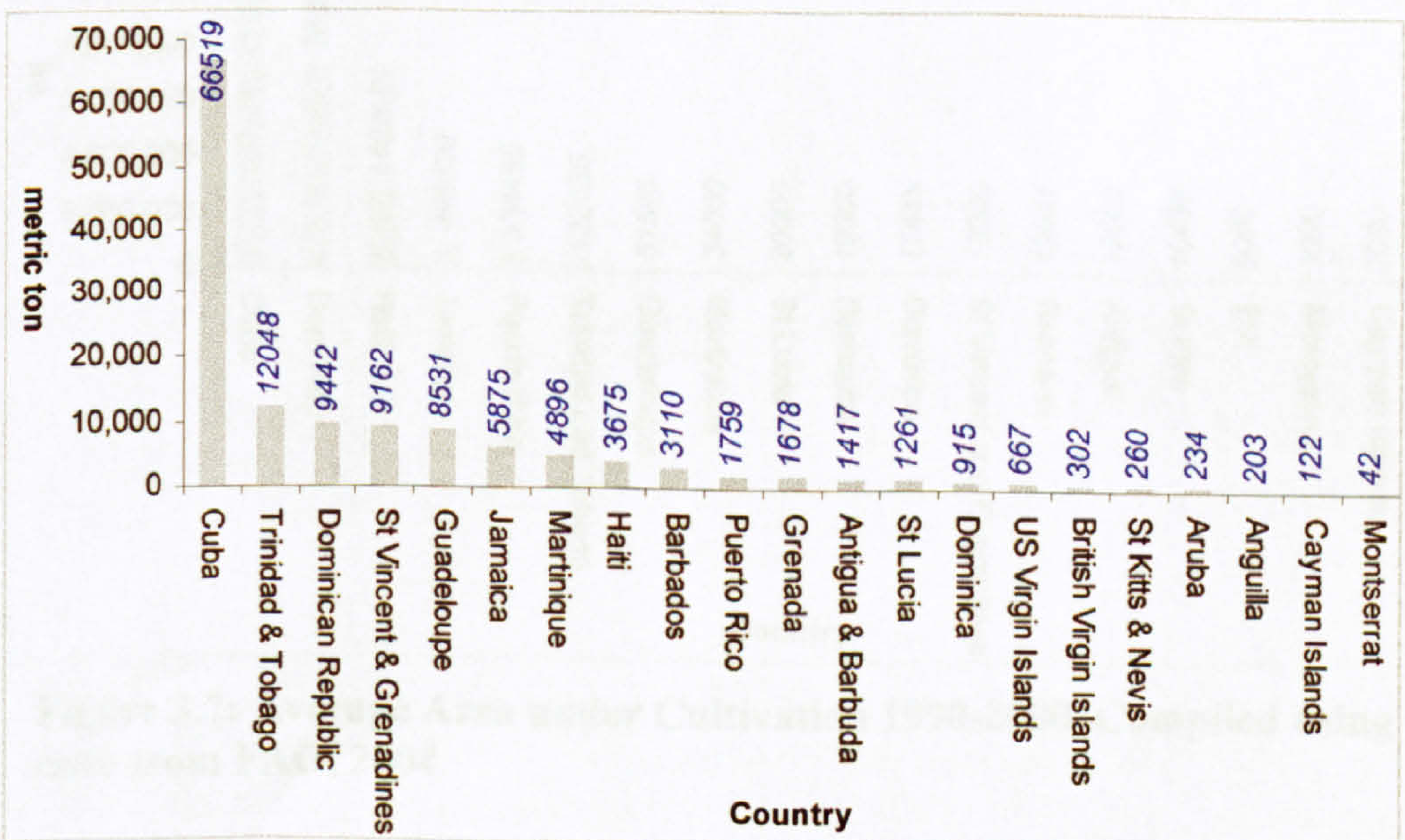


Figure 3.6: Average Marine Production 1990-2000. Compiled using data from FAO, 2004

Cuba has a large-scale commercial fisheries sector including longline fleet (Adams *et. al.*, 2000) and it has the largest extent of territorial claims of all the islands. These factors may have contributed to Cuba's high fisheries landings. In addition, this country has a large investment in boats and equipment which has allowed the exploitation of its offshore fisheries. Countries like Montserrat and the Cayman Islands have a low fisheries output. Cayman Islands small island shelf area may be the reason for its low output.

Agriculture

Overall, Cuba has the highest area of land under agricultural cultivation and has the largest decline in agricultural areas in the period examined (refer to Appendix One, Cuba profile). The Dominican Republic and Haiti are the other islands with large land area as shown in Figure 3.7. Cayman Islands and Aruba have the lowest agricultural area. These islands have karstic soils, which may have restricted agricultural activities.

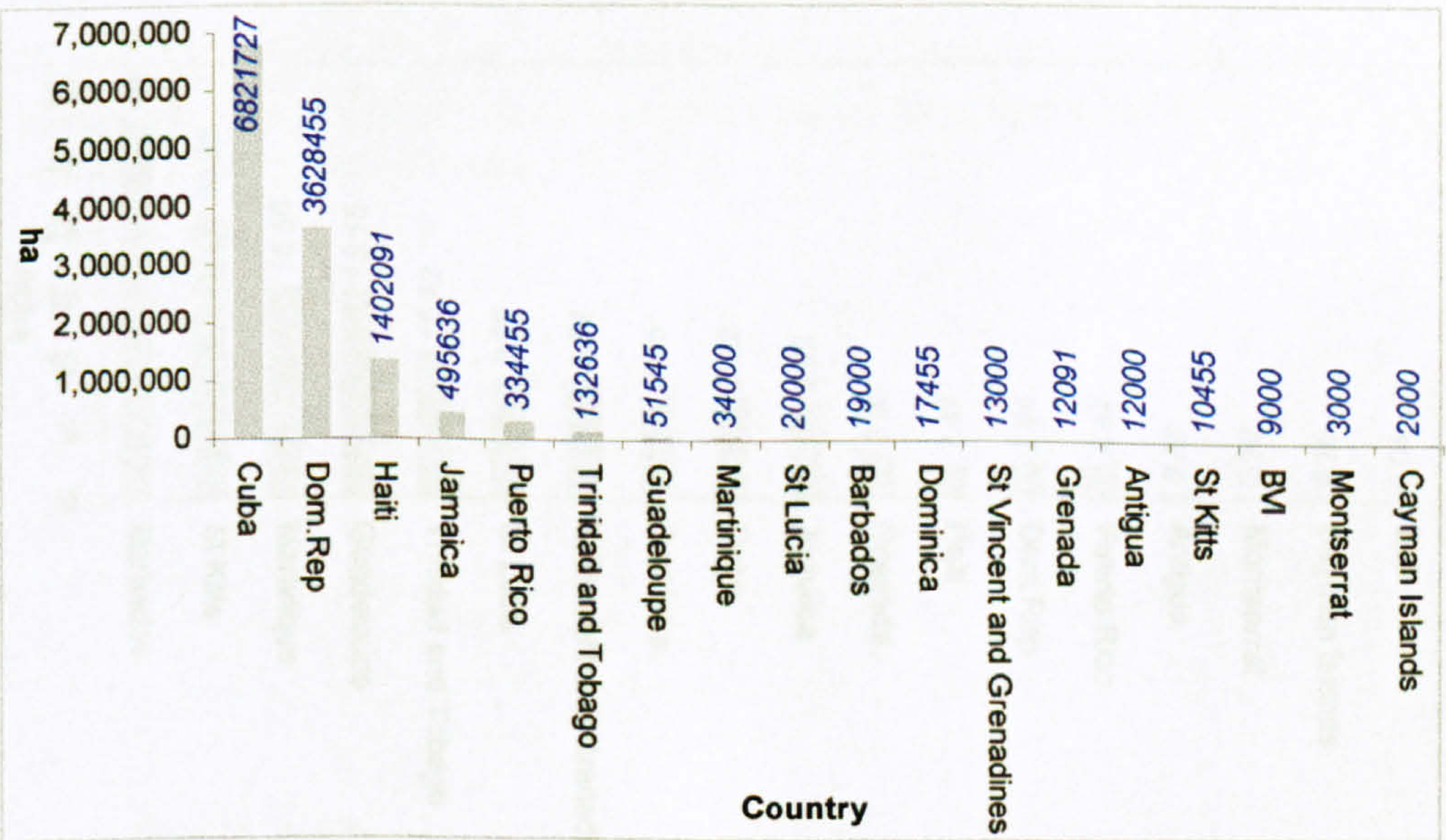


Figure 3.7: Average Area under Cultivation 1990-2000. Compiled using data from FAO, 2004

The smaller islands in the study area seem to be more efficient, in terms of production per hectare, as shown in Figure 3.8. Barbados on average produced twenty- seven metric tons per hectare, while the Cayman Islands managed less than one metric ton per hectare. These extreme differences between these two islands maybe due to the type of crops grown and the soil geology. Barbados has the highest production per hectare, when it is compared to other sugar cane cultivating islands such as Cuba and Trinidad. Both of these islands have lower average yields, as shown in Figure 3.8. Land use management varies within the islands, which influence the differences in the yield per land area. Haiti, which has suffered from large-scale deforestation, has similar yields to its neighbours, the Dominican Republic and Puerto Rico.

The types of crops grown vary slightly in each island. However, rice (*Oryza sativa*), sugar cane and bananas (*Musa spp*) are the main crops grown in the agricultural oriented economies. Vegetables and tubers are grown in almost all the islands.

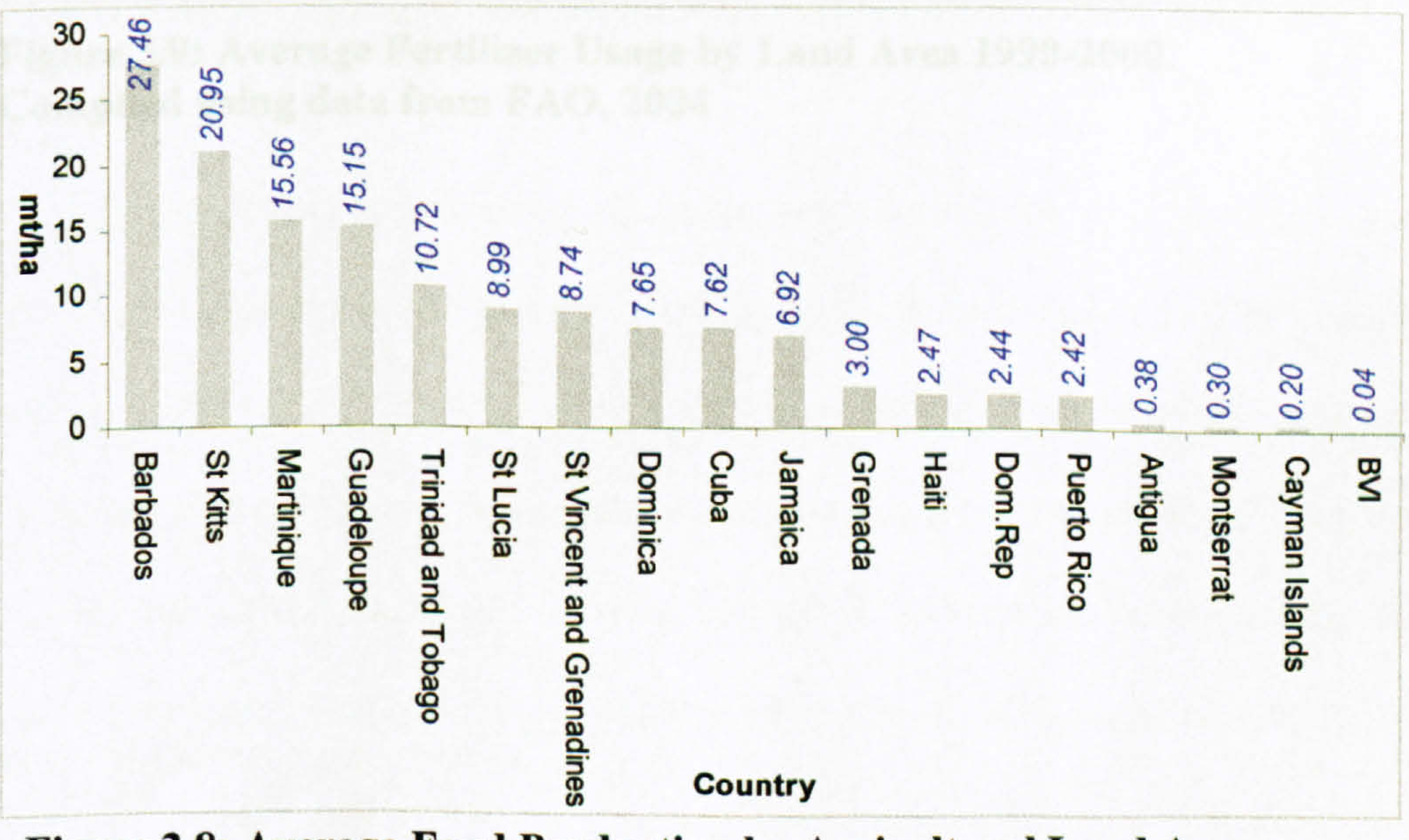


Figure 3.8: Average Food Production by Agricultural Land Area 1990-2000. Compiled using data from FAO, 2004

Fertilizer usage on the islands also varies. Although Cuba is the highest fertilizer user Martinique consumes the most fertilizer per hectare when compared with any of the islands, as shown in Figure 3.9. Barbados uses less fertilizer per hectare although it has the highest production efficiency. Dominican Republic uses more fertilizer than Haiti although the production per hectare is similar.

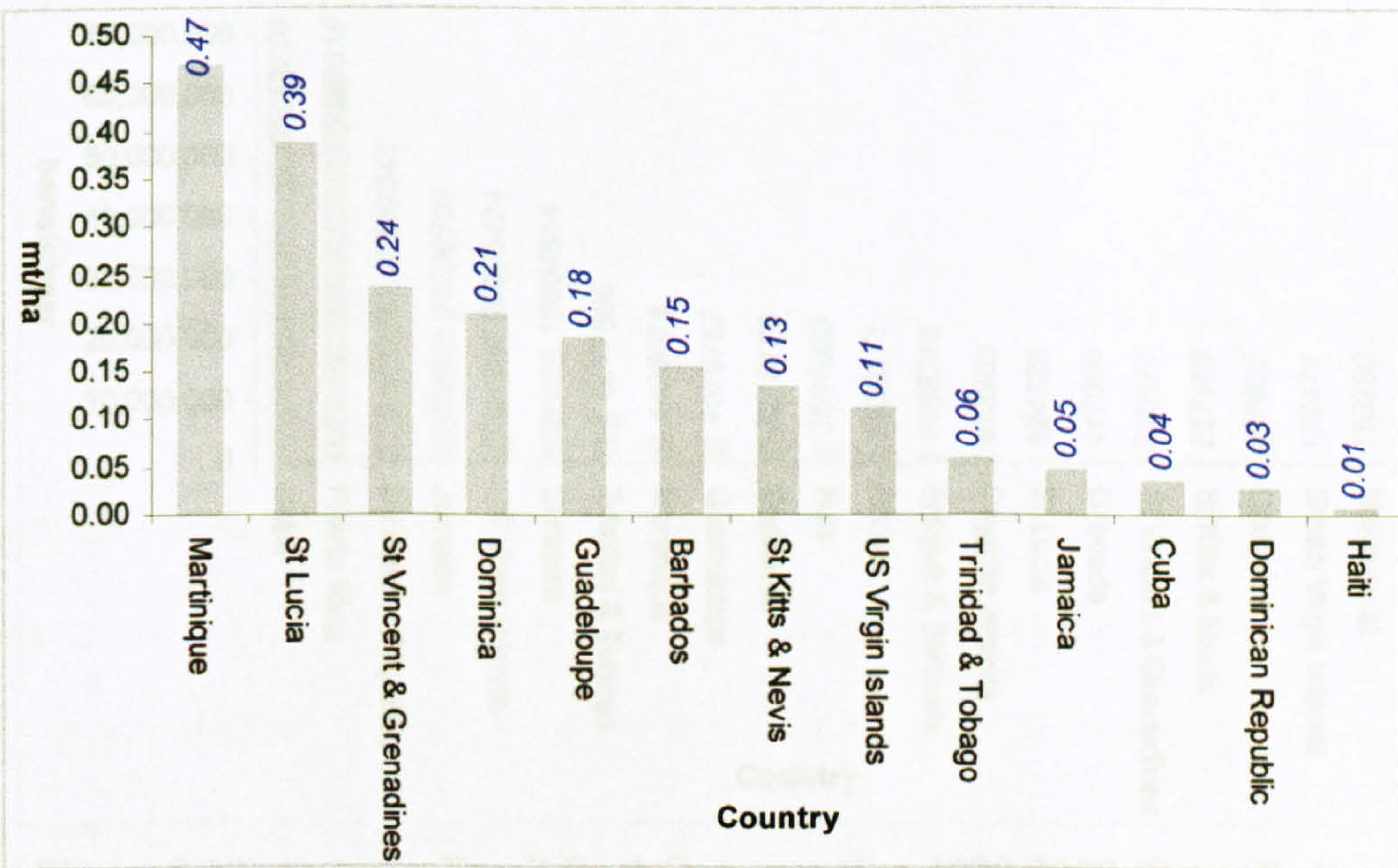


Figure 3.9: Average Fertilizer Usage by Land Area 1990-2000. Compiled using data from FAO, 2004

On average, Cuba consumes the most fuel in the eleven-year period (1990-2000), followed closely by Puerto Rico, as shown in Figure 3.10. These high fuel usages may be the result of the high population in these islands. Montserrat recorded the lowest average for the data period.

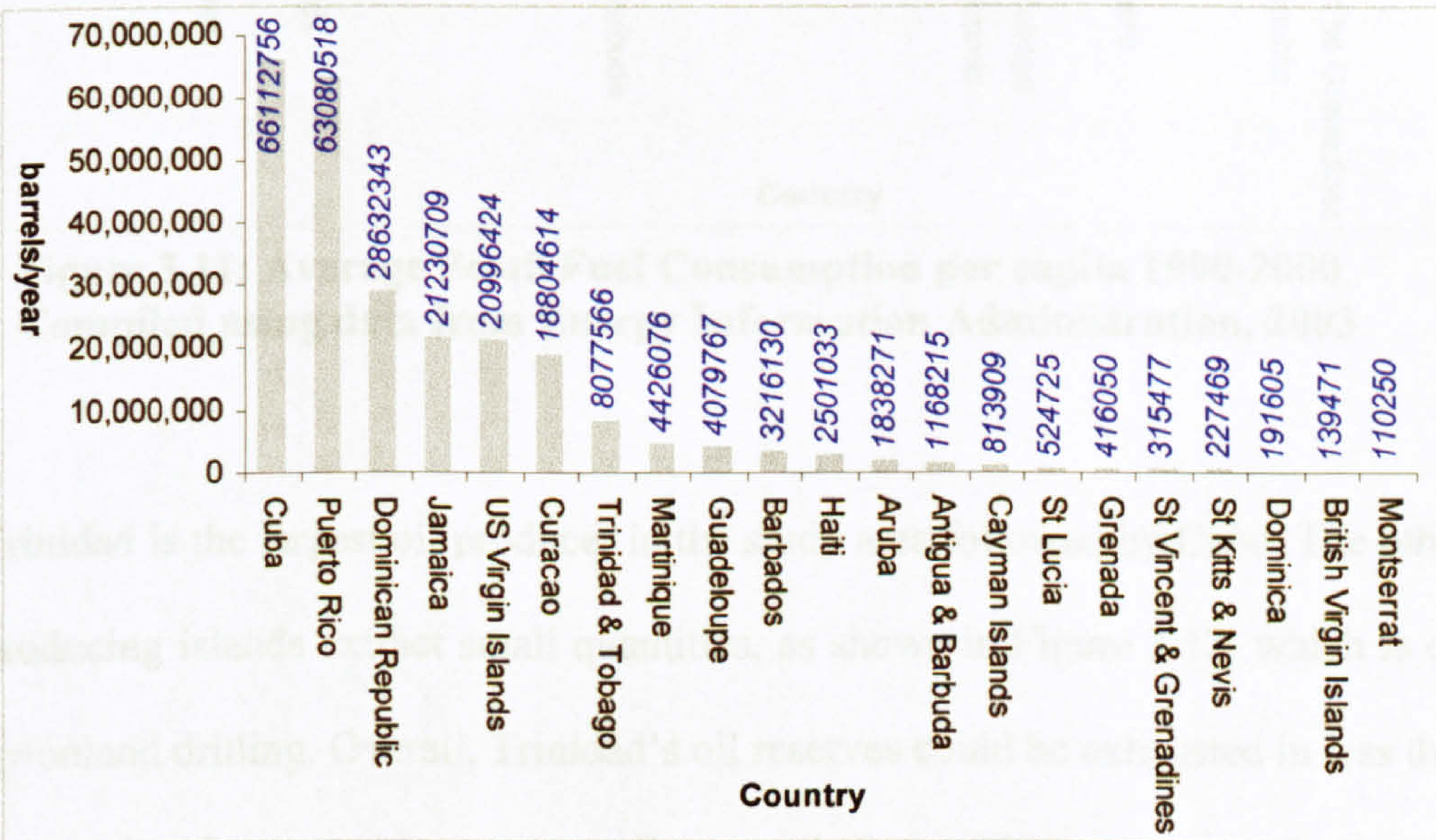


Figure 3.10: Average Fossil Fuel Consumption 1990-2000. Compiled using data from Energy Information Administration, 2003

The per capita fuel consumption varies between the islands, as shown in Figure 3.11. The US Virgin Islands has the highest average usage of approximately 200 barrels of fuel per person. Haiti on the other hand uses less than half of a barrel of fuel per person. These differences in consumption are due to economic status of these countries. The USVI has one of the highest standards of living in terms of national wealth in the study area in contrast to Haiti, which is the poorest country in the western hemisphere (CIA, 2004r, l).

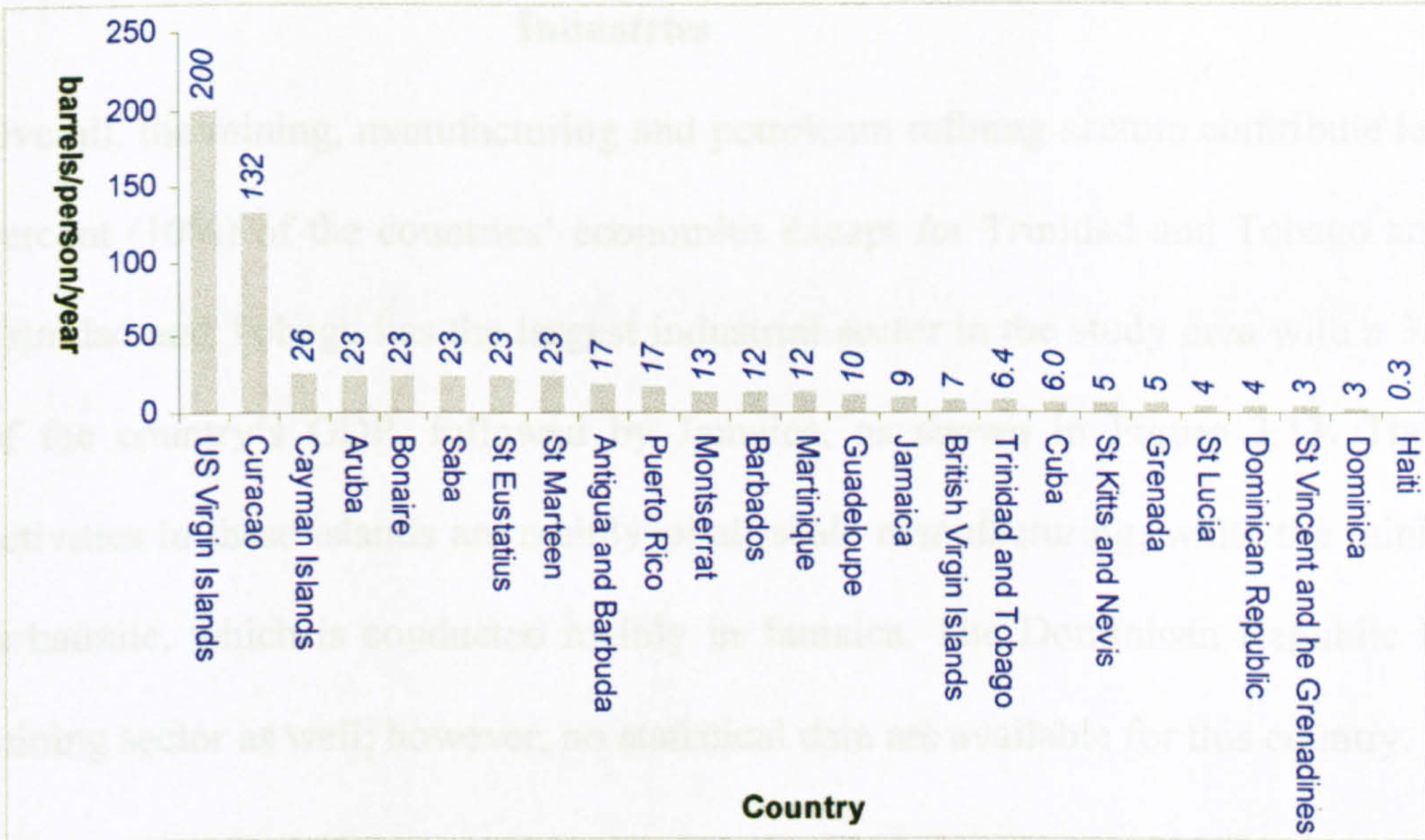


Figure 3.11: Average Fossil Fuel Consumption per capita 1990-2000 Compiled using data from Energy Information Administration, 2003

Trinidad is the largest oil producer in the study area followed by Cuba. The other three oil-producing islands extract small quantities, as shown in Figure 3.12, which is done mostly by onland drilling. Overall, Trinidad's oil reserves could be exhausted in less than a decade unless significant new reserves are discovered (Esser, 2005).

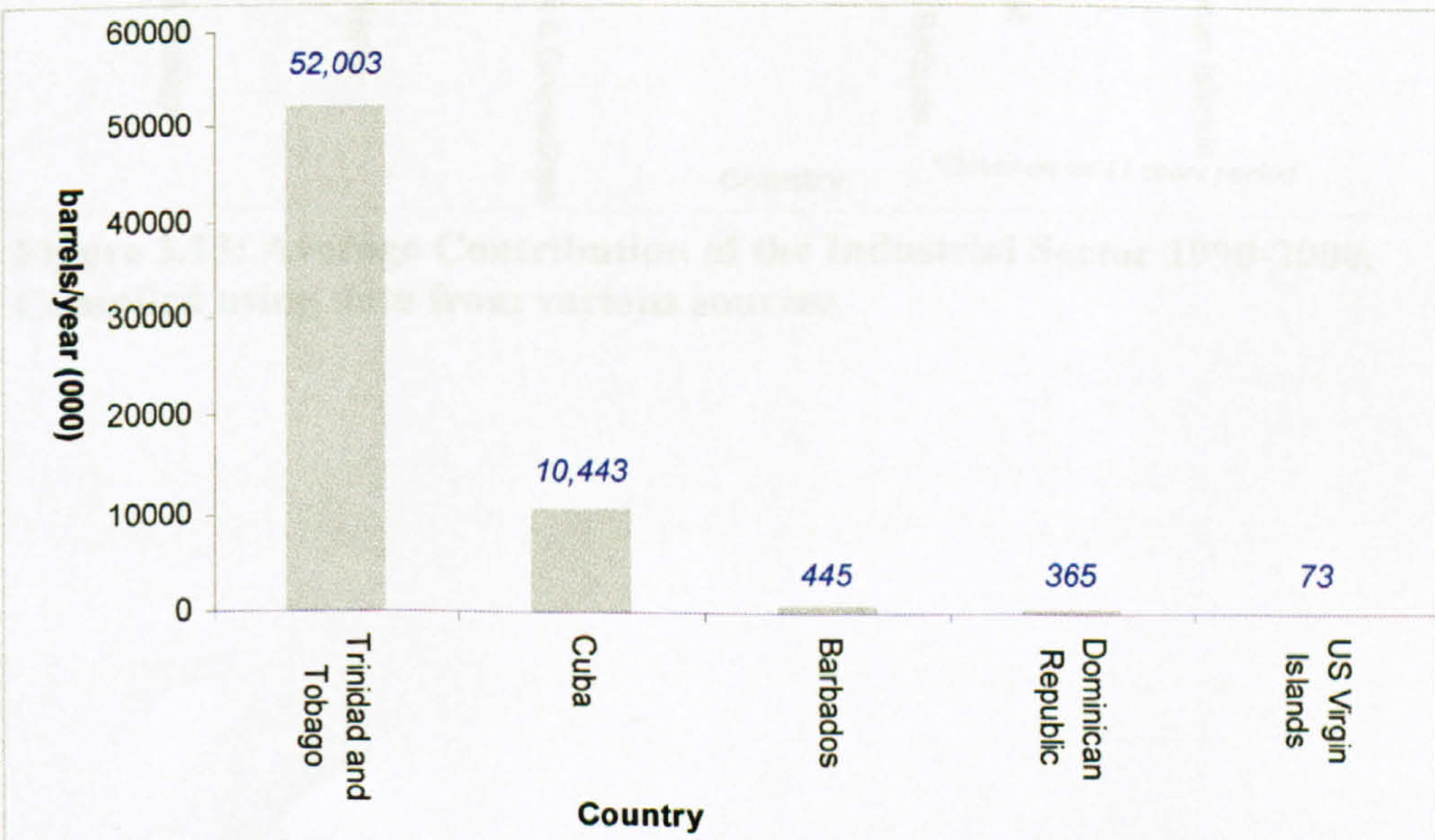


Figure 3.12: Average Crude Oil Production 1990-2000. Compiled using data from Energy Information Administration, 2003

Industries

Overall, the mining, manufacturing and petroleum refining sectors contribute less than ten percent (10%) of the countries' economies except for Trinidad and Tobago and Jamaica. Trinidad and Tobago has the largest industrial sector in the study area with a 32.8% share of the country's GDP, followed by Jamaica, as shown in Figure 3.13. The industrial activities in these islands are mainly small-scale manufacturing, while the mining activity is bauxite, which is conducted mainly in Jamaica. The Dominican Republic has a large mining sector as well; however, no statistical data are available for this country.

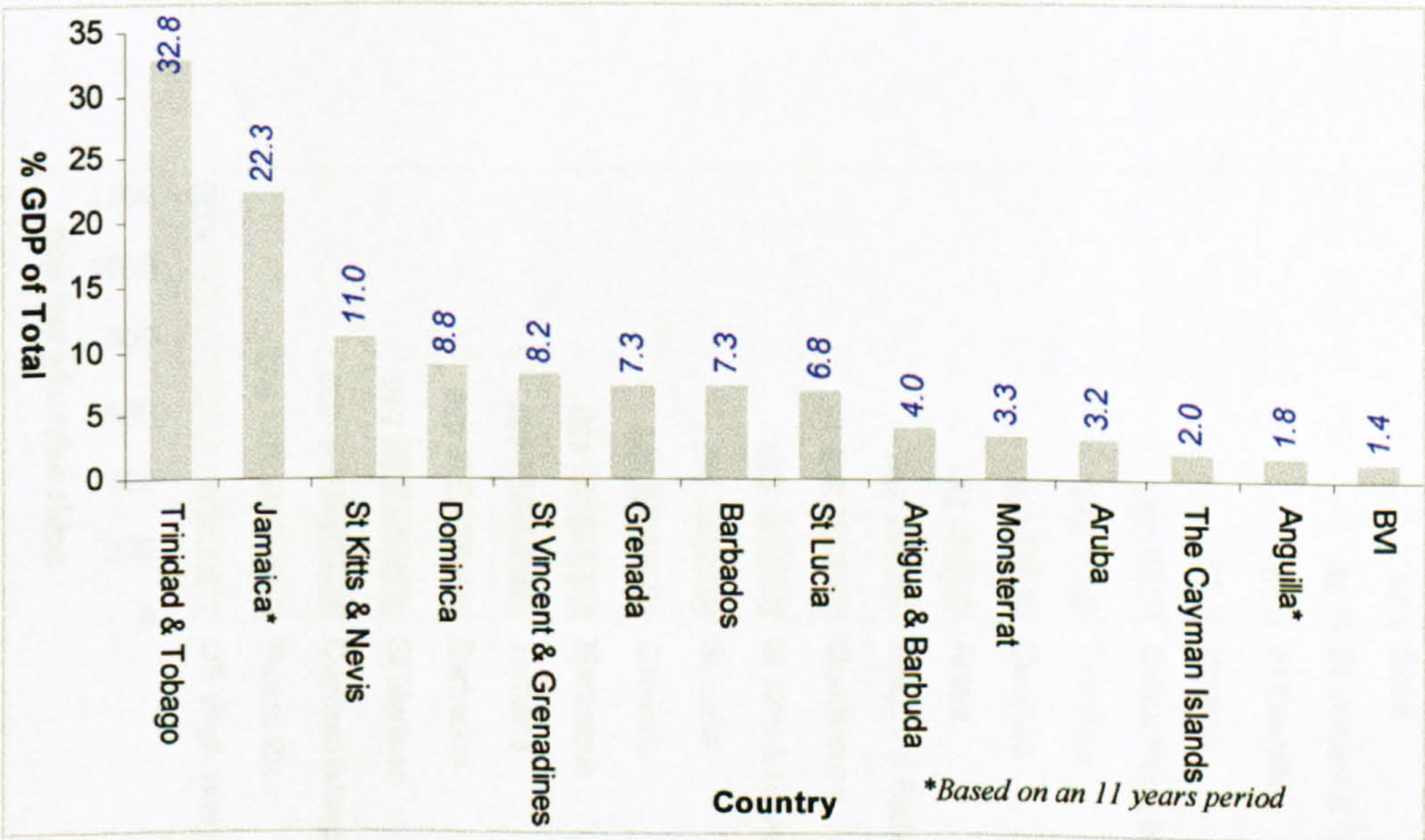


Figure 3.13: Average Contribution of the Industrial Sector 1990-2000. Compiled using data from various sources

Tourism

The US Virgin Islands receives on average the most cruise ships for the data period when compared to the other islands in the study area as shown in Figure 3.14. This is followed by Puerto Rico and the Cayman Islands. The US Virgin Islands is the top cruise destination in the Caribbean, receiving on average over a million visitors per year followed by Puerto Rico, as shown in Table 3.6. The Eastern Caribbean group receives most tourists and has the highest level of traffic than the other two regions of the study area. The traffic of cruise ships in the Southern Caribbean is larger than represented in this data because some destinations are Mexico, Panama and Belize, which are not part of the SIDS. These cruises however, use the Caribbean Sea.

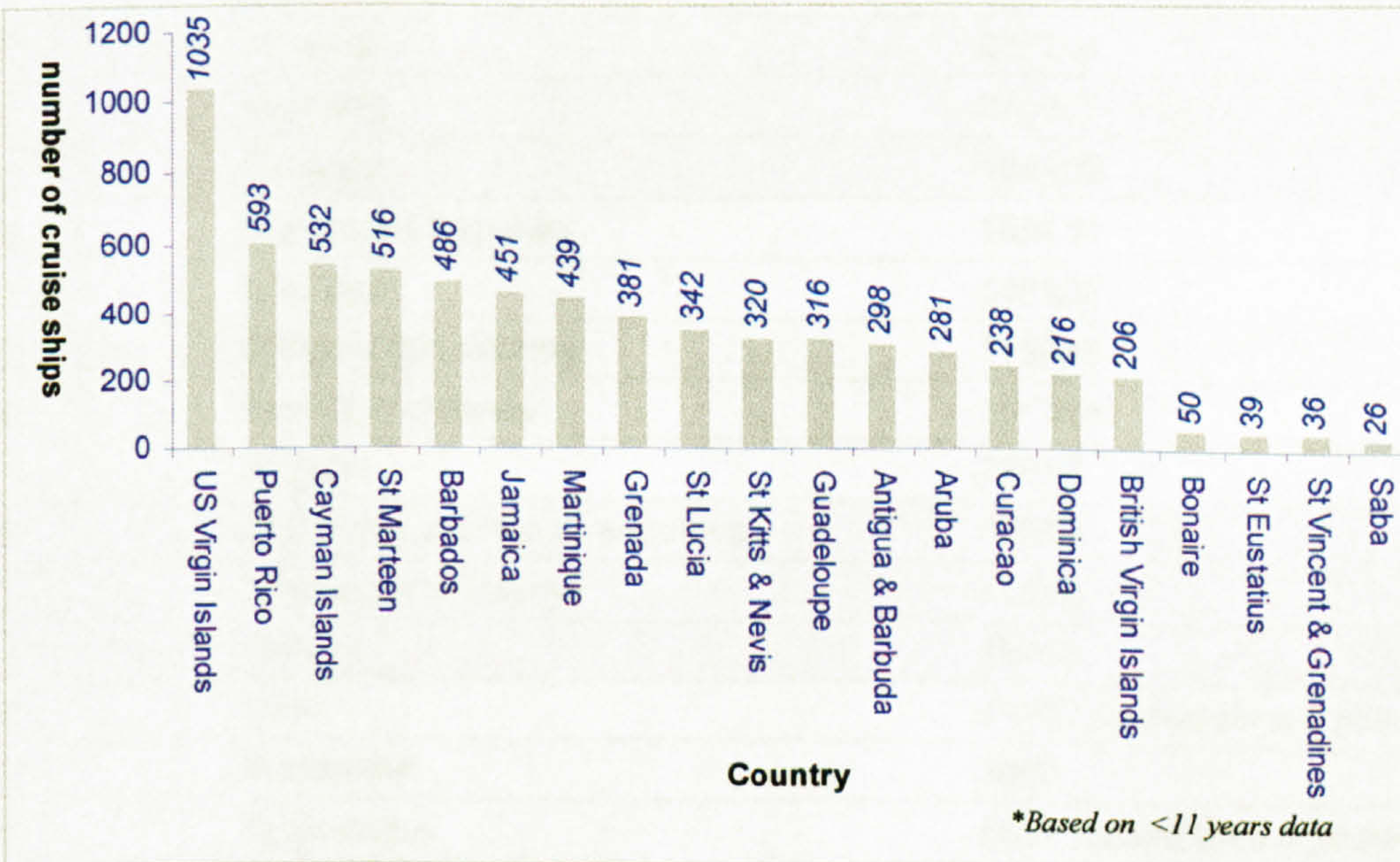


Figure 3.14: Average Number Cruise Ship Arrival 1990-2000. Compiled using data from CTO, (2002) and other national agencies

Table 3.6: Average Cruise Passenger Arrivals (1990-2000) and Categories of Cruise Destinations. Compiled using data from CTO, (2002). The Southern and Western Caribbean cruise includes destinations in South and Central America e.g. Belize, Mexico and Panama. Despite these destinations are not part of SIDS, the cruise routes are in the Caribbean Sea[20]

Rank	Country	Average Passengers
1	US Virgin Islands	1360091
2	Puerto Rico	1066925
3	Cayman Islands	717700
4	Jamaica	642827
5	St Marteen	620948
6	Barbados	455291
7	Martinique	395355
8	Guadeloupe	338018
9	Antigua and Barbuda	280318
10	Aruba	266682
11	Haiti	253960 *(based on a 5 years average)*
12	St Lucia	236264
13	Grenada	220955
14	Curacao	194409
15	Dominican Republic	155489
17	Dominica	146809
18	British Virgin Islands	119845
19	St Kitts and Nevis	101364
20	Anguilla	76816
21	St Vincent and the Grenadines	65255
22	Trinidad and Tobago	46018
23	Bonaire	18309
23	Saba	11352 *(based on a 8 years average)*
24	Montserrat	8600
25	St Eustatius	6851 *(based on a 3 years average)*

Eastern Caribbean *Southern Caribbean* *Western Caribbean*

[20] See Chapter Six for Cruise Routes

(c) Comparison of Sectors in 1960 and 2000

Urban Population

The analysis revealed an increase in urban population in almost all the islands between 1960 and 2000 as shown in Table 3.7. All the islands have a large percentage increase except Montserrat. The BVI has the largest increase of 500 % followed by St Vincent and the Grenadines and the US Virgin Islands with percentage increases of 491 and 461 respectively. St Kitts and Nevis urban population has fluctuated over this 40-year period and in 2000 returned to its 1960 level.

Table 3.7: Comparison of Urban Population in the SIDS for 1960 and 2000. Compiled using data from FAO, 2004

COUNTRY	YEAR (URBAN) 1960 (000)	2000 (000)	CALCULATED % CHANGE
British Virgin Islands	2	12	500
St Vincent & Grenadines	11	65	491
US Virgin Islands	18	101	461
Dominican Republic	977	4,862	398
Haiti	592	2,851	382
Cayman Islands	8	37	363
Puerto Rico	1,051	3,611	244
Martinique	113	366	224
Guadeloupe	156	426	173
Jamaica	550	1,343	144
Saint Lucia	18	43	139
Cuba	3,832	8,424	120
Dominica	28	55	96
Anguilla	6	11	83
Trinidad and Tobago	543	955	76
Aruba	27	44	63
Barbados	93	134	44
Antigua and Barbuda	22	26	18
Grenada	27	31	15
Saint Kitts and Nevis	14	14	0
Montserrat	2	1	-50

Fisheries

Comparison of fisheries production between 1961 and 2000 showed that the percentage increase is large in some islands such as St Vincent and the Grenadines and the Netherlands Antilles. St Vincent and Grenadines showed over 6, 000 percentage increase over the 40-year period. It also shows that some islands landed a lower catch in 2000 when compared to 1961 as shown in Table 3.8. This includes islands such as Puerto Rico, Barbados, St Kitts and Nevis, USVI, Montserrat, Jamaica and BVI. This may be an indication of a collapse in the fisheries sector. It is already evident that the fisheries in the Caribbean are declining in all the sub groups, both the near shore and pelagic, as shown in Chapter Two and in this chapter.

Table 3.8: Comparison of Marine Production in the SIDS for 1960 and 2000 Compiled using data from FAO, 2004

COUNTRY	Fish (mt)		Calculated % Change
	1961	2000	
Saint Vincent & Grenadines	400	27,652	6813
Netherlands Antilles[21]	600	20,489	3315
Dominican Republic	1,400	7,554	440
Trinidad and Tobago	2,100	8,934	325
Saint Lucia	500	1,790	258
Grenada	500	1,649	230
Guadeloupe	3,200	9,400	194
Dominica	500	1,200	140
Cuba	18,300	32,034	75
Martinique	3,000	5,224	74
Antigua and Barbuda	700	1,164	66
Haiti	2,800	3,800	36
Puerto Rico	2,600	2,179	-16
Aruba	200	163	-19
Barbados	4,600	3,100	-33
Saint Kitts and Nevis	600	389	-35
US Virgin Islands	500	264	-47
Montserrat	100	50	-50
Jamaica	11,500	4,664	-59
British Virgin Islands	300	34	-89

[21] The Netherlands Antilles is all the Dutch dependent islands in the Caribbean Sea.

Agriculture

The comparison of agricultural areas for 1960 and 2000, has shown little changes, which is reflected in Table 3.9. In terms of employment, over 80% of all the islands have shown a decrease in the number of persons involved in agriculture as an occupation. All the islands that showed a decrease in agricultural population, are now tourism based economies (refer to Table 3.1, pg. 49).

Table 3.9: Comparison of Agricultural Areas in the SIDS for 1961 and 2000 Compiled using data from FAO, 2002

COUNTRY	AGRI. AREA (000)		CAL % CHANGE	AGRI. POP (000)		CAL % CHANGE
	1960	2000		1960	2000	
Cuba	3,550	7,100	100	2775	1831	-13
Saint Vincent/Grenadines	10	16	60	40	28	0
British Virgin Islands	6	9	50	4	5	100
Antigua and Barbuda	10	14	40	28	17	-27
Trinidad and Tobago	102	133	30	184	112	-18
Dominica	17	21	24	30	18	-33
Dominican Republic	3,082	3,696	20	2108	1479	-5
Saint Lucia	17	20	18	43	34	0
Aruba	2	2	0	27	22	0
Barbados	19	19	0	61	11	-75
Cayman Islands	3	3	0	4	9	300
Martinique	34	33	-3	115	16	-83
Haiti	1,660	1,590	-4	3038	4986	26
Jamaica	533	513	-4	676	531	-4
Guadeloupe	58	49	-16	115	14	-83
US Virgin Islands	12	10	-17	16	24	100
Montserrat	5	3	-40	6	1	-100
Grenada	22	12	-45	45	19	-47
Saint Kitts and Nevis	20	10	-50	26	10	-60
Puerto Rico	616	294	-52	724	113	-80

All the islands where data are available showed increased fertilizer usage between 1960 and 2000. Haiti recorded the largest increase followed by St Lucia. These calculated values are shown in Table 3.10. The decline in soil fertility from years of agricultural activities may be the reason for this increase in organic fertilizer usage in many of the islands. The increased use of fertilizer has implications for the marine environment. More usage can increase the magnitude of agro chemical pollution in the absence of efficient land management.

Table 3.10: Comparison of Fertilizer Usage in the SIDS for 1960 and 2000 Compiled using data from FAO, 2002

Country	Fertilizer (MT) 1960	2000	Calculated % Change
Haiti	100	14,429	14329
Saint Lucia	450	5,300	1078
Dominican Republic	13,997	91,695	555
Saint Vincent/Grenadines	1,110	3,900	251
Guadeloupe	7,600	19,300	154
Saint Kitts and Nevis	735	1,700	131
US Virgin Islands	300	600	100
Trinidad and Tobago	5,280	9,204	74
Jamaica	13,506	22,400	66
Martinique	7,060	11,100	57
Cuba	105,000	130,400	24
Barbados	5,126	3,000	-41

(d) Grouping of Islands by Levels for the Economic Sectors

Table 3.11: Ranking of Economic Sectors in the SIDS. The ranking is based on outcome of the percentile ranking using the calculated mean (Appendix Two). URP = urban population, FIH = fisheries, AG = agriculture, ID = industrial, SO = stay over visitors, CR = cruise passengers

Country	Sectors						
	URP	FIH	AG	EG	ID	Tourism	
						SO	CR
Aruba	Medium	Low	Low	Medium	Low	High	Medium
Curacao	ND	ND	ND	ND	ND	Medium	Medium
Bonaire	ND	ND	ND	ND	ND	Low	Low
Trinidad and Tobago	Medium	High	Medium	Medium	High	Medium	Low
Grenada	Low	Medium	Medium	Medium	Medium	Medium	Medium
St Vincent &Grenadines	Medium	High	Medium	Low	Medium	Low	Low
Barbados	Medium	Medium	Medium	Medium	Medium	Medium	High
St Lucia	Low	Medium	Medium	Medium	Medium	Medium	Medium
Martinique	High	Medium	Medium	Medium	ND	Medium	High
Dominica	Medium	Medium	Medium	Low	High	Low	Medium
Guadeloupe	High	High	Medium	Medium	ND	High	Medium
Montserrat	Low	Low	Low	Low	Medium	Low	Low
Antigua and Barbuda	Low	Medium	Medium	Medium	Medium	Medium	Medium
St Kitts and Nevis	Low	Low	Medium	Low	High	Medium	Medium
Saba	ND	ND	ND	ND	ND	Low	Low
St Eustatius	ND	ND	ND	ND	ND	Low	Low
St Marteen	ND	ND	ND	ND	ND	Medium	High
Anguilla	High	Low	ND	ND	Low	Low	Low
British Virgin Islands	Medium	Low	Low	Low	Low	Medium	Medium
US Virgin Islands	Medium	Medium	Low	High	ND	High	High
Puerto Rico	High	Medium	High	High	ND	High	High
Dominican Republic	Medium	High	High	High	ND	High	Medium
Haiti	Low	Medium	High	Medium	ND	Medium	Medium
Cuba	High	High	High	High	ND	High	ND
Cayman Islands	High	Low	Low	Medium	Low	Medium	High
Jamaica	Medium	High	High	High	High	High	High

Key *High* *Medium* *Low*

ND – no data

The ranking in Table 3.11 shows that Jamaica is ranked the highest in economic sectors along with Cuba. Anguilla is the only island, which has a low ranking in all its economic sectors.

(e) Grouping of Islands by Spatially Normalised Sectoral Pressure

Table 3.12: Derived Spatial Pressures by Sector in the SIDS. The ranking is based on outcome of the percentile ranking using the derived values (Refer to Appendix Four).

COUNTRY	Sectors		
	Agriculture	Fisheries	Cruise Tourism
Aruba	Low	Low	High
Curacao	ND	ND	Medium
Bonaire	ND	ND	Low
Trinidad and Tobago	Low	High	Low
Grenada	Medium	High	Medium
St Vincent and Grenadines	Medium	High	Medium
Barbados	Medium	Medium	High
St Lucia	Medium	High	High
Martinique	Medium	High	Low
Dominica	Low	Medium	Medium
Guadeloupe	Medium	High	Medium
Montserrat	Medium	Low	ND
Antigua and Barbuda	Low	Medium	Medium
St Kitts and Nevis	Medium	Medium	Medium
Saba	ND	ND	ND
St Eustatius	ND	ND	Low
St Martin	ND	ND	ND
St Marteen	ND	ND	High
Anguilla	ND	Medium	Medium
British Virgin Islands	High	Low	Medium
US Virgin Islands	Medium	Low	High
Puerto Rico	Medium	Medium	Medium
Dominican Republic	High	Medium	Low
Haiti	High	Low	ND
Cuba	High	Medium	ND
Cayman Islands	Low	Low	High
Jamaica	High	Medium	Low

Key *High* *Medium* *Low*

ND – No Data

The results in Table 3.12 show that the smaller islands have the highest cruise pressure, while the islands with the larger land area have the highest agricultural pressure. In terms of fisheries Trinidad and Tobago, St Lucia, Guadeloupe and Martinique are among the islands with high fishing pressures.

(f) Coastal Pressure from Cruise Passengers

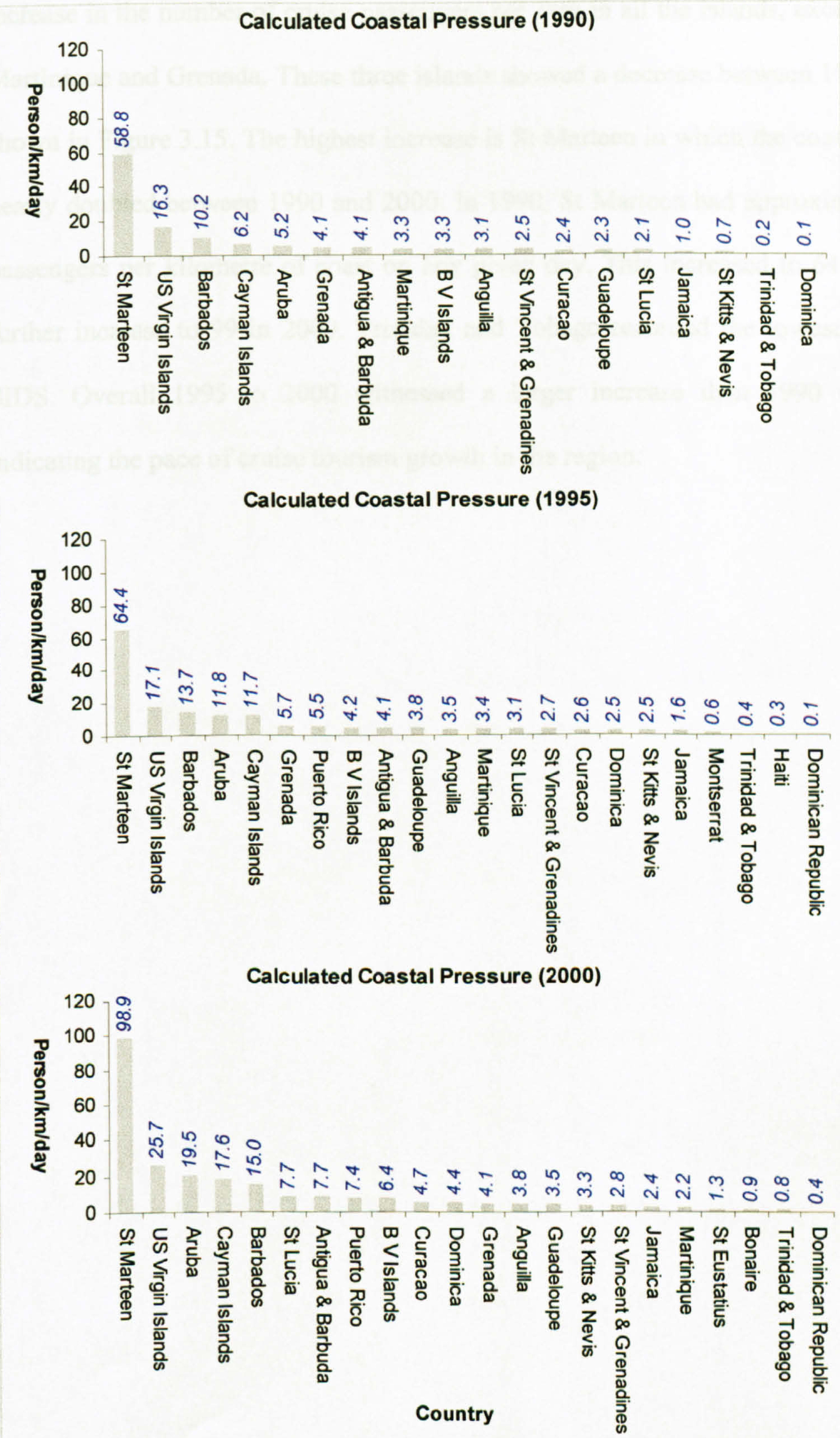


Figure 3.15: Comparison of Coastal Pressure from Cruise Passengers in the Caribbean SIDS. Derived using data from CTO, 2002 and WTO, 2005

The analyses of the coastal pressure for 1990, 1995 and 2000 showed a progressive increase in the number of cruise passengers per area in all the islands, except Guadeloupe, Martinique and Grenada. These three islands showed a decrease between 1995 and 2000 as shown in Figure 3.15. The highest increase is St Marteen in which the coastal pressure has nearly doubled between 1990 and 2000. In 1990, St Marteen had approximately 58 cruise passengers per kilometre of coast on any given day. This increased to 64 in 1995 with a further increase to 99 in 2000. Trinidad and Tobago recorded the lowest increase in the SIDS. Overall 1995 to 2000 witnessed a larger increase than 1990 to 1995, hence indicating the pace of cruise tourism growth in the region.

(g) Fishing Pressure vs. Affluence

BARBADOS

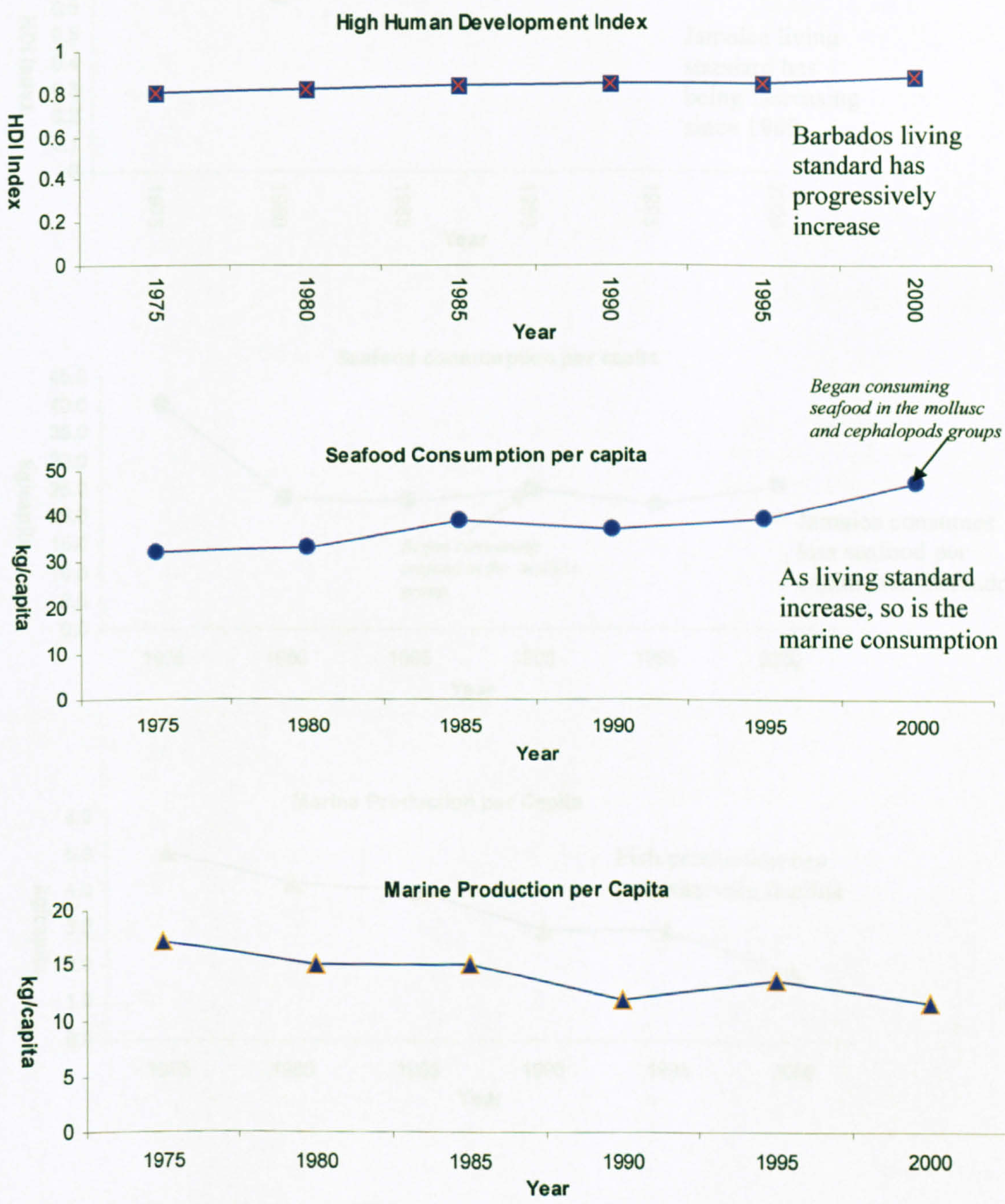


Figure 3.16: Comparison of HDI, per capita seafood consumption and per capita marine production for Barbados. Compiled using data from FAO, 2002 and UNDP, 2005. The data displayed in the Figure shows that Barbados' capita fish production cannot compensate for the increase consumption. The per capita fish production has declined while the per capita consumption has increased also the HDI

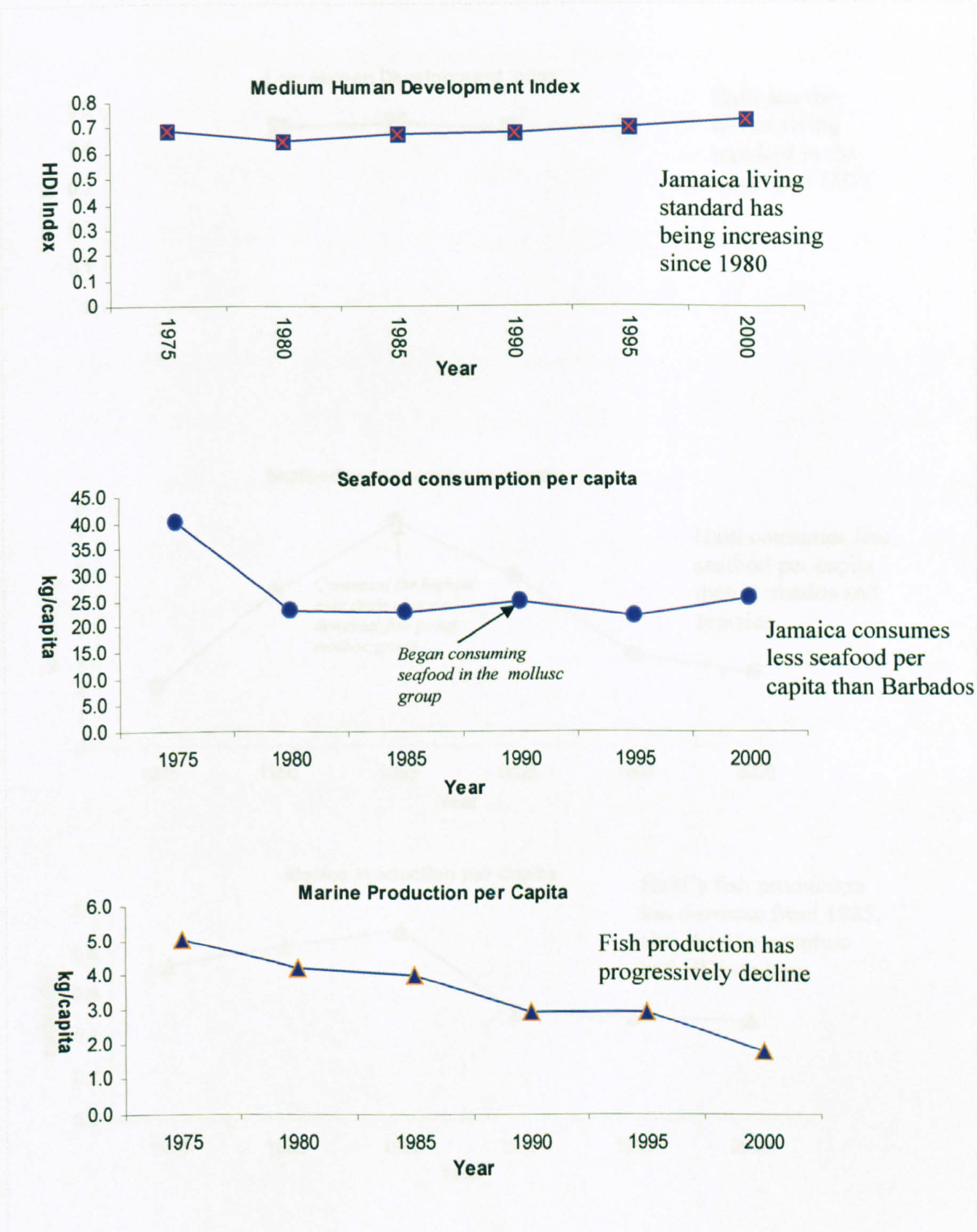


Figure 3.17: Comparison of HDI, per capita seafood consumption and per capita marine production for Jamaica. Compiled using data from FAO, 2002 and UNDP, 2005. Jamaica is less affluent than Barbados recording a lower HDI. The per capita consumption of seafood for Jamaica is less than Barbados. Like Barbados, the per capita production has decreased while the per capita consumption has increase indicating a collapse in the fishery.

HAITI

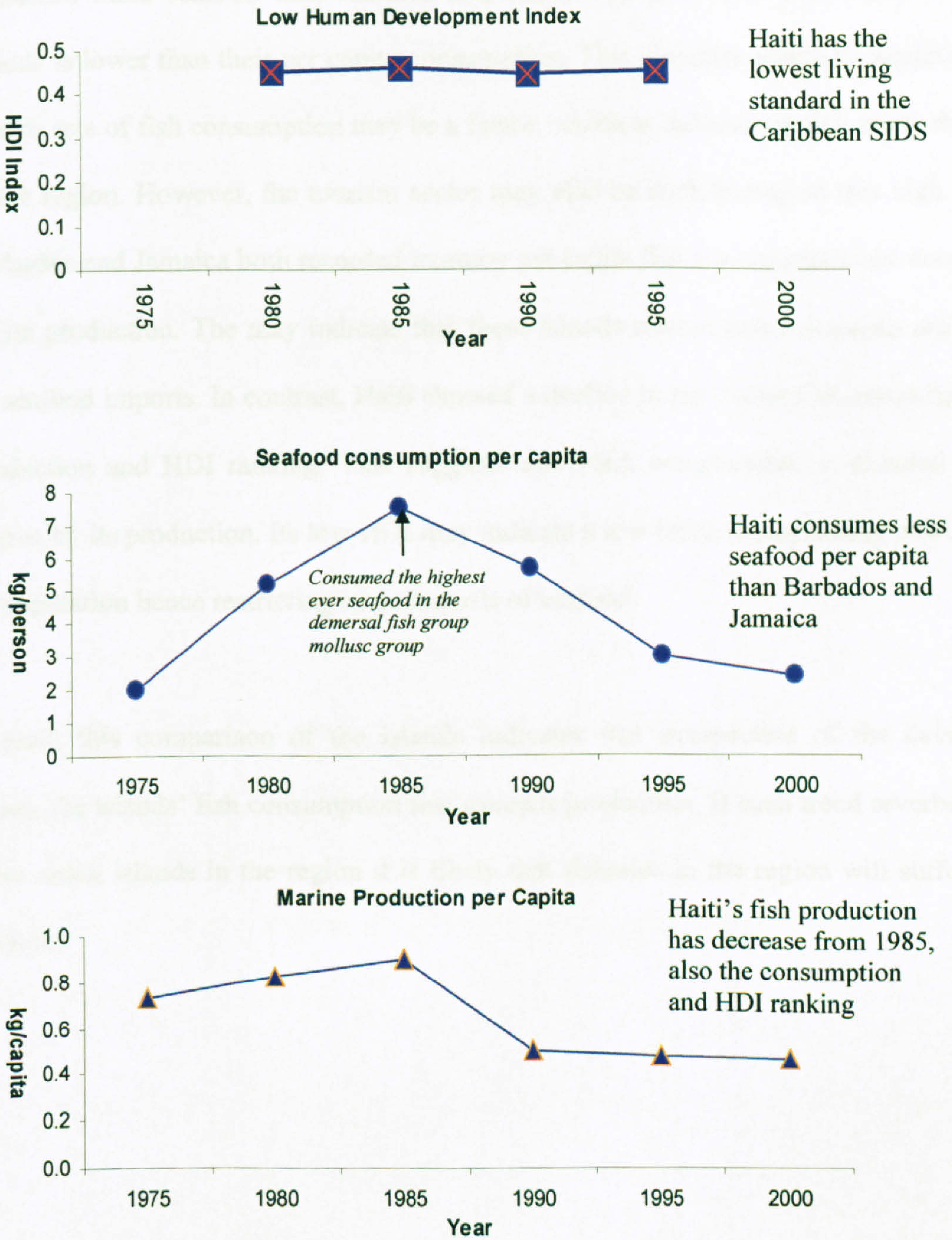


Figure 3.18: Comparison of HDI, per capita seafood consumption and per capita marine production for Haiti. Compiled using data from FAO, 2002 and UNDP, 2005. Haiti consumes more seafood per capita in 1985 than any other year. The HDI was the highest for that year also. In general, its per capita consumption of seafood is the lowest when compared to Barbados and Jamaica.

This comparison revealed that the per capita consumption of fish increases with the level of affluence (HDI). Barbados being the most affluent society in the Caribbean SIDS, consumes more seafood than Jamaica and Haiti. The per capita production for all the islands is lower than their per capita consumption. This disparity seems to suggest that the islands rate of fish consumption may be a factor, which is influencing fish stock abundance in the region. However, the tourism sector may also be contributing to this high demand. Barbados and Jamaica both recorded increase per capita fish consumption and decrease per capita production. The may indicate that these islands consumption demands are fulfilled by seafood imports. In contrast, Haiti showed a decline in per capita fish consumption and production and HDI ranking. This suggests that Haiti consumption is dictated to some degree by its production. Its low HDI may indicate a low level of purchasing power among its population hence restricting large imports of seafood.

Overall, this comparison of the islands indicates that irrespective of the development status, the islands' fish consumption rate exceeds production. If such trend reverberates for other small islands in the region it is likely that fisheries in the region will suffer further decline.

3.5 OVERALL DISCUSSION AND FUTURE IMPLICATIONS

3.5.1 Population

The results showed that the urban sector in the islands consisted of a large and growing proportion of the total population. The analysis revealed that in the Caribbean island states more than 62% (21,723,833) of the total population (35,507,226) resides in urban areas. This high urbanisation may be due to the increasing shift from agricultural based economies to other sectors such as tourism.

Most of the urban areas in the Caribbean are characterised by one large city (usually the capital city) which accounts for most of the urban population, with the exception of Cuba, Trinidad and the Dominican Republic, which have more than one large urban area. This high urban population makes the Caribbean, together with Latin America, the most urbanized region of the developing countries (UN-HABITAT, 2003). In addition to its large population, all the capital cities are found on the coastal regions of these islands, which border the Caribbean Sea (Figure 3.3, pg. 65) except for Puerto Rico and Cuba. Therefore, the pressure on the marine environment will be high in close proximities of these cities.

As mentioned in the profiles in Appendix One and Table 3.1, most of the islands identify sewage as a problem. Therefore inadequate sewage treatment facilities (refer to Table 2.3, pg. 32) coupled with increase urban population growth will result in greater anthropogenic pressures on the marine areas. Similarly, Letson, Suman and Shivlani (1998) noted that human population patterns are the principal indicator of coastal pollution and stress.

This stress can further magnify into impacts if there is inadequate, or an absence of effective integrated coastal zone management plans or policies. For example, it is estimated that approximately 90% of the land based pollutants have a "sink" in the coastal water, sediments and biota (Oregon Sea Grant, 1996). This estimation is particularly alarming for the Caribbean Sea because most of the coral reefs and seagrass areas are found in the coastal areas of the sea (refer to Figure 2.5, pg. 29). In addition, most islands do not have any coastal or marine policy which can address these threats.

3.5.2 Fisheries

The results showed that some islands have annual increases in fishery production while others recorded a decrease in all groups. The comparison between 1960 and 2000 has shown that fish landings have generally decreased in most of the islands, which may indicate an overall decline. The total production data which were analysed in Chapter Two (refer to Figure 2.9, pg. 43) add further evidence that the fisheries in the region has decline. This decline seems to be driven by the region's high marine fish consumption. The SIDS are not large exporters of marine fisheries, which was less than 4% in 2000[22]. The sample of islands shows a direct correlation between standard of living and level of consumption of the island's marine resources. This trend if it is common in the region may provide serious challenges to the region's fisheries sector. The reason being, most of the islands are recording an increase in the levels of living standard (HDI) due to the increase in economic growth. Therefore, it is likely that pressure on the fisheries will increase. In the present scenario, effective fisheries management is inadequate in the region, therefore this can exacerbate the fisheries problem. It is likely that many islands will also suffer collapses in the fisheries sector, which may have long-term effects on fisheries in general in the region. Other studies have reported that the fisheries especially the shelf resources in the Caribbean (e.g. lobster, conch, reef fish, shrimps) are either fully exploited or already over exploited (FAO, 1993, 1996b).

[22] Trinidad and Tobago and St Vincent and the Grenadines are the largest exporter of fisheries in the SIDS. The export market from the Caribbean is mainly from lobster, shrimp and groupers.

This analysis highlights an even bigger challenge in the region in terms of consumption and fishery resources. If higher HDI means greater consumption, then it may be impossible for SIDS to achieve any form of sustainable fisheries without lifestyle changes. The high demand for fish may compromise effective management.

Other reason for the decline in fisheries may be the regions management efforts. In terms of migratory species such as tuna, maximising catch is still a priority in the region. For example, in 2002 Dominica exported tuna to Canada, which was caught in its territorial water (Andrew Magloire, *pers. comm.*). Such action is justified under international law, (UNCLOS gives the rights to fish within the territorial claims), but in the absence of information on stock biology, this may affect these straddling and migratory stock population.

Another problem is that of 'reflagging' of fishing vessels. St Vincent and the Grenadines and the Netherlands Antilles register a large number of foreign owned[23] fishing vessels. These fishing vessels use this mechanism to fish in areas, which would otherwise be prohibited. This action of 'reflagging' also avoids the regulatory systems set up by international agreements to manage fisheries such as FAO compliance agreement[24] (FAO, 1995). This issue of registration may explain the high increases exhibited by St Vincent and the Netherlands Antilles (refer to Table 3.8 - pg. 86).

Other factors, which may be influencing the overall decline in fisheries in some islands and the region, may be policies. Berkes (1987) attributed the decline of fisheries in Barbados and Jamaica to the open access policy (common property resources). This type of policy does not only exist in Jamaica and Barbados, but throughout the Caribbean SIDS. Fisheries are treated as an open access resource (Laya and Weidner, 2001a) and entry into the

[23] This term is used for vessels which are owned by Companies outside the Caribbean SIDS
[24] See Chapter Seven for more information regarding this Agreement

fishery sector is open to all at no cost, except for acquiring gear and equipment. An example of such policy exists in Dominica. In some jurisdictions, Governments subsidize this sector because they view it as an opportunity to create jobs with very little investments.

Other hindrances to the management of fisheries in the Caribbean are lack of cooperation and inadequate scientific understanding of stock biology and assessment. Individual governments pursue their own fisheries initiatives and in some cases, management plans are adopted. Even with such intervention, there is still no strong indication that the region is making a collective effort to manage its fisheries at an ecosystem level. There are existing programmes in place, which will be discussed further in Chapter Seven.

In addition to the ad-hoc cooperation and the lack of a common policy, the region is also complex. The Caribbean has the highest density of separate states per unit area in the world (Chakalall *et. al.*, 1998) which leads to conflicts of ownership. An example of such conflict is the ongoing legal battle between Trinidad and Tobago and Barbados over territorial claim of EEZ.

3.5.3 Agriculture

As discussed in Chapter One, agriculture was once the mainstay of many economies under this study. The results from the analysis conducted in this chapter, showed a large variation in agricultural area, fertilizer usage and crop production. It also revealed that many of the islands have declining agricultural output and a declining sector in general. This current decline in the sector can be attributed to increased global trade, poor agronomic practices, disparities in trading and loss of markets.

The influx of cheaper products into the Caribbean from international suppliers in the late 1980s began competing with local producers. From as early as 1993, the region's agricultural exports fell to less than half of the 1987-1989 levels (Valenzuela, 1999). This reduction in exports, resulted in the region becoming a net agricultural importer with an agricultural trade deficit compared to a surplus in 1987-1989 (Valenzuela, 1999).

In addition to the loss of agricultural markets from external competition the sector also had to deal with rapid land degradation due to high rates of deforestation, soil erosion and poor water management practices (Paul, 2001). Another emerging problem from this analysis of the agricultural sector is the demand for land by other sectors. This demand has resulted in many of the traditional farming areas being replaced by alternative land use, such as settlements. These settlements are used to accommodate the increasing population and facilities for the growing tourism sector. In St Kitts and Nevis, this was found to be the reason for the decline in agricultural areas (Department of Environment, 2001).

The decrease in agricultural output in islands such as St Lucia, Grenada and Dominica is mainly due to the ease of preferential access of bananas to the EU markets[25]. These islands were the hardest hit as they were largely practicing monoculture banana farming. Currently, agriculture is likely to decline further, especially in the sugar producing islands such as Barbados and St Kitts and Nevis with the pending ease of preferential markets for sugar by the European Union. Thus, governments in the Caribbean will have to reshuffle their policies to continually take into account these shifts and impending loss in trade opportunities. This may even become more challenging with the onset of trade liberalization and globalization. Where the agricultural sector is ranked in terms of

[25] The preferential deal by the EU policy operated to deliver aid to several developing nations by raising the payments these countries received for their products in the EU market (Borrel and Cuthbertson,1991). This access has been ruled against by the WTO and several European legal entities. Consumers in Europe were paying more for bananas supplied by the Caribbean compared to those supplied from Africa and Latin America. According to (Borrel,1999), it costs EU consumers an extra $2 billion a year, with only a small proportion of $150 million a year reaching the developing countries, with the rest being diverted to the big businesses in Europe.

economic sectors in the Caribbean is contentious, but according to Paul (2001), it is still the largest employer in the region. However, it may now have competition from the tourism sector.

The analyses revealed that the high fertilizer users are mostly the banana producing islands such as St Lucia. However, the fertilizer usage in Martinique may increase because of the increased trade and market quota for bananas to the European Union.

Overall, the general decline in agriculture may be a 'blessing in disguise' for the marine environment of the Caribbean, as this may reflect a decrease in agricultural waste entering the marine system via the rivers or other drainage networks. Any future programmes and/or policies undertaken to revive the agricultural sector should take into consideration the effects it may have in the marine system. The historical agricultural system, did not take into account the effects on the marine environment and this practice should not be repeated. Policy makers should learn from this and manage the tourism sector to minimise environmental degradation.

3.5.4 Cruise Tourism

The results showed the growing trends in the cruise sector from both visitors and cruise ships alike. Some islands receive more cruise passengers than stay-over visitors (CTO, 2002; WTO, 2004).

In addition, many islands host a higher number of visitors than their resident population in any given year. This seems to concur with similar findings by Hobson (1993), and Dickenson and Vladimir (1997) in which they contended that Caribbean cruises are the fastest growing activity in the tourism sector. Similarly, The Economist (1998) noted that the growth in cruise tourism has doubled compare to the other sectors of tourism. In 1997 this sector grew by 8.6 % (PR Newswire, 1998 taken from Wood, 2000).

The Caribbean is the most visited destination in the world. In 1998 it commanded 26.96% of the world's cruise industry, followed by a 12.82% for the western Caribbean (Ocean Conservancy, 2002), which is technically part of the Caribbean region. Therefore, the Caribbean has an industry share of 49.78%. In total, there are over seventy cruise ships from approximately twenty-four cruise companies that operate in the Caribbean Sea. These companies conduct both seasonal[26] and year-round travels to various destinations[27] in the Caribbean.

The Caribbean cruise sector continues to stake a large claim in the world's cruise market. However, cruise tourism is a growing business worldwide and a growth in cruise tourism requires a constant search for new destinations, especially in and around Asia. This has resulted in a more global spread of cruise tourism hence, the Caribbean destinations are in competition. According to the Ocean Conservancy (2002) for the past decade the Caribbean market shares in cruise tourism has being declining, but overall it still remains the leading destination. Overall, there are an increasing number of arrivals to the Caribbean, and new destinations are opening in the region due to new berths and cruise facilities in some countries. Anguilla for example, began receiving cruise ships in 1998, when a cruise berth was constructed.

The increase in new destinations has resulted in fierce competition among cruise companies, and now the trend is moving towards bigger ships with floating city-like facilities. For example, Carnival's Destiny, which cruises the Caribbean, was for a long time the largest cruise ship with a capacity of 3,400 passengers (Wood, 2000), but this position is now threaten by much larger ships. These larger ships have aligned themselves in a new category and an era called "Post Panama" – as they are too big to use the Panama Canal. Therefore, the Caribbean cruise sector could be affected in the short term because

[26] The high tourist season is mid December to mid April and off-season from June to November.
[27] See Chapter Six Cruise Routes

most of the cruise ships enter the Caribbean via the canal (efforts are currently being made to expand the canal). In addition to access logistics, this post Panama engineering bias can have serious implications for the Caribbean cruise sector as bigger ships translate into larger cruise facilities. Therefore, governments may have to direct policies toward rehabilitating or building these facilities where necessary, or risk losing future shares of the cruise market to other worldwide destinations.

The most visited destination "the Caribbean" also means the highest amount of waste generation and according to IMO, each tourist generates about 3.5 kilos of waste per day. In 2000, the Caribbean had 21,510,142 beddays[28] and generated in excess of 75 metric tons of waste (Ocean Conservancy, 2002). This is followed by the Mediterranean, which had 6,277,064 beddays and generated close to 22 metric tons for the corresponding year. This data suggest that the Caribbean cruise industry produced close to four times more waste than the Mediterranean.

The amount of waste generated by the cruise industry is not very large when compared to municipal waste in some islands. In 1992, Trinidad generated approximately 500 tons of municipal waste (IMO, 1995), therefore in comparison, the cruise industry generates only 15% of Trinidad's total municipal waste. Another example is in St Lucia, according to the World Bank, tourist in St Lucia generate twice the amount of waste per day as residents, but in total contribute only 5% of the total waste because of the short length of stay (Dixon *et. al.*, 2001). In comparison, the waste generated by the cruise ships is significant but not overwhelming. However, if the waste generated by the cruise industry is not disposed properly, there can be far reaching consequences to marine life such as diseases and physical damage. The Caribbean Sea is regarded as a special area under the MARPOL Convention Annex V, thus prohibiting the dumping of garbage (includes all kinds of foods,

[28] It is a common measurement used in the cruise industry. Beddays are calculated by multiplying the number of beds occupied on a ship by the number of days (Ocean Conversancy, 2002).

domestic and operational waste excluding fresh fish, generated during the normal operation of the vessel and liable to be disposed of continuously or periodically) in the sea (IMO, 2002). This special status obliges governments in port states to have adequate garbage reception facilities to accommodate waste from cruise ships.

Other types of waste generated by the cruise industry are sewage and grey water[29]. According to Ocean Conservancy (2000), a typical cruise ship with 3,000 capacity is capable of producing 30,000 gallons of sewage and 255,000 gallons of grey water per day. This data are alarming for the region because of the high intensity of cruise traffic.

How much of this ends up in the marine system of the Caribbean region depends on the discretion of the cruise companies and crew of these ships, as there is no major policing or policy for the Caribbean Sea[30]. In addition, there is no monitoring of cruise ship waste in the region. The cruise industry is regulated through the international treaty MARPOL. This convention allows cruise ships to discharge untreated sewage and grey water beyond 3 to 12 nautical miles (NM) from a shore (Ocean Conservancy, 2002). This restriction seems inadequate in avoiding pollution in nearshore areas. Ocean currents in some areas can divert a large amount of this waste to the shores or to marine habitats such as coral reefs.

The analysis also showed that the growing cruise industry has resulted in an increasing number of people on beaches for a specific period. This can result in overcrowded coastal areas and increase pressure on nearby marine areas (refer to Figure 3.15, pg. 88).

In addition, the tourism sector in general is built on external regional demands making it a fragile economic sector. The issue of the pending head tax for cruise passengers and the boycott by the cruise companies elucidates the challenges and compromises decision-

[29] See Chapter Seven for more on MARPOL and other types of waste
[30] See Chapter Seven for Caribbean Policies towards these emerging issues.

makers face to ensure that this sector remains viable. This also illustrates the difficulty to internalise environmental externalities through levies. This control exerted by the cruise industry is similar to the sugar empires in the past (Chapter One) because the growth of the cruise sector is largely dictated by the cruise companies. The lack of a common policy in the SIDS has fuelled disunity and allowed the cruise companies to exercise greater control in this sector.

Another issue that remains a challenge for the region is that of prosecuting offenders of pollution (cruise ships). Although many of cruise companies are owned by USA based companies, many are registered in Flag of Convenience (FOC) states such as Antigua and Barbuda, Cayman Islands, Aruba, Netherlands Antilles and St Vincent and the Grenadines. This FOC registration presents a challenge to persecute offenders. However, NGOs in the USA have successfully brought legal actions against some cruise companies for pollution of coastal areas in the USA, hence such actions are possible in the Caribbean.

These issues discussed in this section demonstrate potential problems for the marine environment by the cruise tourism sector. Therefore, it may be useful to have a common strategy, which considers the impacts on marine environment.

3.5.5 Energy

The Caribbean is highly dependent on fossil fuels to satisfy its growing energy demands. The results showed an increasing trend in fossil fuel consumption. Most of this fuel is supplied from within the region particularly from Trinidad and Venezuela with a small percentage being supplied from outside of the region. This high fossil fuel dependency of the islands make their economies very vulnerable to price changes.

Of particular importance to this study, are oil production and movement within the Caribbean Sea. Within the Sea and Gulf of Mexico there are a few major oil production zones, which include Lake Maracaibo in Venezuela, the Gulf of Paria in Trinidad and the production area in the Gulf of Mexico. These zones are collectively classified as one of the largest oil producing areas in the world (Botello *et. al.*, 1997). However, for the purpose of this discussion, only oil production within the Caribbean Sea and the SIDS will be considered.

Barbados, Trinidad and Tobago, Dominican Republic, USVI and Cuba are the only oil producing countries in the Caribbean SIDS. Trinidad has the largest reserve and is the largest producer in the region (Esser, 2005). In 2004, Trinidad and Tobago produced 165,000 barrels per day (bbl/d) of total oil production, of which 131,600 bbl/d was crude oil (Esser, 2005). Barbados has no refining capacity, thus its oil is refined in Trinidad and Tobago, and then returned for domestic consumption. Barbados' domestic natural gas production is used for local demand. However, it is projected that Barbados will be forced to import larger quantities of natural gas or find alternatives in order to meet future consumption growth from power generation, households and the tourist industry (Esser, 2005).

Trinidad has a large oil deposit with many offshore wells and platforms in the Gulf of Paria in the Caribbean Sea. This island is rank among the top 40 oil-producing countries in the world (Esser, 2005). In 1995, it had a proven reserve of 0.5 billion barrels (Riva, 1995). In terms of oil movement, both Trinidad and Venezuela export large quantities of crude oil and processed products worldwide, hence contributing to the very high traffic and movement of oil and processed products in the Caribbean Sea. It is estimated that in excess of five million barrels of crude products are transported daily from the Caribbean (Botello *et. al.*, 1997) to various destinations, forming an intricate transportation network across the

Caribbean Sea[31]. This high level of movement increases the Caribbean Sea's vulnerability to petroleum related incidents, which was discussed in Chapter Two.

3.5.6 Industrial

The analysis showed that the Caribbean SIDS have relatively small industrial sectors, both mining and manufacturing. Jamaica is the world's third largest producer of bauxite and alumina (Barclay *et. al.*, 2001), and constitutes the largest mining sector for the countries in the study area. A few other islands have a small mining/quarrying sector, and overall this sector contributes between 0.3 % (St Vincent & Grenadines) and 8.4% (Jamaica) of the GDP for the individual countries (refer to Appendix One for statistics). The manufacturing industry contributes more to the GDP than the mining sector in many islands, ranging from as low as 0.8% in Anguilla to as high as 14% in Jamaica. As globalization continues, the pressures of competing with other countries will affect the small islands because of the small scale of this sector. These effects will be especially felt by small industries in the absence of preferential markets and protection.

Another product of the industrial sector is petroleum refining. Overall, the Caribbean is a major oil refining centre. According to Feld (1999), the region has a refining capacity of more than 1.6 million barrels per day (bbl/d). Refineries are found in many countries in the study area (Figure 3.4, pg. 65). The smaller refineries in the Dominican Republic as well as the larger refineries in the Netherlands Antilles (Curaçao), Trinidad and Tobago, and the USVI serve both the local and the export markets. In Aruba, the Coastal Aruba refinery has recently completed rehabilitation and has a current capacity of 280,000 bbl/d of production. Hovensa Oil Refinery in St. Croix of the USVI is the second largest oil refinery in the Western Hemisphere (Probasco, 2005). Curaçao is also another refining centre in the Caribbean with a refining capacity of 320,000 mbl/d (Lounnas, 1997).

[31] See Chapter Six for Oil Routes

Many of the mining and refining activities were established many decades ago, thus many did not require any form of environmental compliance such as Environmental Impact Assessments (EIAs). To date, there are many unsustainable practices within their operations. These are causing contamination to nearby marine areas in islands such as Curaçao (Buth and Ras, 1992). For example, Curaçao has an ongoing contamination problem of the marine environment because of poor construction of the Isla Refinery[32].

3.6 Conclusion

Overall, the analysis and discussion conducted in this chapter demonstrate that the level of resources used and commitment pressure on the environment varies among the islands. The analysis showed that politics, economics, availability of resources and population pressures are the main issues, which are driving the environmental issues relating to the Caribbean Sea.

The key findings of this analysis are summarised below.

- The analysis demonstrates the threats and challenges faced by the region in all the sectors especially tourism.
- The fisheries sector in general has declined which seem to be influenced by the region's consumption pattern.
- Environmental stress on the marine environment emanates from all the sectors on the island and the analyses and discussion demonstrates the need for the region to collectively address these pressures.

A further approach to this analysis will be to link the economic sectors to pressures on the marine environment (Caribbean Sea). This is important in order to assess the level of pressure on the Caribbean Sea from land based activities. This type of assessment does not

[32] Refer to Chapter Four for impact on the marine environment from the Isla Refinery

exist for the Caribbean Sea. The examination of pressures on the marine environment will focus on a selection of islands. This selection is based on the availability of data and the size of the economic sectors.

Relevant approaches to the scope of pressure assessment in the region include DPSIR, Ecological footprinting tool and GIS based analytical tool. In Chapter Four, the DPSIR approach in combination with GIS will be used to determine the linkages between economic sectors and the pressures on the marine environment. This will include the examination of sectors, impacts and policy responses in some islands.

CHAPTER FOUR

4.0 ASSESSING EFFECTS OF LAND BASED ACTIVITIES ON THE MARINE ENVIRONMENT

4.1 Introduction

The physical environment is a complex system, which involves the interaction of the biotic and abiotic ecosystems. In many countries, such as the SIDS in the Caribbean, the human activities result in environmental degradation as discussed in Chapters Two and Three. The increasing awareness of the inherent complexities of human activities and environmental interactions within a country can be very difficult to demonstrate. Ecosystem research has promoted a more integrative view and approach to such environmental problems. Therefore, conceptual tools can be created as a means to simplify and present a manageable view of reality for systems under study. These system approaches are being used to describe how factors work in the real world, thus furthering our understanding of human interaction within the environmental system. Many types of system approaches have been developed to demonstrate the interactions between anthropogenic activities and effects on the physical environment. These tools include Driver - Pressure - State Changes - Impact - Response (DPSIR) and Ecological Footprint (EF). In this chapter, the DPSIR framework tool will be used in combination with Geographical Information Systems (GIS) to demonstrate the effects of land based activities on the marine system in three islands in the Caribbean Sea.

4.2 Review of System Approaches Applicable to this Study

4.2.1 The Ecological Footprint

In 1996, Wackernagel and Rees developed the ecological footprint (EF) tool. It is defined as an accounting tool that enables the estimation of resource consumption and waste assimilation requirements of a defined human population and/or economy in terms of a corresponding productive area (Wackernagel and Rees, 1996). The idea of the EF is based on the premise that every person, process and activity has an impact on the earth. These impacts are caused by the usage of resource, generation of waste and the use of services provided by nature (Wackernagel and Rees, 1996). In the EF calculation, these impacts are translated into biological productive areas (Wackernagel and Rees, 1996). The proponents of the EF note that sustainability is achieved if the carbon sink[33] is achieved (Global Footprint Network, 2003). The EF has six land categories which is used to make its estimation (Wackernagel and Rees, 1996; Van Den Bergh and Verbruggen, 1999; Van Kooten and Bulte, 1999)

The EF can be calculated for a population, a city, a nation, a sport event (Collins and Flynn, 2005) or for the global population. According to Wackernagel and Rees (1996), this method can assess the overdraft of a population with regard to the amount of resources available on earth. An EF was calculated for the current global human population using the current way of living. The result showed that the human population needs about 12-20% more resources than what the planet can generate (Global Footprint Network, 2003). Also, it is estimated that it takes more than 14 months for the earth to regenerate the resources consumed in one year (Global Footprint Network, 2003).

To date, the EF is recognised as a tool to assist in achieving sustainability and has been internationally endorsed for its application in many programmes such as UNDP. It is regarded as user-friendly because of its apparent ease to aggregate sustainability data, resource and waste flow into measurable data. However, many shortcomings were identified in the EF method. These flaws have been highlighted in many reviews. Critics such as Van Den Bergh *et. al.* and Van Kooten *et al* (1999) suggest that the EF is over ambitious in its application. The shortcomings are summarised in Table 4.1.

[33] Forests and other ecosystems that absorb carbon, thereby removing it from the atmosphere and offsetting CO^2 emissions. (EEA,2004)

Table 4.1: A Review of the Identified Shortcomings of the Ecological Footprint

THEMES	SHORTCOMINGS
Usefulness of EF	Van Kooten *et. al.* (1999) argued that the developer of the EF tool attempted to replace existing measures of monetary (Hueting, 1989; Pearce and Atkinson, 1995) and biophysical (Rennings and Wiggering, 1997) sustainability with the single measurement of the EF. This can lead to a much less useful indicator (Van Kooten and Bulte, 1999).
Aggregation Techniques	Van Kooten *et. al.* (1999) and Van Bergh *et. al.* (1999) argued against this method because they claimed that too little is known about how to convert resources and waste flows into productive land area.
Discounting	The EF is a static measure in which discounting is not considered. This omission and the aggregation technique are viewed as flawed assumptions upon which the EF was devised and according to Van Den Bergh *et. al.* (1999), the EF has not dealt with sustainability effectively.
One Dimensional Indicator	Van Den Bergh *et. al.* (1999) argued that the EF provides a one-dimensional indicator by summing up all the consumption related directly or indirectly to ecological impacts of a region or person in terms of land use. Such conversion takes no account of local features of land use and/or land use types.
Land Categories	The EF categories of land received fixed weight schemes (Van Kooten and Bulte, 1999), even though their environmental impacts are very distinct and different. For example, land use by infrastructure has the same weight as land use by agriculture. This weight schemes can produce odd results (Van Den Bergh and Verbruggen, 1999). Also Van Den Bergh *et. al.* (1999) noted that the EF does not distinguish between sustainable and unsustainable use of land and does not focus on the processes that contribute to unsustainability. This inadequacy of the land categories will not provide a good indication of impacts, if applied to this study and can misinform the process.
Use of Energy Concept	The EF uses an estimated land area, which is needed to assimilate CO_2 emission from burning fossil fuels. It relies heavily on this to measure sustainability. This generalisation has failed to consider the varying levels of carbon sequestration rate of forest. It is known that CO_2 is used in photosynthesis process also for storage however, carbon storage is not equal in all forest types. Research has suggested that longer lived higher density trees store more carbon than short lived low density fast growing plants (Costa Moura, 1996). Therefore, the EF usage of land area and forest types may be flawed primarily because sequestration rates vary. Van Den Bergh *et. al.* (1999) and Lomburg (2001) questioned the practicality of the EF sustainability energy concept of planting green spaces to absorb emitted CO_2. They pronounced this measure as impractical because of the inadequate available land, which is suitable for the forest. This inadequacy is evident in the SIDS of the Caribbean as there are already competing demands for the land area. This demand does not allow for many green spaces that are needed for the EF to work.
Land Area Calculation	The EF includes calculations, which are done at regional and national scales. These are geo-political borders, which in many cases do not correspond with the border of the land use types and/or land categories. Van Kooten *et. al.* (1996) noted that the EF does not account for soil erosion, which is important in deciding the sustainability status of a particular place.

From the above account, it is evident that the EF has its shortcomings and Van Kooten *et. al.* (1999), Van Den Bergh *et.al.* (1999), Levett (1998) have all questioned the proclaimed ability of the EF. However, they all agreed that it is a useful tool in increasing awareness of human consumption trends. This is important especially where consumption patterns have direct and/or indirect bearings on carbon emissions. It should not be used to inform policy because as Van Den Bergh *et. al.* (1999, page 69) concluded *"the EF is an unsuitable tool for informing policy making – it can support unsustainable, inefficient and even immoral policy options."*

Overall, this review presents the advantages and disadvantages of the EF. It is evident that the EF is a step forward in attempting to deal with the complexities of sustainability. In this regard, the attempt made by Wackernagel and Rees in producing such tool is a breakthrough in conceiving a method of its kind. However, in view of the shortcomings discussed above, the EF if applied to this study would produce more unanswered questions. It would not be a desired method in producing information for policy making within the scope of this study. Another concern with the application of the EF in this study is that it does not provide information or scope on the spatial distribution of environmental impacts, effects or the causes of environmental pressures. In addition, it has no provision to deal with the marine environment.

4.2.2 DPSIR (Driver-Pressure-State Changes-Impact-Response)

The DPSIR as it is known now has evolved from many different forms as shown in Figure 4.1. It was first conceptualised as Stress - Response (SR) and then modified to many versions including the DPSIR by various agencies. The definitions of the terms used by the credited agencies are summarised in Table 4.2.

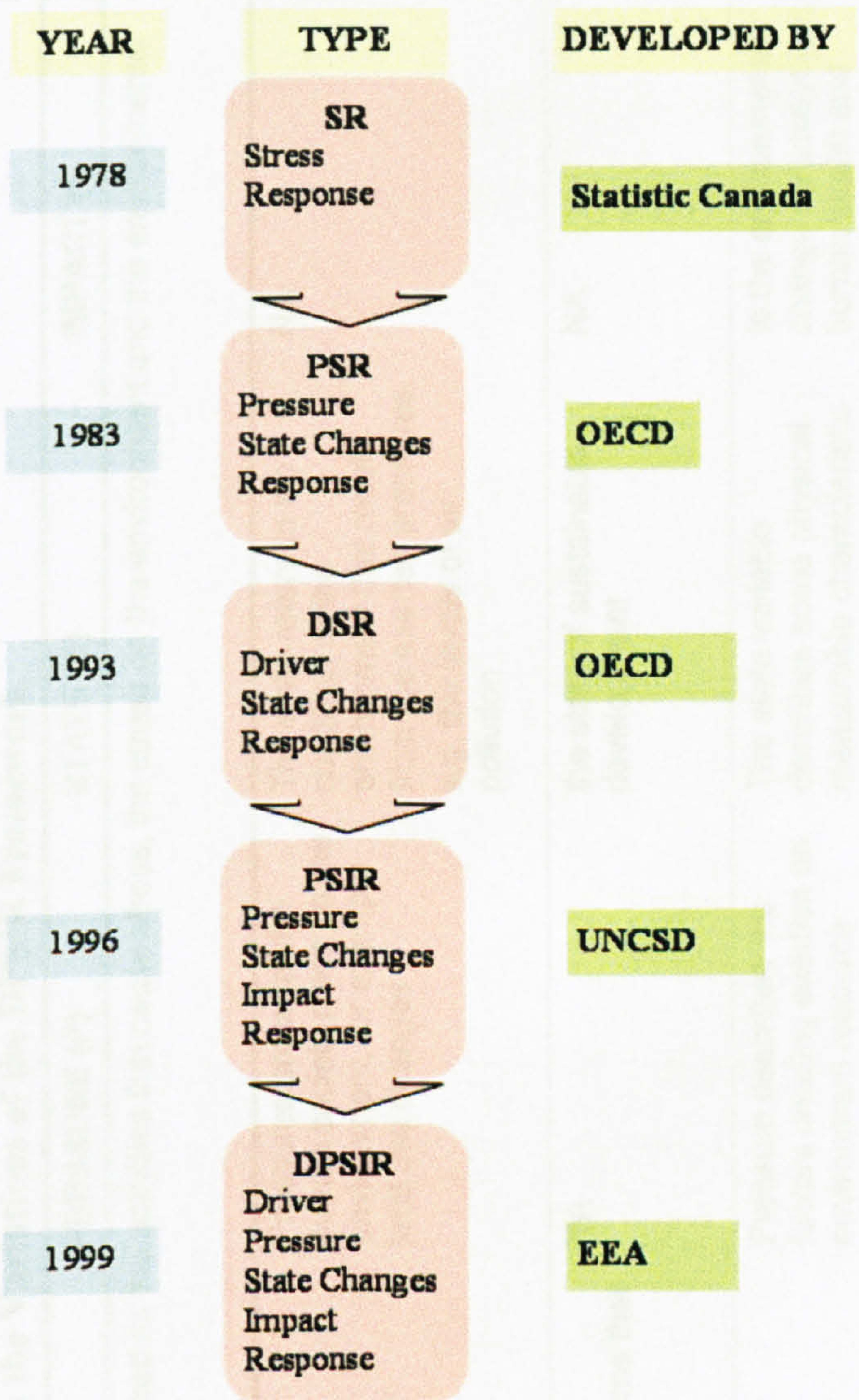


Figure 4.1: The Evolution of the DPSIR Framework
OECD = Organisation of Economic Cooperation and Development,
UNCSD = United Nation Commission on Sustainable Development,
EEA = European Environment Agency

Table 4.2: The Definitions used in the Variations of the DPSIR Framework

FRAMEWORK	DRIVER (D)	PRESSURE (P)	STATE (S)	IMPACT (I)	RESPONSE (R)
SR Rapport and Friend, (1979)	The Stress was defined as the activities that cause stress, the stress on the environment and the environmental response.				Actions taken by human to respond to the stress
PSR OECD, (1983)	NA	Pressures are what the human society place on the environment, for example land use changes	The state refers to the condition of the environment that results from the exerted pressures, e.g. the levels of air pollution	NA	Actions taken by society either individually or collectively, that are designed to ease or prevent negative environmental impacts e.g. regulatory actions
DSR OECD, (1994)	Human activities, processes and patterns that impact on the environment	NA	the state of sustainable development	NA	Policy options and other responses to changes in sustainable development
PSIR UNCSD, (1996)	NA	Pressure describes the factors creating exertion on environment resource based	The *state* variable describes some physical measurable characteristic of the environment that results from the pressure.	Is the environmental change on ecosystem, human health and wellbeing	The response variables are those policies, actions or investments that are introduced to solve the problem
DPSIR Smeets & Weterings, (1999)	Processes and anthropogenic activities (production, consumption, recreation etc) in an area (country, watershed etc)	The direct stress, deriving from the anthropogenic system and affecting the natural environment, i.e. pollutant release	Reflects the environmental conditions of the natural systems (air, soil and water quality)	A measure of the effects on humans due to changes in the state of environmental systems	The evaluations of actions oriented to solve environmental problems in terms of management strategies

NA = Not Assessed

The Stress - Response (SR) framework was the first version of the DPSIR. It was developed by Statistics Canada to organised environmental statistics (Rapport and Friend, 1979). The SR focused on the interface between production-consumption activities of human and the transformation of the state of the environment. This framework has been applied in studies such as Gabriel and Kreutzwiser, (2000).

Pressure - State Changes - Response (PSR) framework is the second variation developed by OCED. This variation is based on a concept of causality (OECD, 1993b) and has the advantage of highlighting links (Segnestam, 2002). However, the PSR framework was deemed inadequate because of its inability to demonstrate how a degraded environment affects human welfare (Segnestam, 2002) . In addition, Berger and Hodge (1998) argued that the PSR ignores background natural processes that play a major role in determining environment and ecosystems health. The PSR framework has been applied to many studies. These include OECD (1993a), OECD (1993b), Gouzee *et. al.*(1995), Hammond *et. al.* (1995), Kjellstrom and Corvalan, (1995), Dumanski and Pieri (1997) and Turner (2000).

The third version is the Driver - State Changes - Response (DSR). In this framework, the 'driver' replaced the 'pressure'. This version allowed for a wider usage, because the DSR accommodates social and economic aspects in its application. The proponents of DSR version, noted that the 'driver' can highlight both positive and negative impacts of sustainable development (Virtual Research and Development Centre, 2002). Studies such as Tung *et. al.* (2005) utilised the DSR approach.

The fourth version is the Pressure - State Changes - Impact - Response (PSIR), in which an impact category was added to the framework. This was developed as a result of a need to separate the state of the environment, from the impacts on the environment and human wellbeing (Winograd *et. al.*, 1998). This is being widely used in health related programmes and studies such as Turner *et. al.* (1998a), UNCSD (1996) and UNDP (2002).

The fifth version is the Driver - Pressure - State Changes - Impact - Response (DPSIR), which combines all the categories. According to The Virtual Research and Development Centre (2002), it provides an overall mechanism for analyzing environmental problems. In particular, the DPSIR is a tool for organising environmental information and presenting causal connections between various environmental parameters for decision makers. It is the most widely used of all the variations of this framework. Its application included studies such as Donta (2005), Karageorgis *et. al.* (2005), Pirrone *et. al.* (2005), Bidone and Lacerda (2004), Turner *et. al.* (2004), Vacca and Marrone (2004), Pirrone *et. al.* (2003), Walmsley (2002), Turner *et. al.* (1998b), Yoon and Lee (2003), Cassazza *et. al.* , Seppo *et.al.* (2003), Elliot (2002), Caeiro *et. al.* (2003) and Nunneri (2003)

Among the advantages of the DPSIR and its variations (hereon refers to as DPSIR), is its ability to analyze the cause-effect relationship between human actions and environmental consequences through a systems approach (OECD, 1993b; IIED, 2002). The DPSIR manages the information flow in order to logically decipher the policy and actions needed and links policy objectives and targets (Cassazza *et. al.*, 2002).

The major advantage of DPSIR is that it accommodates the use of indicators (OECD, 1993b), which can be used as proxies in the absence of empirical data. Mysiak *et. al.* noted that in order for the DPSIR to support specific use, the number and types of indicators, as well as available data have to be well defined. Where data are incomplete, the approach can still be used to show the inter-relationship between the anthropogenic activities and environmental pressures. Overall, the main strength of the DPSIR framework is that is it can logically demonstrate the linkages between activities in a system. Therefore, it is a useful approach to understanding the complexity of environmental issues in a logical way.

DPSIR has many shortcomings, which has been criticised in many studies. These are summarised in Table 4.3.

Table 4.3: Identified Shortcomings of the DPSIR

THEMES	SHORTCOMINGS	SOURCES
Over Simplification	The relationships between the different parts of society are over simplified in this approach when in fact these relationships are complex. In addition, it ignores the many linkages between issues and feedback within the socio-ecological system.	Seppo *et. al.* (2003) Rapport *et. al.*(1998) Rapport and Whitford,(1999)
Static Properties	DPSIR is performed on static indicators and cannot take into account the system dynamic, for example, pollution can only be dealt with if it has already happened. The response are always reactive.	Seppo *et al* (2003) Rapport *et al.*(1998) Rapport and Whitford,(1999)
Relationships	DPSIR cannot handle cause - consequence relationships.	Seppo *et al* (2003) Rapport *et al.*(1998) Rapport and Whitford,(1999) Segnestam, (2002)
Linear	It offers linear and unidirectional causal chains (cause - effect models). It cannot deal with vertical or horizontal integration.	Seppo *et. al.* (2003) Rapport *et al.*(1998) Rapport and Whitford,(1999) Segnestam, (2002)
Analytical Ability	Environmental trends can be analysed only by repeating the indicator reports at regular intervals.	Seppo *et. al.* (2003) Rapport *et al.*(1998) Rapport and Whitford,(1999)
Shift of Pressure	The response to one pressure can become a pressure on another part of the system.	Garcia and Stapleton Lenz *et. al.* (2000)

It is evident from the discussion above that this framework has its advantages and disadvantages. Regardless, the DPSIR approach is particularly applicable to the scope of this study. Therefore, it will be used to chronicle land based activities (economic sectors) on the islands and their influences in the marine environment (causal links). The integrated approach proposed for this study is based on the modified DPSIR framework as shown in

Figure 4.2. The stakeholders contributing to these pressures in the islands along with the marine habitats that are at risk are also included in this application. In addition, based on Table 4.2, the working definitions of the DPSIR were adapted and modified to reflect the application to this study. These modified definitions are presented in Figure 4.2.

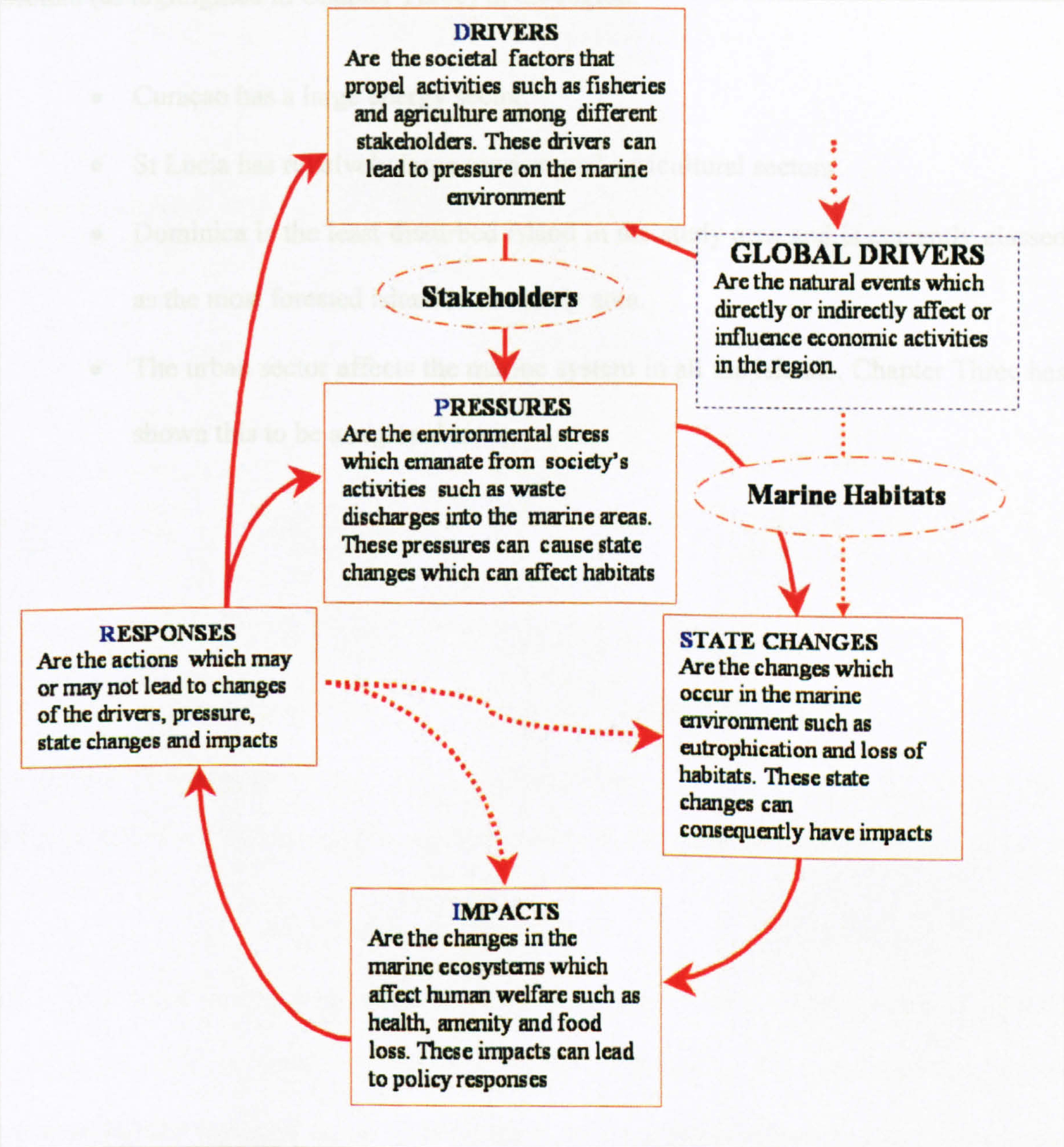


Figure 4.2: Conceptual DPSIR Model applied to islands in the Caribbean. The derived definitions of each component is shown in the DPSIR. Modified from LOCIZ Approach (Kremer *et. al.*, 2004).

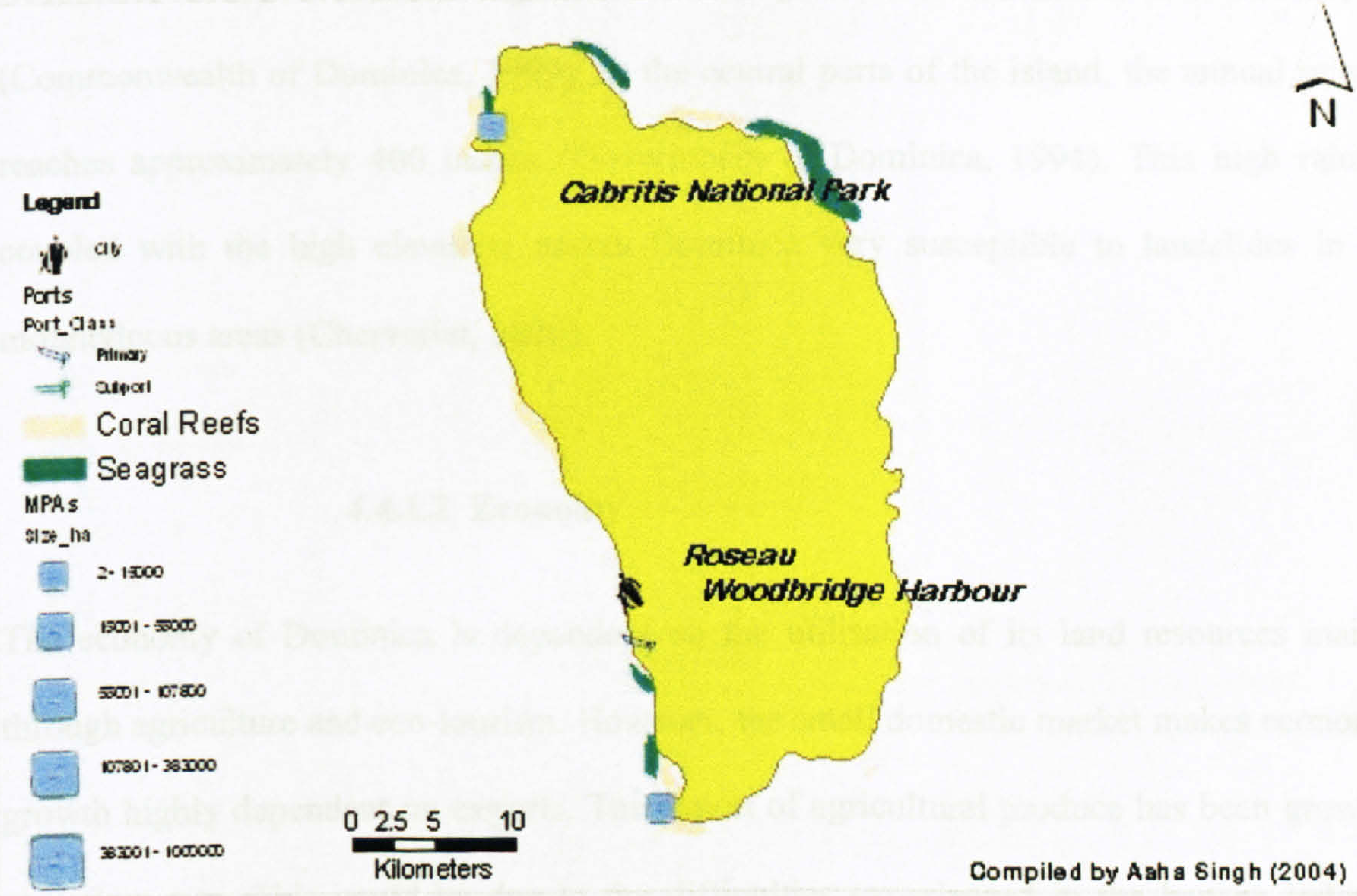
4.3 DPSIR Application to Three Islands in the Caribbean

In this study, the DPSIR framework will be applied to Dominica, St Lucia and Curaçao to show the causal links between economic sectors and effects on the marine environment. These islands were chosen in order to provide representative examples of the economic sectors (as highlighted in Chapter Three) in the region:

- Curaçao has a large energy sector.
- St Lucia has relatively large tourism and agricultural sectors.
- Dominica is the least disturbed island in the study area and is currently classed as the most forested island in the study area.
- The urban sector affects the marine system in all the islands. Chapter Three has shown this to be a regional issue.

4.4 Description of Study Area

4.4.1 DOMINICA



Area	**754 sq km** *(CIA,2004)*
Capital	**Roseau**
Population& Density	**Total 75 000, 100/sqkm**
Location	**15^0,13' N, 61^0, 25' W**
Language	**English**

Figure 4.3: Geographic and Demographic Features of Dominica.

4.4.1.1 General Description

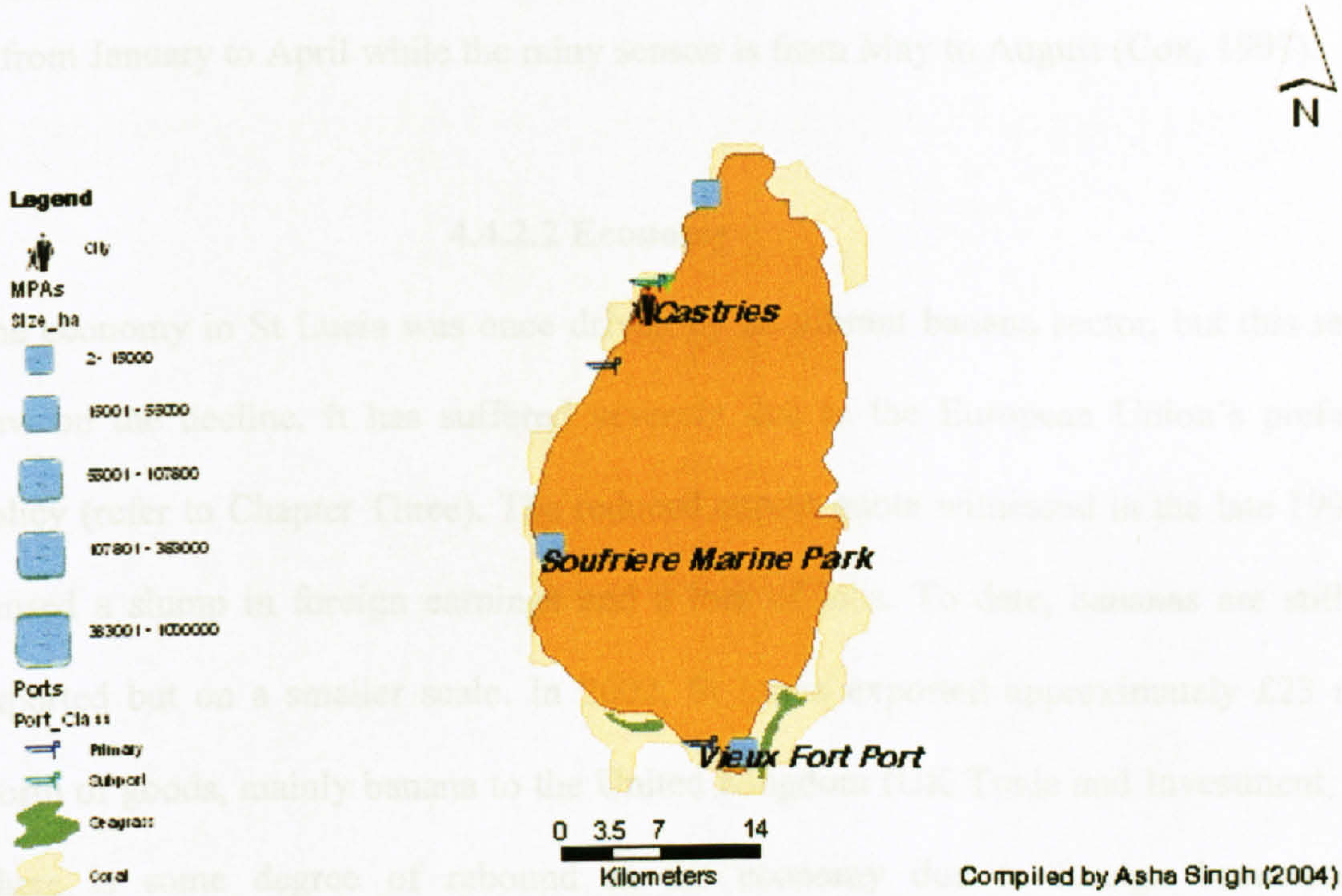
Dominica is an independent territory with approximately sixty - five percent of its land area still covered by natural vegetation (Hypolite *et. al.*, 2002). The vegetation type ranges from dry scrub woodland on the West Coast to lush tropical rainforest in the interior of the island. The large percentage of vegetation cover on the island makes it the "least disturbed ecosystem" within the study area. Forest is estimated to cover 22.6% of the total area, with arable land covering 27.8 % (Ministry of Agriculture and Environment, 2000). The coastline is 148 Km (CIA, 2004e) with maritime claims of 200 NM.

The island's varying elevation allows for microclimates within short distances. This is influenced by the high moisture content of the air masses entering from the Atlantic Ocean, hence the climate of Dominica is classified as a humid tropical marine (Commonwealth of Dominica, 1999). Dominica registers an average annual rainfall of 175 inches/year (Commonwealth of Dominica, 1999). In the central parts of the island, the annual rainfall reaches approximately 400 inches (Government of Dominica, 1994). This high rainfall coupled with the high elevation makes Dominica very susceptible to landslides in the mountainous areas (Cherveriat, 2000).

4.4.1.2 Economy

The economy of Dominica is dependent on the utilisation of its land resources mainly through agriculture and eco-tourism. However, the small domestic market makes economic growth highly dependent on exports. The export of agricultural produce has been growing at a slow rate. This could be due to the difficulties experienced in the banana industry (refer to Chapter Three). In addition, fluctuations in non banana exports have contributed to the deterioration of the trade balance. However, during 1995-1999, Dominica registered an average economic growth of 2% per annum (CDB, 2002e; World Bank, 2002). The economic activities are the main drivers in Dominica. These are further discussed within the DPSIR framework for Dominica.

4.4.2 ST LUCIA



Area	**616 sq km** *(CIA, 2004)*
Capital	**Castries**
Population & Density	**Total 139 000, 226/sqkm**
Location	**13^0, 53' N, 60^0 68' W**
Language	**English**

Figure 4.4: Geographic and Demographic Features of St Lucia

4.4.2.1 General Description

The island of St Lucia is volcanic and mountainous with over 80% of the country's land area having slopes greater than 10 degrees (Cox, 2003). There are a number of fertile valleys, which are occupied by settlements, agriculture and/or industrial activities. The highest area on the island is Mount Gimie, which reaches an elevation of 950 m (Towle *et. al.*, 1991). St Lucia has a coastline of 158 km in length (CIA, 2004j) and a 200NM maritime claim.

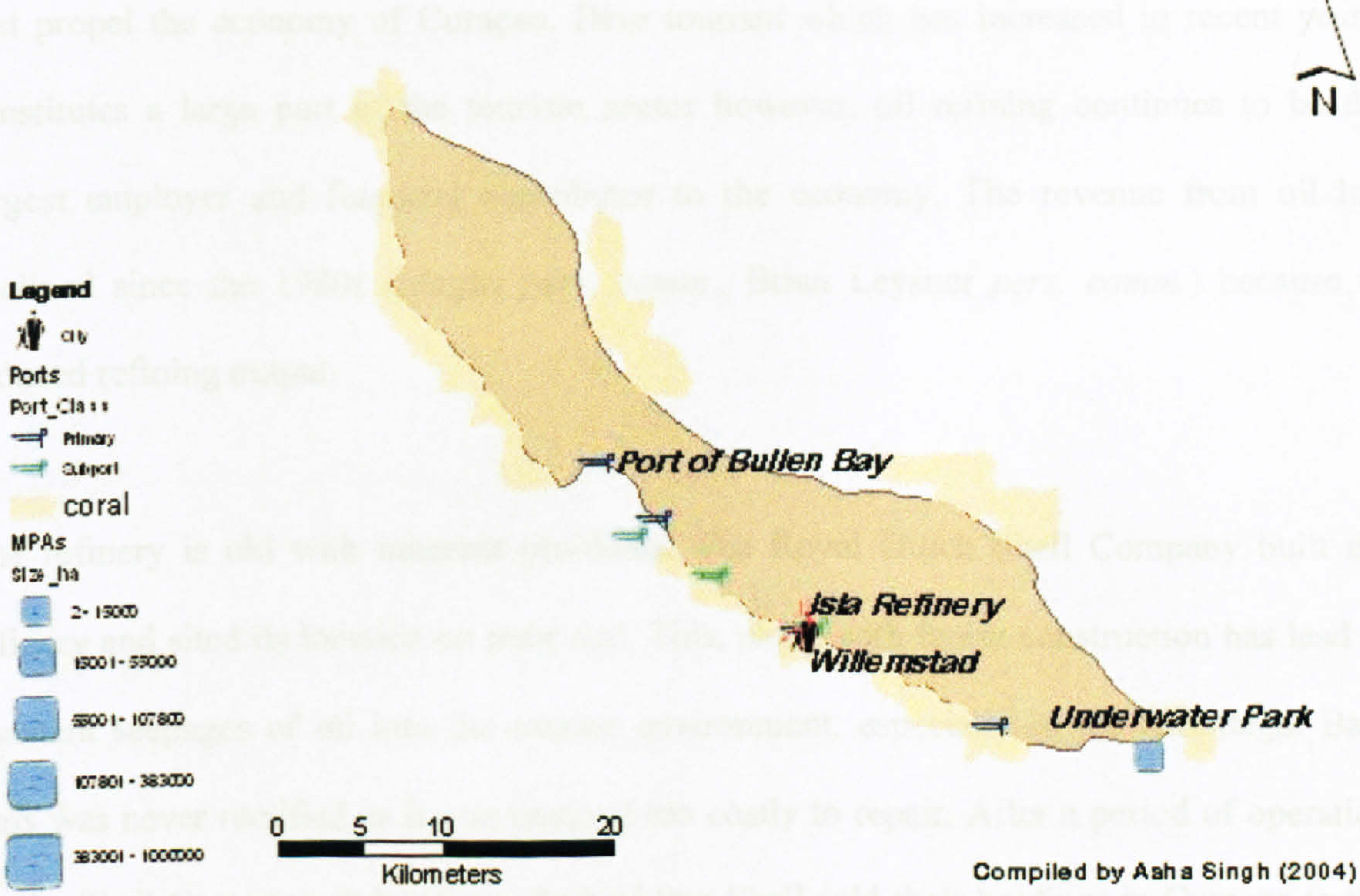
The climate is tropical and is moderated by the northeast trade winds. St Lucia experiences an average temperature of 27°C (Cox and Madramootoo, 1998). The average annual rainfall varies on the island; the coastal area records approximately 2,032 mm while the mountainous areas register in excess of 3,048 mm (Bushnell *et. al.*, 2001). The dry season is from January to April while the rainy season is from May to August (Cox, 1997).

4.4.2.2 Economy

The economy in St Lucia was once driven by its vibrant banana sector, but this sector is now on the decline. It has suffered severely due to the European Union's preferential policy (refer to Chapter Three). The reduced export quota witnessed in the late 1990s has caused a slump in foreign earnings and a loss of jobs. To date, bananas are still being exported but on a smaller scale. In 2002, St Lucia exported approximately £23 million worth of goods, mainly banana to the United Kingdom (UK Trade and Investment, 2003). There is some degree of rebound in the economy due to foreign businesses and investments. The increased earnings are in the offshore banking and tourism sectors (CIA, 2004j). At present, the manufacturing sector is the most diverse in the Eastern Caribbean[34] island block, but tourism remains the most important economic entity and the largest GDP contributor (World Bank, 2002). The activities in the economic sectors in St Lucia are causing pressures on the marine environment. These issues will be discussed within the DPSIR framework for this island.

[34] The Eastern Caribbean (EC) is a group of countries which shares a common currency and other institutional mechanisms. The EC islands are Anguilla, Antigua and Barbuda, Dominica, Grenada, Montserrat, St Kitts and Nevis, St Lucia and St Vincent and the Grenadines

4.4.3 CURAÇAO



Area	**444 sq km** *(CBS, 2004)*
Capital	**Willemstad**
Population & Density	**Total 142112, 320/sqkm**
Location	**12^0, 10' N, 68^0, 93' W**
Language	**Dutch (Papiamento)**

Figure 4.5: Geographic and Demographic Features of Curaçao

4.4.3.1 General Description

Curaçao is the largest of the islands that make up the Kingdom of the Netherlands Antilles. It is 61 km in length and is approximately 14 km wide (Anonymous, 2003a). This island is relatively flat, except for Mount Christoffel which reaches a height of 375 m (Graphic Maps, 2004). The geology of Curaçao is comprised of karstic soil and in general, the island is classified as semi arid. Annual rainfall averages at 570 mm (Curaçao Travelguide, 2005), with one rainfall season from October to February. The average temperature on the island is 27^0C (Martis *et. al.*, 2001).

4.4.3.2 Economy

Oil refining, transhipments, container repairs, offshore banking and tourism are the sectors that propel the economy of Curaçao. Dive tourism which has increased in recent years, constitutes a large part of the tourism sector however, oil refining continues to be the largest employer and financial contributor to the economy. The revenue from oil has declined since the 1980s (Magda *pers. comm.*, Brian Leysner *pers. comm.*) because of reduced refining output.

The refinery is old with inherent problems. The Royal Dutch Shell Company built the refinery and sited its location on poor soil. This, along with faulty construction has lead to constant seepages of oil into the marine environment, especially in the Schottegat Bay. This was never rectified as it was deemed too costly to repair. After a period of operation by the Shell Company, it has been claimed that Shell sold their holdings in Curaçao to the Dutch Government. As part of this deal, the government cannot make the Shell Company liable for any pollution and/or environmental damages that occurred while in business on the island (Faizal *pers. comm.)*. The environmental implications of the oil industry in Curaçao are further discussed within the DPSIR.

4.5 Methodology

The linkages between activities in the economic sectors and their influences on the marine environment were demonstrated via the DPSIR framework. To populate the DPSIR framework for each island, indicators were used to demonstrate the linkages in the various components of the DPSIR. The selection of indicators for the DPSIR was based on their relevance and data availability. It should be noted, that data availability in the assessment is inadequate, thus in some instances, evaluation of literature and interviews were used to demonstrate various components of the DPSIR.

The application of the DPSIR in the context of this study is limited by adequate monitoring data on marine parameters. In some cases, the information does exist, but is not in the public domain. This is a regional problem, which has affected the management of the marine environment. The absence of adequate monitoring data has resulted in the inadequate response by policy makers to deal with these issues. In general, land based management does not take into account marine issues. To deal with the inadequacy of data and to propose the incorporation of the marine environment into planning, a devised GIS based approach of using land use information was incorporated within the DPSIR to demonstrate pressures on the marine system. In addition, the DPSIR does not decipher which activity or sector is causing the stated pressure because of its lack of spatial analysis. Therefore, the incorporation of GIS into this framework will address some of the shortcoming of the DPSIR.

4.5.1 Data Collection

4.5.1.1 Interviews and Other Information

Individual face - to- face interviews (Brenner, 1987; Easterby-Smith, 1991; Lee, 1993; Hussey and Hussey, 1997) were conducted during a field visit to Dominica (6 days), St Lucia (4 days) and Curaçao (2 days), in August 2004. The interviewees were employees of various government agencies in each country. These agencies are responsible for various aspects of environmental and resource management within their portfolio. The interviews were semi-structured and were based on open-ended questions regarding issues relating to the marine environment. The interviews were transcribed and crosschecked with other interviewees and/or available literature. This was done in order to ensure that the information provided were accurate accounts and reflected the current situation in each island. These interviews were important because there is a deficit in published literature regarding these issues. In addition, the field visits provided an insight and visual assessment into the problems, which were incorporated into this study.

Other information including statistical data were collected from published/unpublished which are used as indicators within the DPSIR.

4.5.1.2 Spatial Data

Spatial data on various types of land use were compiled from various sources for the islands. These are presented in Tables 4.4 for Dominica, St Lucia and Curaçao respectively. Land use data were used as indicators to represent the economic sectors of the islands. Seagrass and coral reef data were used as indicators to represent the ecosystems, which are subjected to pressures from the land based activities.

Table 4.4: Indicators and Sources of data used for the Economic Sectors in Dominica, St Lucia and Curaçao

Sectors	Indicators Compiled as Themes	Format	Source
		DOMINICA	
Fisheries	coral reef	Digital data provided	Dominica Fisheries Department, (2004)
	sea grass		
	conch sites		
Tourism	hotels	Digital data compiled	Compiled using information from Ministry of Planning (2004)
Agriculture	agricultural areas –land use		Compiled using information from Drigo (2001)
Energy	fuel station locations	Digital data provided	Ministry of Planning (2004)
Industrial	factories		
	industries		
	quarries		Ministry of Planning (2004)
Human Activities	settlement locations	Digital data compiled	Compiled using information from Drigo, 2001
		ST LUCIA	
Fisheries	coral reef	Digital data provided	St Lucia Ministry of Planning, (2004)
	seagrass		
Tourism	hotels	Digital data compiled	Compiled using information from Reconnaissance Survey (GPS coordinates), Map (Anonymous, 2003d) ,
	golf course		
Agriculture	agricultural areas –land use		
Energy	fuel stations		
Industrial	factories		
	industries		
Human Activities	settlement locations		
		CURAÇAO	
Fisheries	coral reef	Digital data provided	UNEP/WCMC, 2003
Tourism	hotels	Digital data compiled	Compiled using information from Reconnaissance Survey GPS coordinates, Curacao Road Map (Van Koophandel and Nijverheid, 2003), Ministry of Health and Social Development (2005)
Energy	oil terminal		
Industrial	factories		
	industries		
	refinery		
Human Activities	settlement locations		

4.5.2 Data Analysis

4.5.2.1 Interviews and Information Collection

Information was gathered from reconnaissance visit to the islands, literature and interviews were analysed and evaluated to inform the DPSIR for each island. The issues and indicators complied for each component of the DPSIR are outlined in Tables 4.5, 4.6 and 4.7 for Dominica, St Lucia and Curaçao respectively.

Table 4.5: Selection of Issues and Indicators of the DPSIR for Dominica

Type	Issues	Indicator	Notes	Source
Driver	Urbanisation	Urban population (1961-2000)	Dominica has one city, which is classified as the urban area. This city is located on the coast	FAO, (2002)
	Population	Total population (1961-2000)	Over 80% of the total population lives in coastal areas	FAO, (2002)
	Agriculture	Crop production		FAO, (2002)
	Fisheries	Number of fishermen	The fishing industry mainly coastal based	Compiled from various sources and interviews.
	Tourism	Cruise and stay – over visitors (1990-2000)	Most of the activities are coastal based (e.g. diving, snorkelling)	Compiled from WTO, (2005), and CTO, (2002)
	Industrial Activities	% Industrial contribution of the total GDP	Only available data	CDB (2002e)
Pressure	Sewage & waste water	Measurement of faecal coliform (2001) and BOD (2001)	Indicates the presence of sewage	Dominica Ministry of Health, (2001)
	Nutrient Input	Nitrates and phosphates measurement (2001)	Indicates pollution from sources such as agriculture, and other industries (detergent, sewage)	Dominica Ministry of Health, (2001)
	Sedimentation	Total suspended matter measurements (mg/l)	Indicates the sediment load in the water	Dominica Ministry of Health (2001)
	Fish Landings	Quantity of marine fish catches	extraction rates can provide indication of pressure on stock	FAO, 2002
State	Changes in nutrients, chemical compounds and sediments	Evaluation of literature and interviews; provide conclusions based on information gathered.		
	Loss of habitats	Comparison of coral reef 1988 and 2001		
	Loss of fish stock	Evaluation based on interviews and available literature		
	Eutrophication	Evaluation based on interviews and available literature		
	Pollution	Evaluation based on existing literature and interviews		
Impacts	Amenity area / bathing water	Evaluation based on interviews and available literature		
	Health risks	Evaluation based on interviews and available data on faecal coliform.	Large concentration of pollutants can be a health hazard	
	Aesthetic value	Evaluation based on interviews and available literature		
Response	Various Legislation	Review of relevant legislation and programmes		
	Management Policy & Plans			

Table 4.6: Selection of Issues and Indicators of the DPSIR for St Lucia

Type	Issues	Indicator	Notes	Source
Driver	Urbanisation	Urban population (1961-2000)	St Lucia has one city and four other urban areas. Three of the urban areas are located on the West Coast	FAO,2002
	Population	Total population (1961-2000)	Over 90% of the total population lives in coastal areas	FAO,2002
	Agriculture	Crop production (1960- 2000)	Agriculture is conducted on a large scale in St Lucia	FAO, 2002
	Fisheries	Number of Fishermen	The fishing industry mainly coastal based	Compiled from various sources and interviews.
	Tourism	Cruise and stay – over visitors (1990-2000)	Most of the activities are coastal based e.g. diving, snorkelling and swimming	Compiled from WTO ,(2005) and CTO, (2002)
	Industrial Activities	% Industrial contribution of the total GDP	Only available data	CBD, (2002g)
Pressure	Sewage & waste water	Measurement of faecal coliform (2003)	Indicates the presence of sewage	CEHI, (2004)
	Nutrient Input	Nitrates and phosphates measurement (2003)	Indicates pollution from sources such as agriculture, industries (detergent), sewage	(CEHI, 2004)
	Sedimentation	Total suspended matter (2003)	Indicates the sediment load in the water	CEHI, (2004)
	Industrial chemicals	Evaluation of literature and interviews		
	Fish Landings	Quantity of marine fish catches (1961-2000)	Extraction rates can provide indication of stock	FAO, (2002)
State	Changes in nutrients, chemical compounds and sediments	Evaluation of literature and interviews; provide conclusion based on information gathered		
	Loss of habitats	Comparison of coral reef 1988 and 2001		
	Loss of fish stock	Evaluation based on interviews and available literature		
	Loss of biological diversity	Evaluation based on interviews and available literature		
	Eutrophication	Evaluation based on interviews and available literature		CEHI, (2004)
	Pollution	Evaluation based on existing literature and interviews		
Impacts	Amenity area / bathing water	Evaluation based on interviews and available literature.		
	Health risks	Evaluation based on interviews and available data on faecal coliform.	Large concentration of pollutants can be a health hazard	
	Aesthetic value	Evaluation based on interviews and available literature.		
Response	Legislation Management Policy & Plans	Review of the relevant legislation		

Table 4.7: Selection of Issues and Indicators of the DPSIR for Curaçao

Type	Issues	Indicator	Notes	Source
Driver	Population	Total population	Over 90% of the total population lives in coastal areas	CBS, 2002
	Fisheries	Number of fishermen		Compiled from various sources and interviews.
	Tourism	Cruise and stay – over visitors (1990-2000)	Tourism is coastal based e.g. diving, snorkelling and swimming	compiled from WTO, (2005) and CTO, (2002)
	Industrial development	Evaluation based on interviews and available literature		Compiled from various sources and interviews.
Pressure	Sewage & waste water	Evaluation based on interviews and available literature		Compiled from various sources and interviews
	Hydrocarbon	Evaluation based on interviews and available literature		
	Industrial chemicals	Evaluation based on interviews and available literature		
	Fish Landings	Total catch		
State	Changes in nutrients, chemical compounds and sediments	Evaluation of literature and interviews; provide conclusion based on information gathered.		Compiled from various sources and interviews
	Loss of fish stock	Evaluation based on interviews and available literature		
	Loss of biological diversity	Evaluation based on interviews and available literature		
	Eutrophication	Evaluation based on interviews and available literature		
	Pollution	Evaluation based on existing literature and interviews		
Impacts	Amenity area / bathing water	Evaluation based on interviews and available literature		Compiled from various sources and interviews
	Health risks	Evaluation based on interviews and available data on coliform.	Large concentration of pollutants can be a health hazard	
	Aesthetic value	Evaluation based on interviews and available literature		
	Loss of fish stocks	Evaluation based on interviews and available literature		
Response	Legislation Management Policy & Plans	Review of the relevant legislation and programmes		

The issues for each component of the DPSIR are discussed within each case study to demonstrate the causal links. Further, the information gathered for each island was then compiled into a graphical layout using Microsoft Publisher version 2004, to summarise the connectivity of each component of the DPSIR.

Water quality monitoring data, which illustrate the pressures on the marine system, were compared to international acceptable guideline standards. These standards are shown in Table 4.8. This comparison was used to determine whether the recorded values were higher than the acceptable limit for recreational water. This is reported within the DPSIR for each country.

Table 4.8: Standards for Recreational Water used for Comparison in this Study

PARAMETERS	STANDARDS		
	WHO	LBS	BLUE FLAG
Faecal Coliform	<200 FU/100ML	200 mpn/100ml	< 100/100ml
BOD_5		30 mg/l	
TSS		30 mg/l	
Source	(WHO, 2003)	(UNEP, 1990)	(FEE, 2001)

WHO: International guideline values for recreational water
LBS Protocol: Values are standards for class I[35] recreational water for Caribbean Sea and Gulf of Mexico
Blue Flag: Caribbean guideline values for water quality of its beaches.

[35] Class I waters are areas of coral reef, seagrass and mangroves, critical breeding ground, nursery, protected habitat areas and recreational water

4.5.2.2 Spatial Data

The spatial data were inputted into ARC/GIS 8, where data manipulation was conducted as shown in Figure 4.6 to produce individual themes.

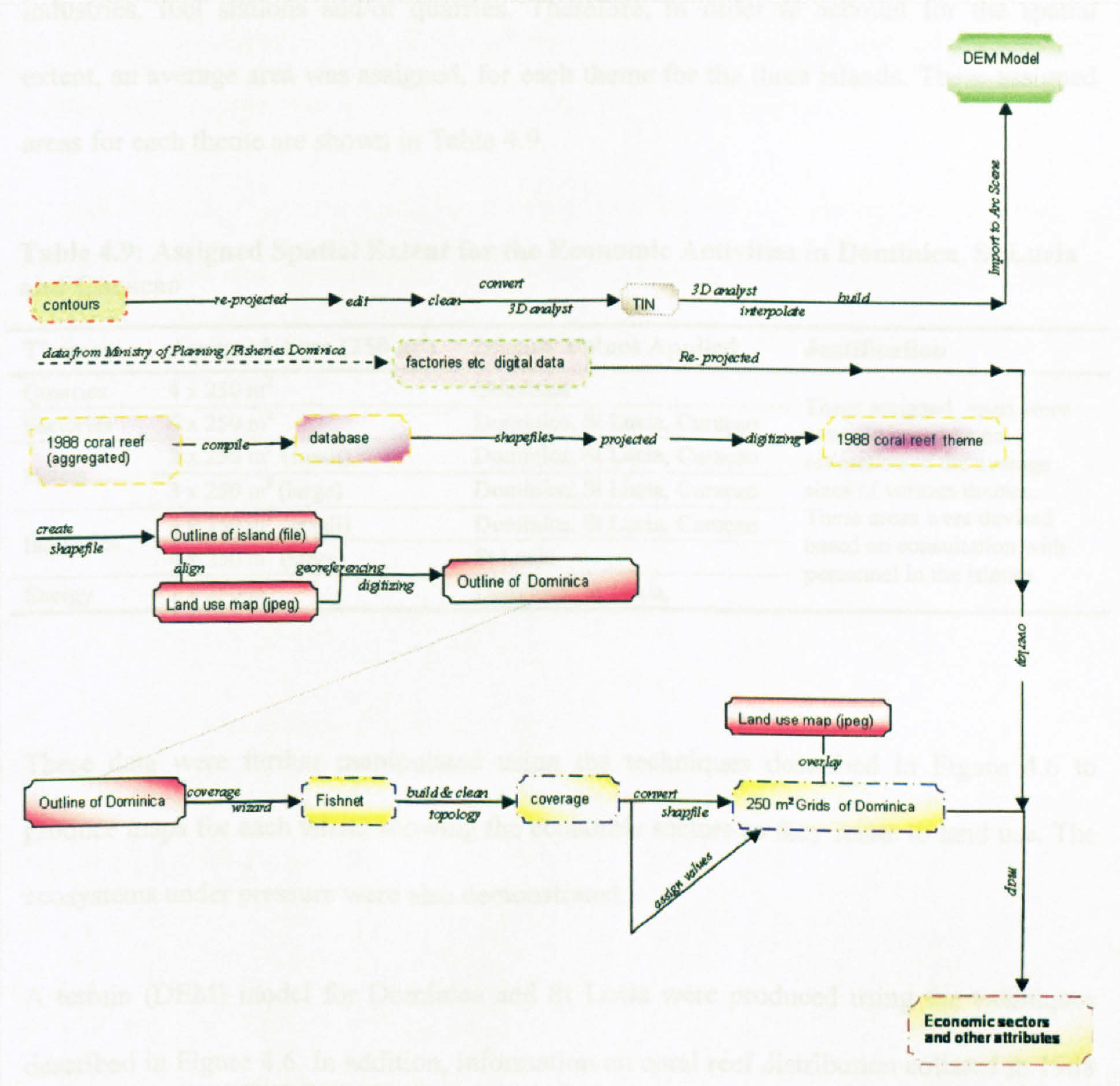


Figure 4.6: A Simplified Decision Tree of Techniques Used in Data Manipulation using Dominica, as an example

The 250 m^2 grid that was created along with the other themes were overlain. Each cell in the grid was assigned a value based on the land use type found within that cell.

No information exists on the spatial area (property size) for individual hotels, factories, industries, fuel stations and/or quarries. Therefore, in order to account for the spatial extent, an average area was assigned, for each theme for the three islands. These assigned areas for each theme are shown in Table 4.9.

Table 4.9: Assigned Spatial Extent for the Economic Activities in Dominica, St Lucia and Curaçao

Themes	Assigned Area (250 m^2)	Islands Values Applied	Justification
Quarries	4 x 250 m^2	Dominica	These assigned areas were selected based on an estimation of the average sizes of various themes. These areas were devised based on consultation with personnel in the islands.
Factories	6 x 250 m^2	Dominica, St Lucia, Curaçao	
Hotels	2 x 250 m^2 (small)	Dominica, St Lucia, Curaçao	
	3 x 250 m^2 (large)	Dominica, St Lucia, Curaçao	
Industries	3 x 250 m^2 (small)	Dominica, St Lucia, Curaçao	
	4 x 250 m^2 (large)	St Lucia	
Energy	1 x 250 m^2	Dominica, St Lucia,	

These data were further manipulated using the techniques described in Figure 4.6 to produce maps for each island showing the economic sectors as they relate to land use. The ecosystems under pressure were also demonstrated.

A terrain (DEM) model for Dominica and St Lucia were produced using the techniques described in Figure 4.6. In addition, information on coral reef distribution collated in 1988 by UNEP/IUCN (1988) was compiled and manipulated in GIS to reproduce the spatial extent of coral reef which were present in 1988 in Dominica and St Lucia. The data were then compared with the current information on the reef distribution to show the coral reef changes, during a 15-year period. The spatial data achieved in this analysis are used within the DPSIR conducted for each case study.

4.5.3 SWOT (Strength, Weaknesses, Opportunities, Threats) Analysis

SWOT analysis is a general tool which is used to assist decision makers in formulating strategies and policies (Johnson *et. al.*, 1989; Bartol and Martin, 1991; Balamuralikrishna and Dugger, 2001). It can be applied across diverse functions and activities. The SWOT analysis is an effective way of identifying the current strengths and weaknesses and examining the opportunities and threats which will require some form of intervention.

In this study, the response component within each DPSIR was further examined and a SWOT analysis was conducted for each island. In this analysis, the current strengths and weaknesses of the responses were identified based on the review of the responses. The opportunities and threats, which need to be considered to minimise the effects on the marine environment, were also identified. The results of the SWOT are presented for each island within the case study.

4.6 Results and Discussion

The results for Dominica, St Lucia and Curaçao are presented as individual case studies within the DPSIR framework.

4.6.1 DOMINICA

4.6.1.1 Drivers

(a) Population

The population of Dominica was approximately 75,000 in 2000 (FAO, 2002). Available data from 1961 showed a general increase in total population from approximately 60,000 in 1961 to 75,000 in 2000. This is shown in Figure 4.7. The largest urban area in Dominica is the City of Roseau. The urban population constitutes a large proportion of the overall population with over 54,000 as shown in Figure 4.7. Overall, the observed distribution of both the total and urban populations is among the identified drivers that are placing stress on the Caribbean Sea.

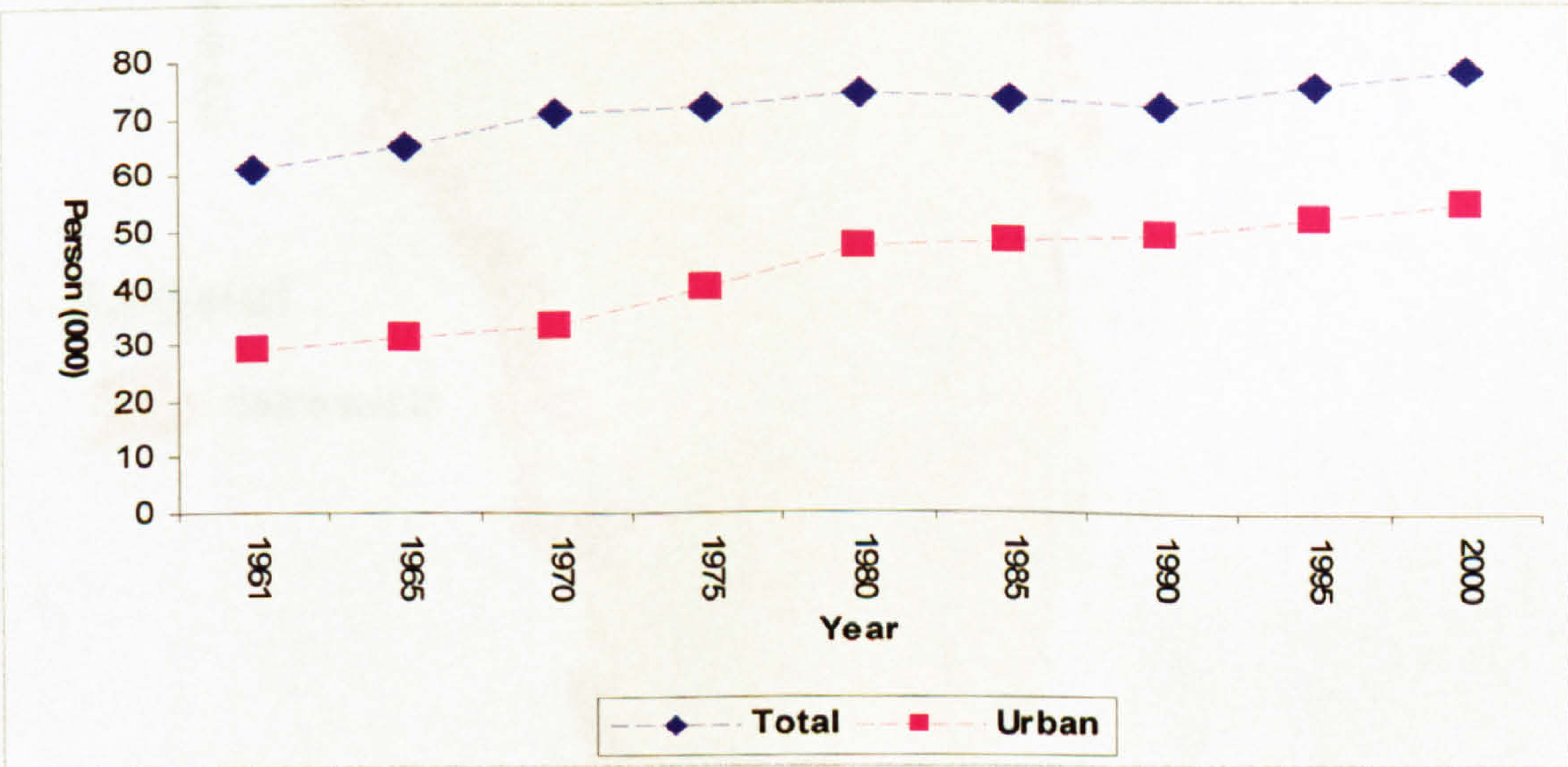


Figure 4.7: Total and Urban Population of Dominica 1961-2000. Compiled using data from FAO, 2002

The settlement pattern as shown in Figure 4.8, is characterised by small pockets of settlements. Most of these settlements are located in close proximity to the Caribbean Sea (West Coast of Dominica), indicating a greater population pressure on the environment in this area than other areas in the country. Geologically, the West Coast of Dominica is the least suitable area for settlements because the water table is high and in many areas, the ground water is susceptible to contamination (John Rapheal *pers. comm.*). This high concentration of West Coast settlement is due to the level of infrastructural development.

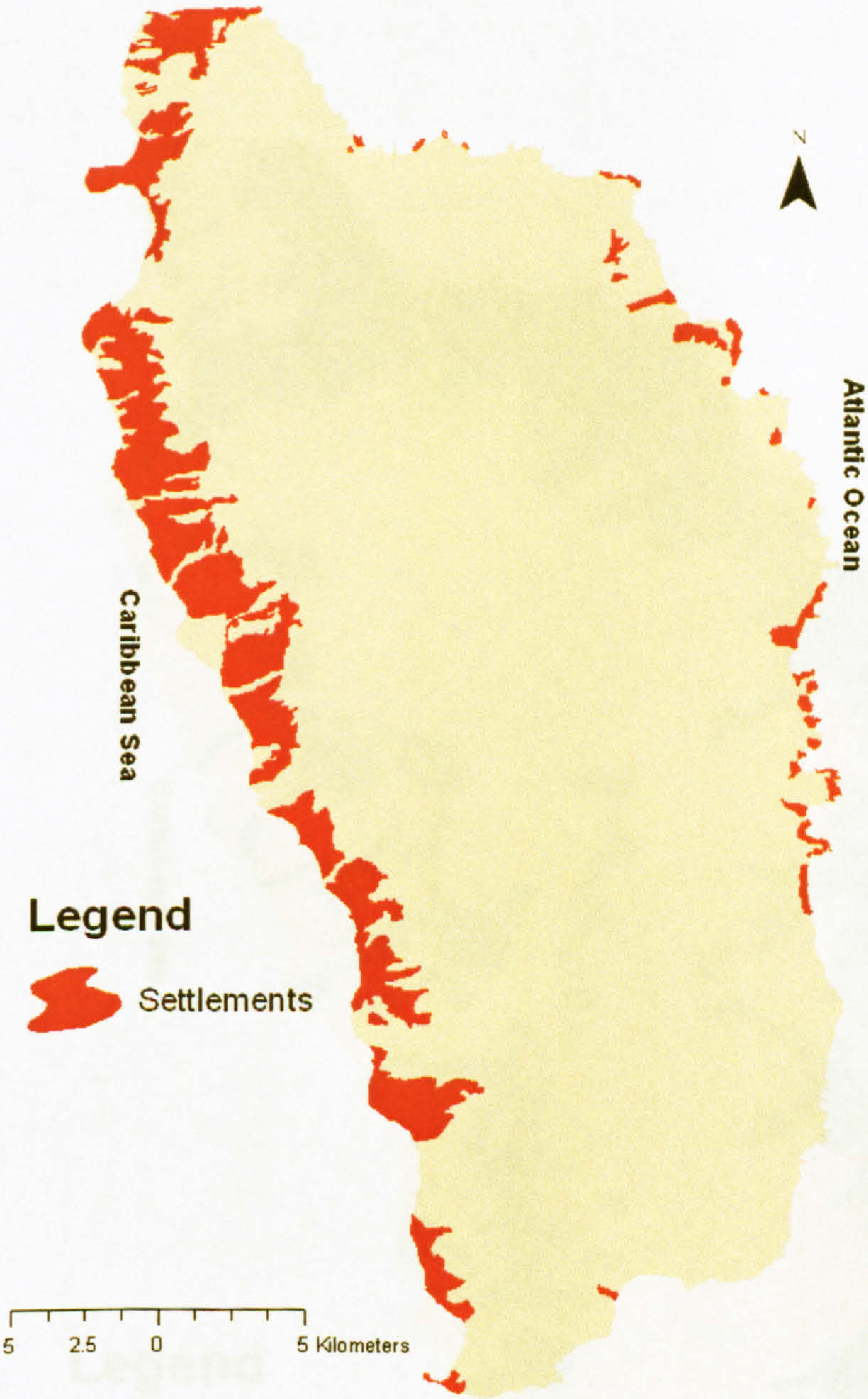


Figure 4.8: Map Showing the Settlements in Dominica. This map was derived using digital information from Ministry of Planning, (2004)

(b) Agricultural Activities

Most of Dominica's land area is unsuitable for agriculture because of its mountainous terrain. Agricultural areas are concentrated on the gentle sloping areas, which are mostly in the coastal region as shown in Figure 4.9.

Figure 4.9: Map showing Agricultural Areas in Dominica. This map was derived using digital information from Ministry of Planning, (2004).

Many different types of crops are cultivated such as bananas (*Musa spp.*L.), maize (*Zea mays* L.), sweet potatoes (*Ipomoea batatas* L.), yams (*Dioscorea spp.*) and vegetables. The highest agricultural output for the data period was in 1990, as shown in Figure 4.10. Banana is the most cultivated crop in Dominica and accounts for over 40% of production output in the agricultural sector. Overall, both total and banana crop production for the period examined has fluctuated in Dominica. In 1979, 1980 and 1995, Dominica was affected by hurricanes. The occurrences of these hurricanes may have contributed to the fall in production for the corresponding years.

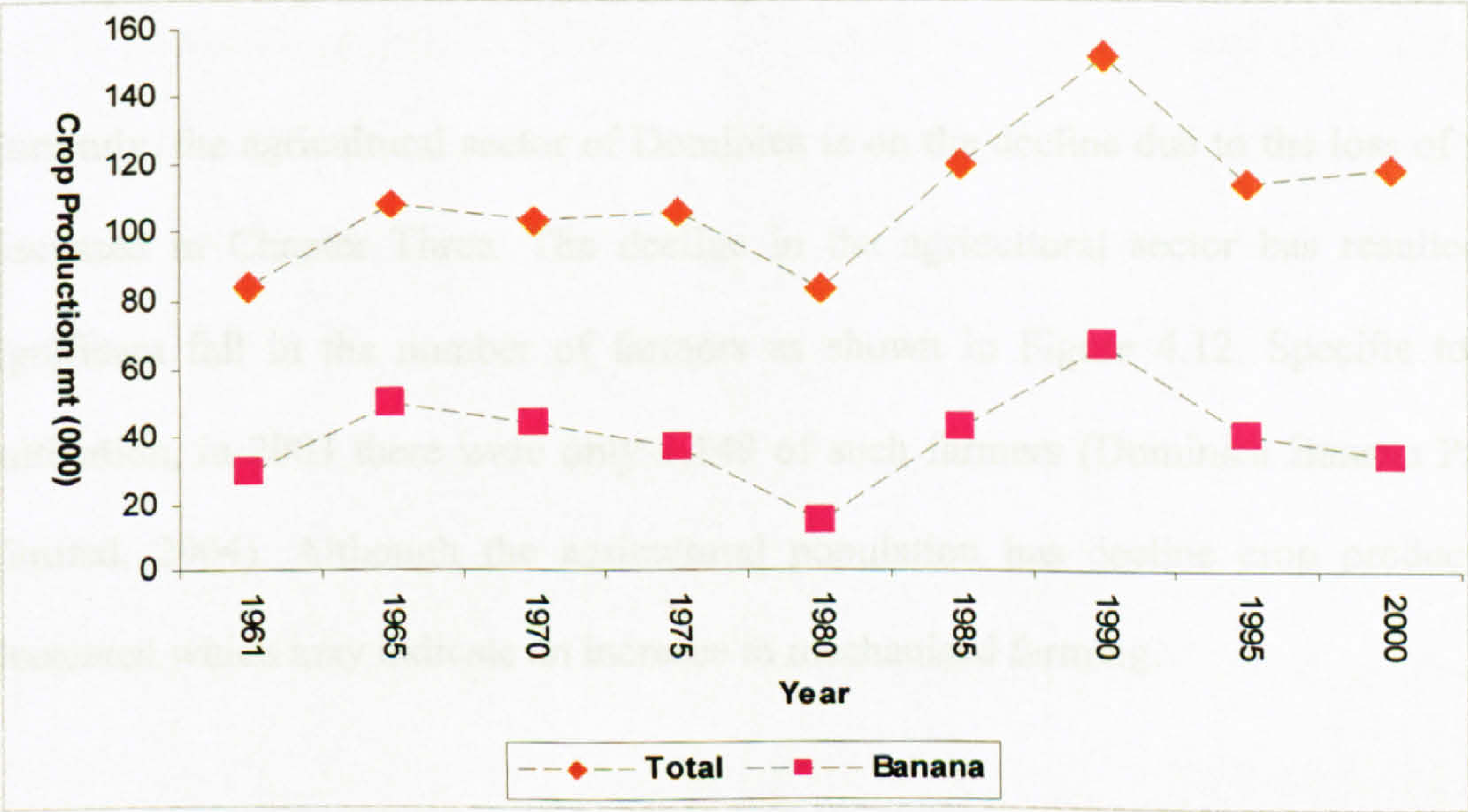


Figure 4.10: Total Crop and Banana Production of Dominica 1961-2000. Compiled using data from FAO, (2002)

Fertilizer is used primarily in banana cultivation. The data showed that Dominica began using inorganic fertilizer in 1980. From 1980 to 2000, its usage has slightly fluctuated, with the highest usage in 1990, shown in Figure 4.11. This corresponds with the high banana output for that specific year.

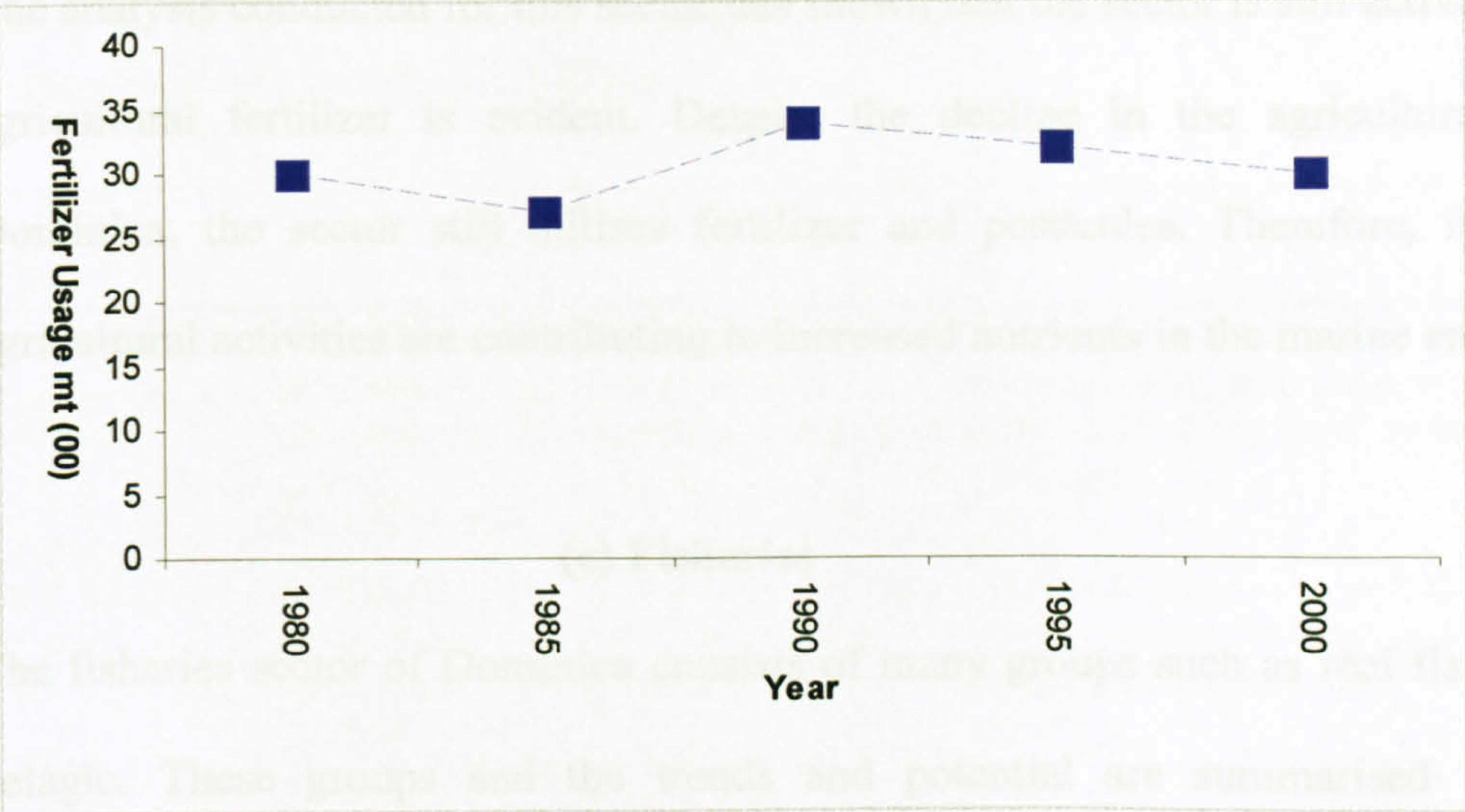


Figure 4.11: Fertilizer Usage in Dominica 1961-2000.
Compiled using data from FAO, (2002)

Currently, the agricultural sector of Dominica is on the decline due to the loss of trade, as discussed in Chapter Three. The decline in the agricultural sector has resulted in the significant fall in the number of farmers as shown in Figure 4.12. Specific to banana cultivation, in 2003 there were only 1,149 of such farmers (Dominica Banana Producers Limited, 2004). Although the agricultural population has decline crop production has fluctuated which may indicate an increase in mechanised farming.

Figure 4.12: Agricultural Population of Dominica 1961-2000.
Compiled using data from FAO, (2002)

The analysis conducted for this sector has shown that the sector is still active and the use of agricultural fertilizer is evident. Despite the decline in the agricultural activities in Dominica, the sector still utilises fertilizer and pesticides. Therefore, it is likely that agricultural activities are contributing to increased nutrients in the marine environment.

(c) Fisheries

The fisheries sector of Dominica consists of many groups such as reef fishes and coastal pelagic. These groups and the trends and potential are summarised in Table 4.10. According to Andrew Magloire (*pers. comm.*), the fisheries sector at one time relied heavily on nearshore pelagic. These species included jack fish (*Caranx spp.*). This resulted in the depletion of the nearshore stock. This brought focus to offshore pelagic including species such as Wahoo (*Acanthocybium solandri*) and Yellow Fin Tuna (*Thunnus albacares*) which are now being targeted. According to Laya and Weidner (2001a), Dominica is located astride the migratory path for pelagic, which include such species as King Mackerel (*Scomberomorus koreanus*), Dorado (*Coryphaena hippurus*) and Flying fish. Therefore, overfishing of these species is also highly probable.

Table 4.10: The State of the Fisheries Sector in Dominica. Compiled from Sebastein, (2001).

Fisheries Groups	Trends	Potential	Constraints
Reef fisheries	Declining both in terms of catches and size of individual fish	Fisheries can be sustainable if managed properly	In addition to heavy fishing pressure, there are negative impacts on habitat from non-fishing, land based sources of pollution
Deep slope fisheries	Production has remained relatively steady over the years at a low level of exploitation	Has great potential for increase in production	Lack of line haulers and other tackle. Small unstable fishing platforms for in use on the Windward coasts
Coastal pelagic fishery	Shows an increasing trend	Shows great potential for development caught in large quantities	Habitat affected by land based sources of pollution. Some species are underutilized.
Migratory pelagic	Increasing trend	Has greatest potential for development in terms of increased landings	Small size of boats Lack of use of navigational aids

This rich resource base has resulted in greater investment by the Government in equipment along with the granting of subsidies to fishermen to exploit these types of fisheries. Tunas are already an export commodity for Dominica. No consideration was given to spawning rates and stock biology of this species. According to Andrew Magloire (*pers. comm.*) Tuna is a straddling stock, and will be fish in accordance with the UNCLOS Convention.

Fishermen in Dominica fish all around the islands but concentrate their efforts along the western coast (Laya and Weidner, 2001a). In 2005, there were 1,050 registered fishermen in Dominica (Derrick Theophille, *pers. comm.*). However, the actual number of fishermen is estimated at 2,500 (Andrew Magloire *pers. comm.*) because not all fishermen are registered as this is not mandatory. External influences like hurricanes also affect the fisheries sector in Dominica. In 1979 and 1999, the industry sustained immense damage in terms of fishing fleets and gears from Hurricanes David and Lenny (Environmental Coordinating Unit, 2001).

This assessment of the fisheries sector in Dominica provides evidence, which indicate that it is growing. It also shows that pressure on various groups of fisheries is also increasing.

(d) Tourism and Recreational Activities

Tourism is a growing economic sector in Dominica. The cruise sector is the largest sub-sector of tourism. It accounted for over 70% of the tourists that visited the island between 1990 to 2000 as shown in Figure 4.13. The number of cruise passengers visiting Dominica is more than double the number of stay-over visitors. This indicates the importance of the cruise industry in this island.

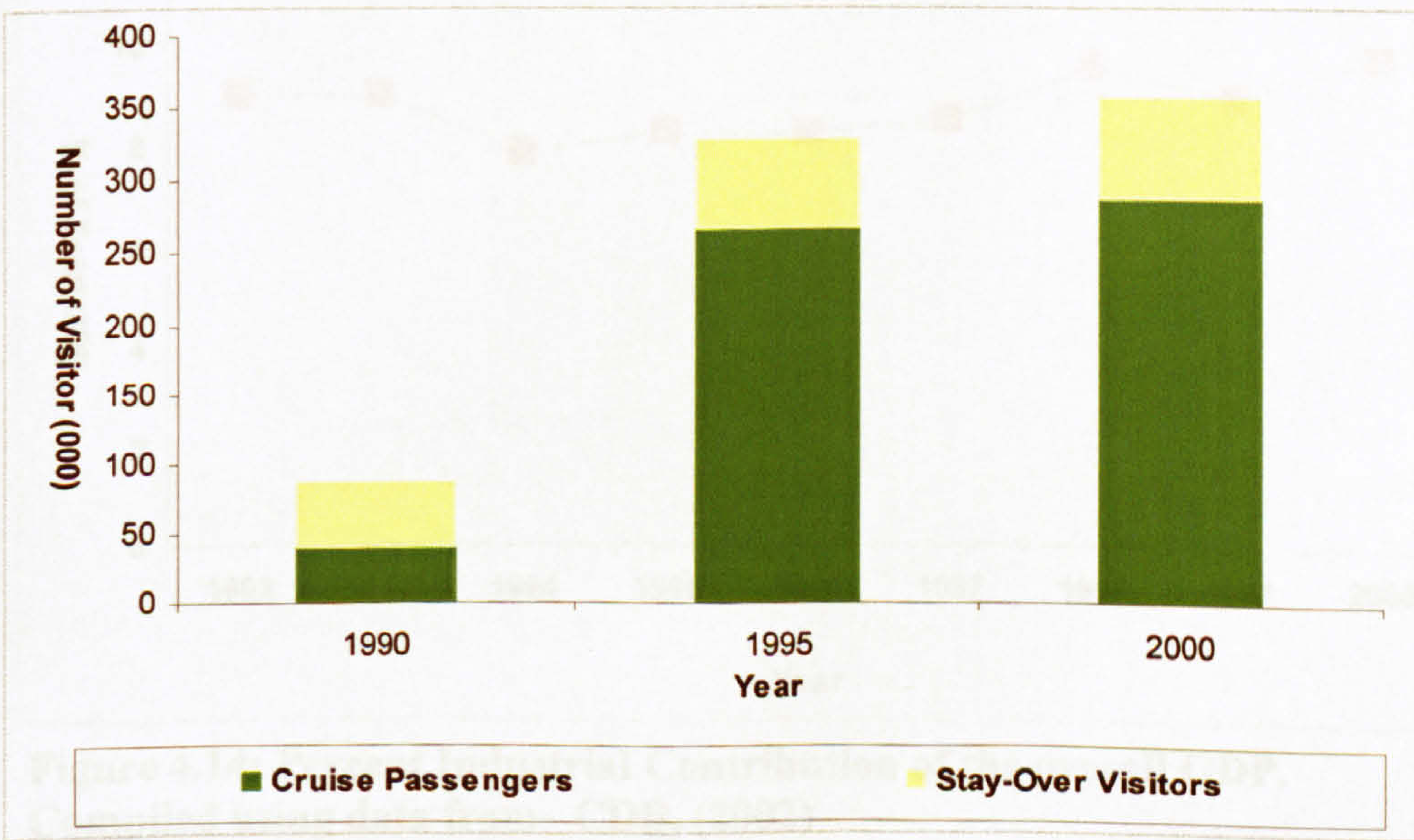


Figure 4.13: Tourism Statistics for Dominica. Compiled using data from CTO, (2002) and WTO, (2005)

Most of the tourism activities are on the coastal areas of Dominica predominantly on the West Coast. Diving, snorkelling and sport fishing attract many tourists to the island. In 2005, Dominica had over nine dive sites, four dive wrecks and one dolphin area, all in the Caribbean Sea and eight of the ten recommended bathing beaches are on the West Coast (Caribbean Sea). The growth in this sector has increased the pressure on the coastal and marine areas, such as waste generation and increase coastal infrastructure.

(e) Industrial Activities

The major companies in Dominica are Harris Paints, a cement factory and Colgate Palmolive, the latter manufactures detergents and other personal hygiene products (PHPs). Additionally, there are cottage industries, which include small-scale food manufacturing. Overall, the industrial sector is very small in terms of GDP contribution. Available data for 1992 to 2000 have shown that the earning from this sector have fluctuated and the differences in the annual contributions are insignificant as shown in Figure 4.14. The highest contribution was in 1998.

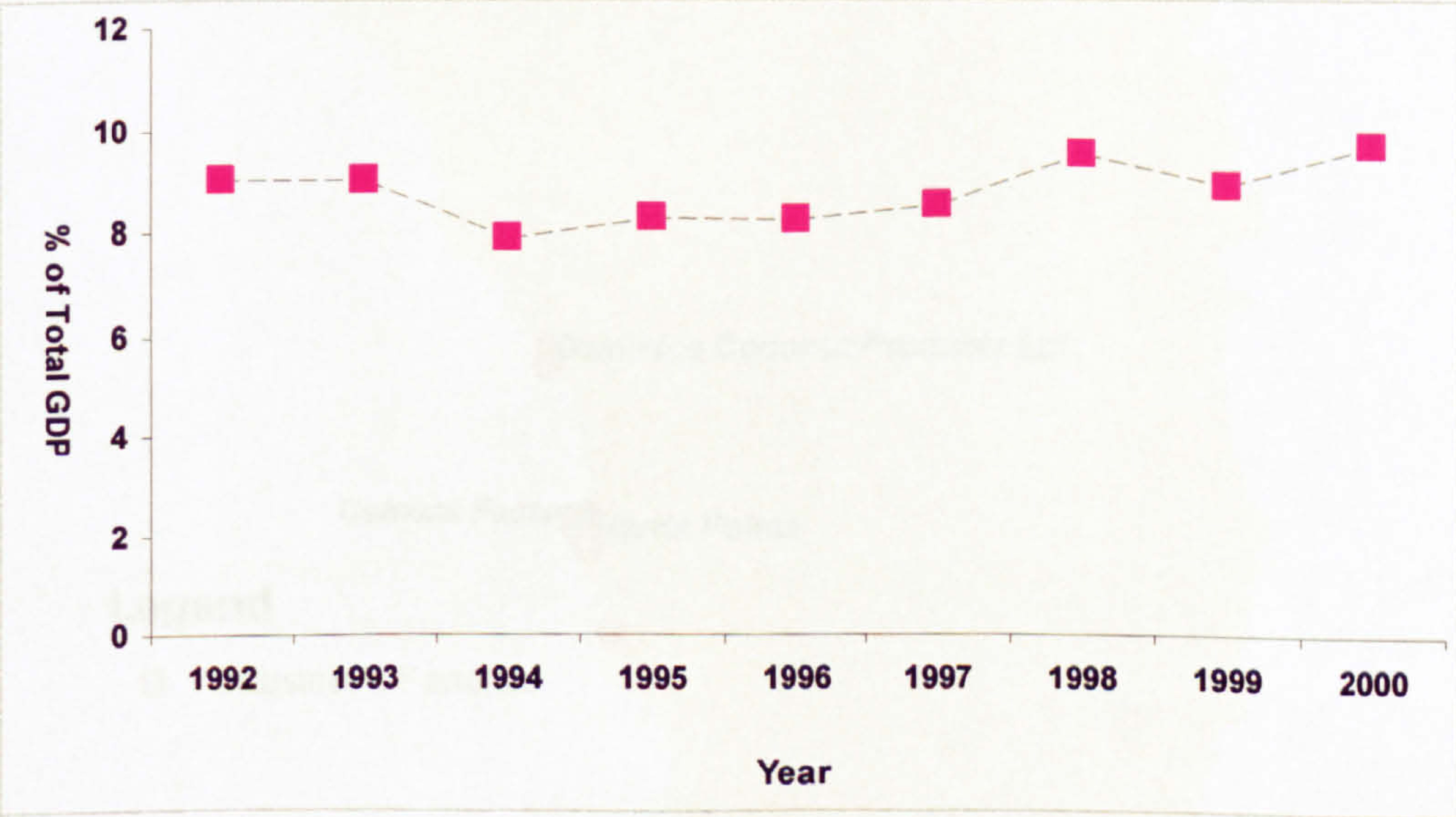


Figure 4.14: Percent Industrial Contribution of the overall GDP. Compiled using data from CDB, (2002)

Most of these companies are located on the coastal area of Dominica as shown in Figure 4.15. The industries and factories are not fully regulated, and there are no legal requirements for wastewater discharges. This inadequacy has resulted in waste being sewer from factories into nearby rivers, which enter the Caribbean Sea. These discharges are influencing the water quality of the Sea.

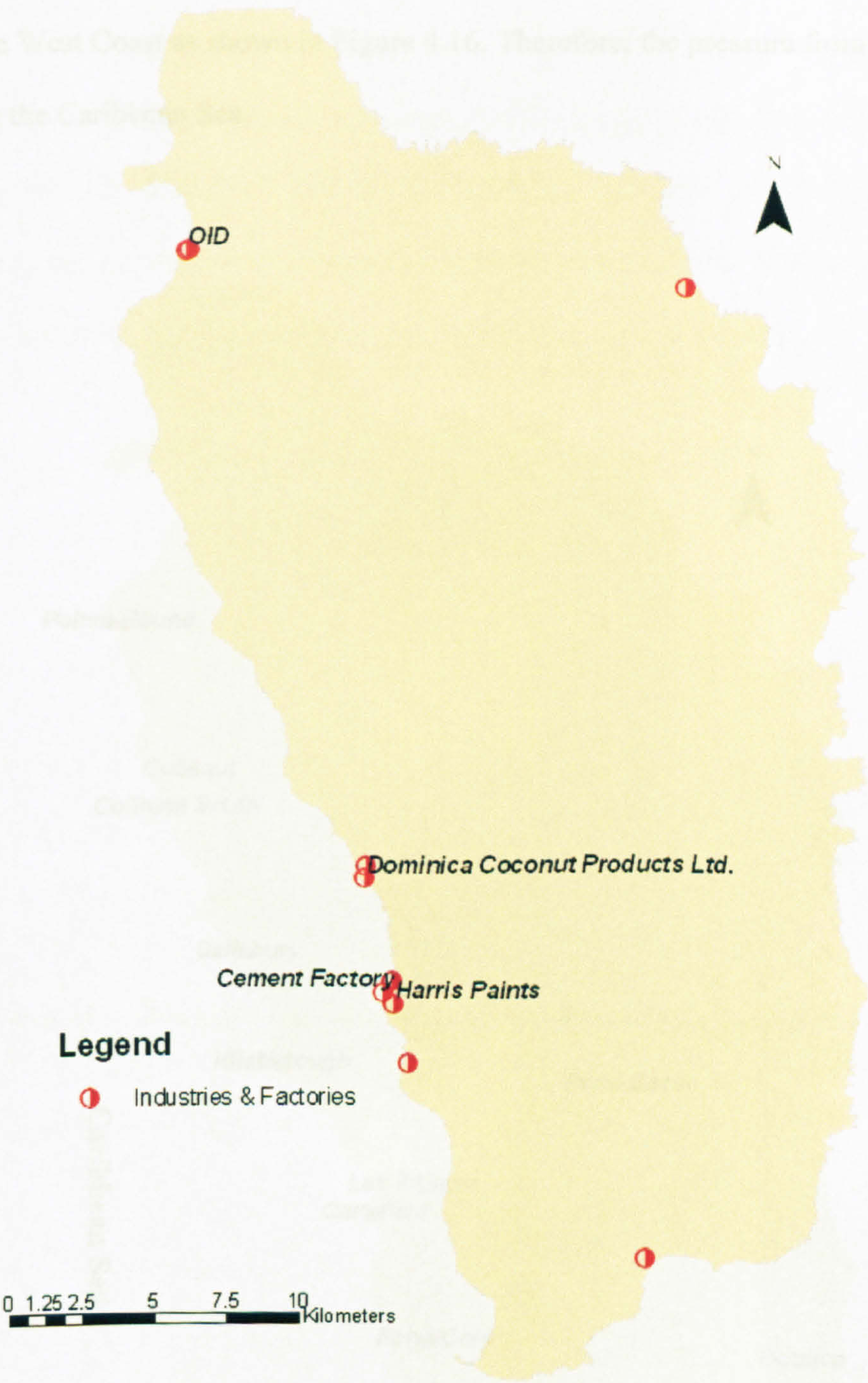


Figure 4.15: Map showing the Location of the Major Factories and Industries in Dominica. This map was derived using digital information from Ministry of Planning, (2004). Most of the major industries are on the West Coast of Dominica.

Another industrial activity in Dominica is quarrying. Most of these quarries are located on the West Coast as shown in Figure 4.16. Therefore, the pressure from quarrying is greater on the Caribbean Sea.

Figure 4.16: Map showing the Location of the Major Quarries in Dominica. Compiled using digital information from Ministry of Planning, (2004). Eleven of the fifteen quarries are on the West Coast of Dominica.

Quarrying activities on the West Coast of Dominica started in the 1970s. At that time, the mining sector consisted of two mining companies (Zamoor, 1999). By 1990, the sector has increased to approximately ten companies (Zamoor, 1999). Due to inadequate restrictions, mining activities have resulted in increased sediment runoff into the nearby marine environment. Increased sedimentation in the water column is smothering the nearby coral reefs and seagrass habitats (Zamoor, 1999; Pascal *pers. comm.*).

4.6.1.2 Pressures

The major pressures on the marine areas are nutrient inputs, sewage, wastewater and sediments.

As shown in Chapter Three, sewage in the region is a major issue. This is also a problem in Dominica. Prior to 2002, Dominica had no form of sewerage treatment facility and the untreated sewage was discharged into the Caribbean Sea from outfalls (some sample sites shown below). The data revealed a high level of faecal coliform in the coastal waters. As shown in Figure 4.17, the level of coliform in the coastal waters is over 1000 times above the acceptable limits of WHO guideline value, LBS Protocol and Blue Flag. All the sites recorded the highest concentration in the 3ft[36] category. This seems to indicate that the sewage contamination is highest closer to the land area. Pottersville and Goodwill show extremely high levels of faecal coliform. This may be as a result of a higher volume of sewage been discharged at these two sites.

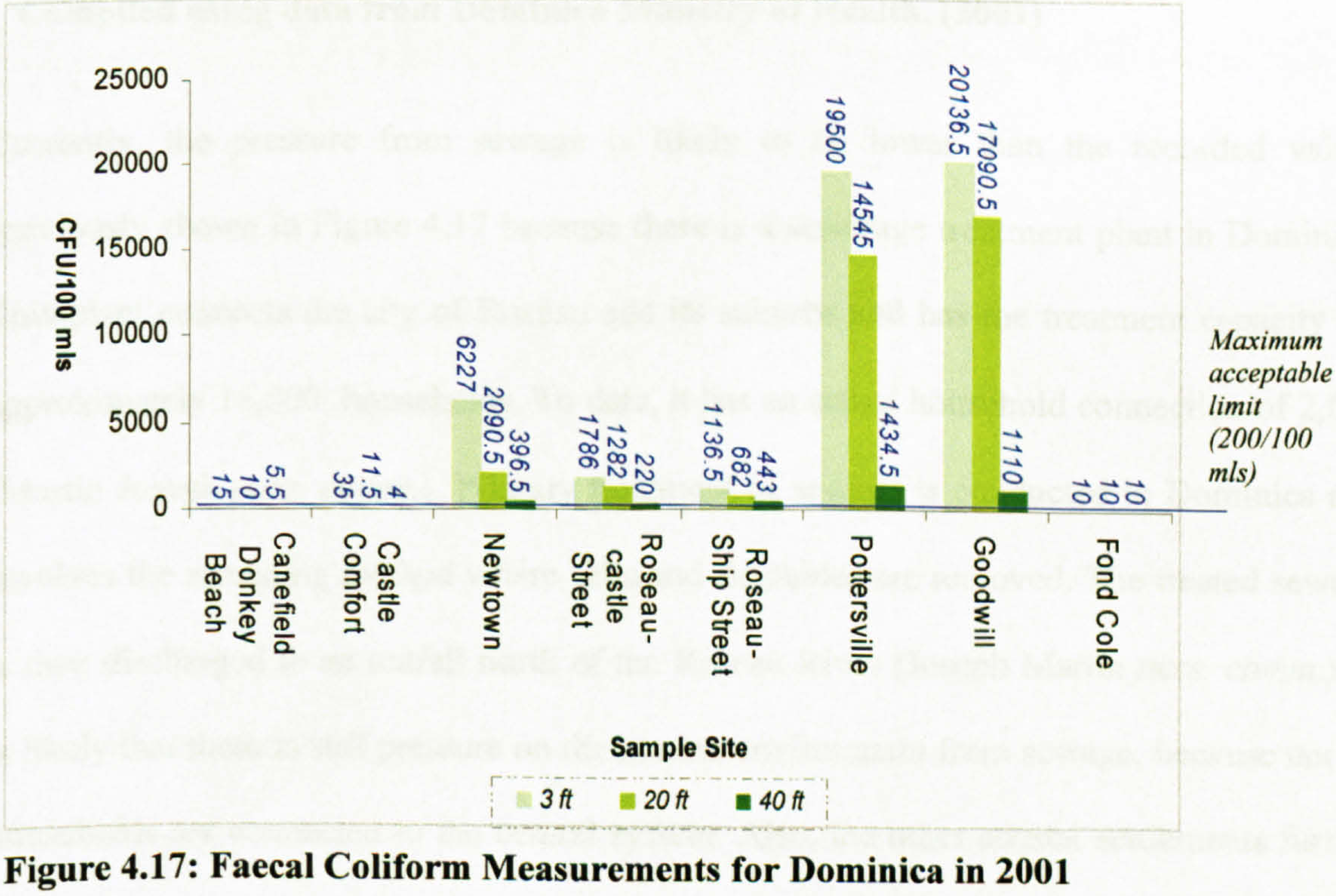


Figure 4.17: Faecal Coliform Measurements for Dominica in 2001 Compiled using data from Dominica Ministry of Health, (2001)

36 the 3, 20 and 40 ft are distances from the shoreline

Another indicator of high levels of nutrients (possibly from sewage) is the Biological Oxygen Demand (BOD) measurement shown in Figure 4.18. This indicates values, which are higher than the acceptable limit, defined in the LBS Protocol.

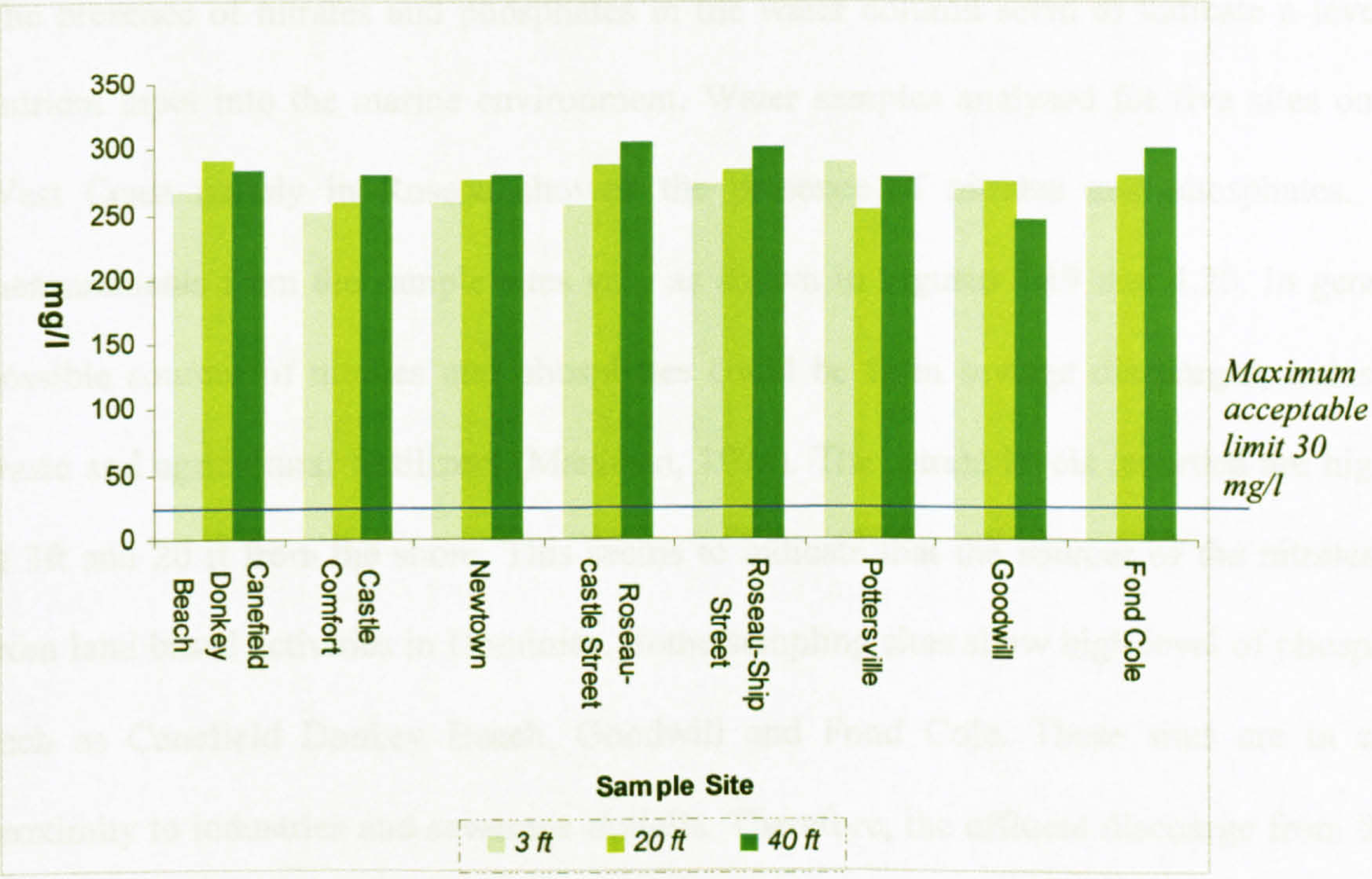


Figure 4.18: BOD Measurements for Dominica in 2001.
Compiled using data from Dominica Ministry of Health, (2001)

Currently, the pressure from sewage is likely to be lower than the recorded values previously shown in Figure 4.17 because there is a sewerage treatment plant in Dominica. This plant connects the city of Roseau and its suburbs and has the treatment capacity for approximately 16,000, households. To date, it has an actual household connection of 2,600 (Martin Joseph *pers. comm.*). Primary treatment of sewage is conducted in Dominica and involves the screening method where grits and floatables are removed. The treated sewage is then discharged to an outfall north of the Roseau River (Joseph Martin *pers. comm.*). It is likely that there is still pressure on the marine environment from sewage, because not all households are connected to the central system. Also, the other coastal settlements further from Roseau do not have any sewerage facilities, thus untreated sewage is likely to be discharged into nearby marine areas. In addition, some of the hotels on the island have independent treatment facilities, but the working conditions of many are very questionable

(John Rapheal, *pers. comm.)*. Most of these hotels are located in the coastal area of Dominica indicating the possibility of increase pressure on the marine environment in the absence of effective treatment of sewage.

The presence of nitrates and phosphates in the water column seem to indicate a level of nutrient input into the marine environment. Water samples analysed for five sites on the West Coast mainly in Roseau showed the presence of nitrates and phosphates. The measurements from the sample sites vary as shown in Figures 4.19 and 4.20. In general, possible sources of nitrates and phosphates could be from sewage discharges, industrial waste and agricultural fertilizers (Manahan, 1994). The nitrate levels recorded are highest at 3ft and 20 ft from the shore. This seems to indicate that the sources of the nitrates are from land based activities in Dominica. Some sampling sites show high level of phosphate such as Canefield Donkey Beach, Goodwill and Fond Cole. These sites are in close proximity to industries and sewerage outfalls. Therefore, the effluent discharge from these activities may have resulted in the elevated phosphorus also nitrate levels. Overall, all the sample sites are in close proximity to human activities, suggesting that the sources may be from sewerage and wastewater. However, Drigo, (2001) noted agricultural runoff as contributing to increased nutrients in the marine environment. Therefore, it is likely that nitrate and phosphates may also be high in other marine areas that are in close proximity to agricultural activities in Dominica.

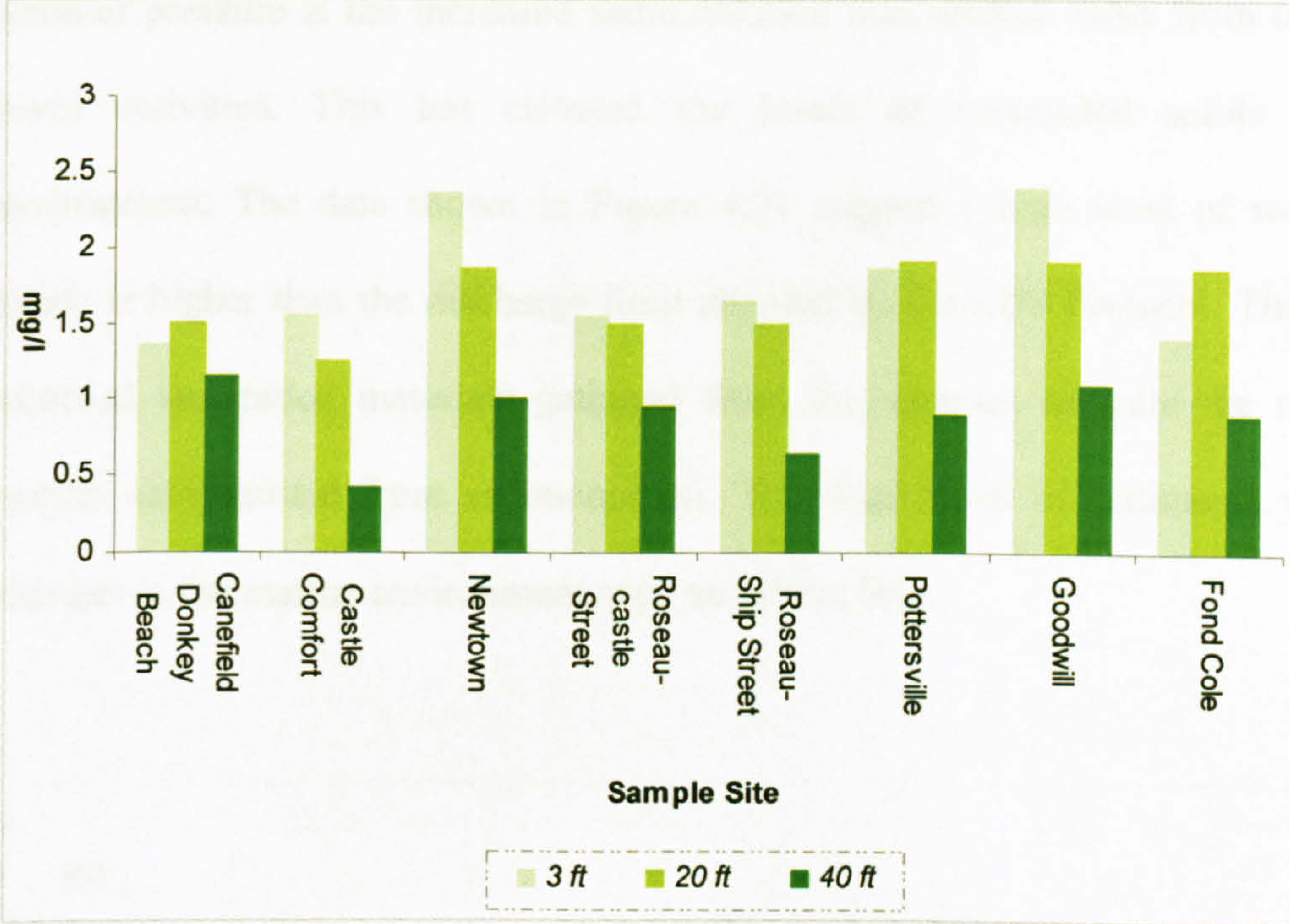


Figure 4.19: Nitrates Measurements for Dominica in 2001. Compiled using data Dominica Ministry of Health, (2001)

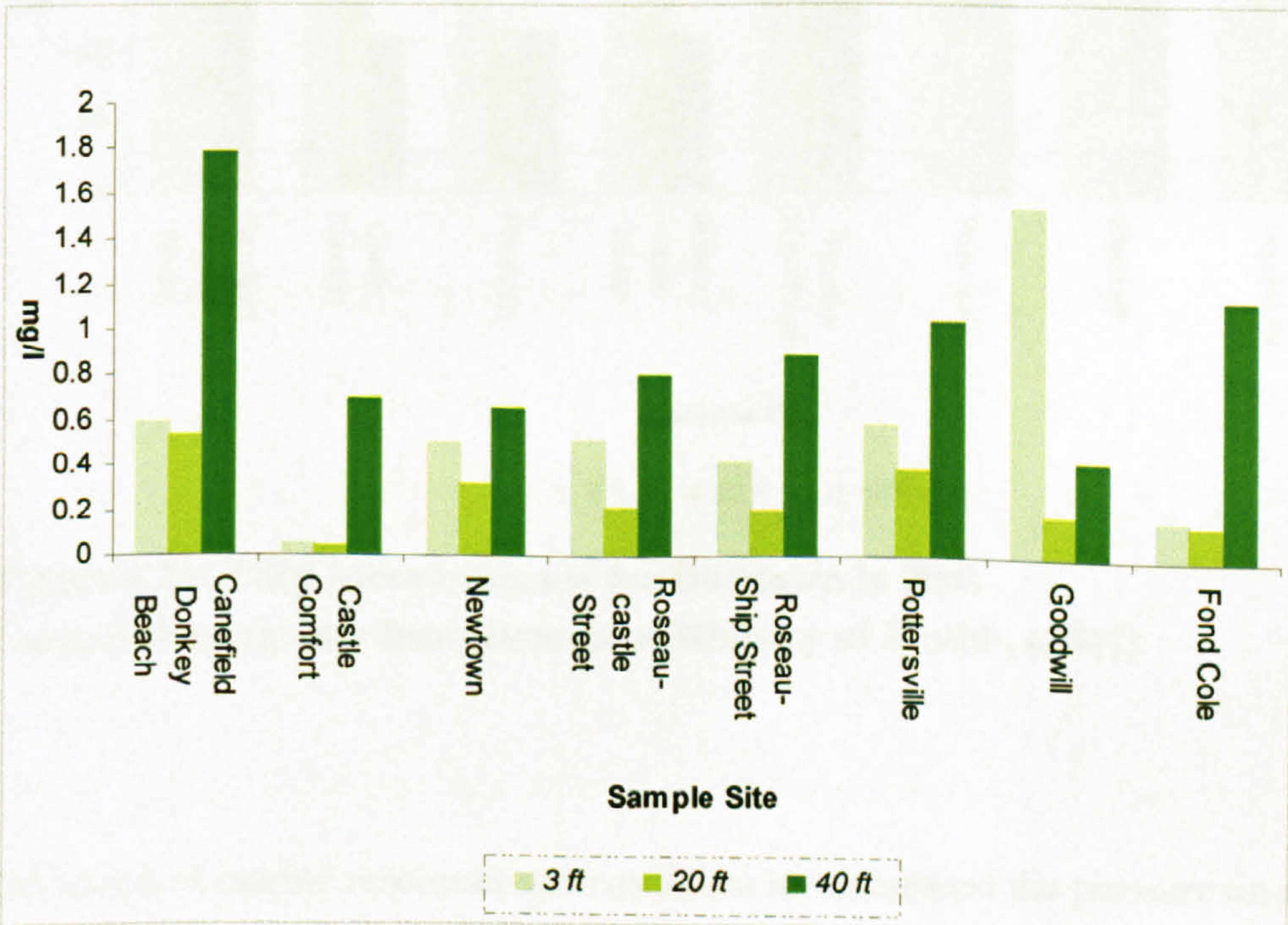


Figure 4.20: Phosphates Measurements for Dominica in 2001 Compiled using data from Dominica Ministry of Health, (2001)

Another pressure is the increased sedimentation into coastal water from unmanaged land based activities. This has elevated the levels of suspended solids in the marine environment. The data shown in Figure 4.21 suggest a high level of suspended solids, which is higher than the discharge limit allowed by the LBS Protocol. The high levels of recorded suspended materials gathered from the samples indicate the pressure on the marine environment from sedimentation. This high level of sediments can cause state changes in the marine environment such as habitat loss.

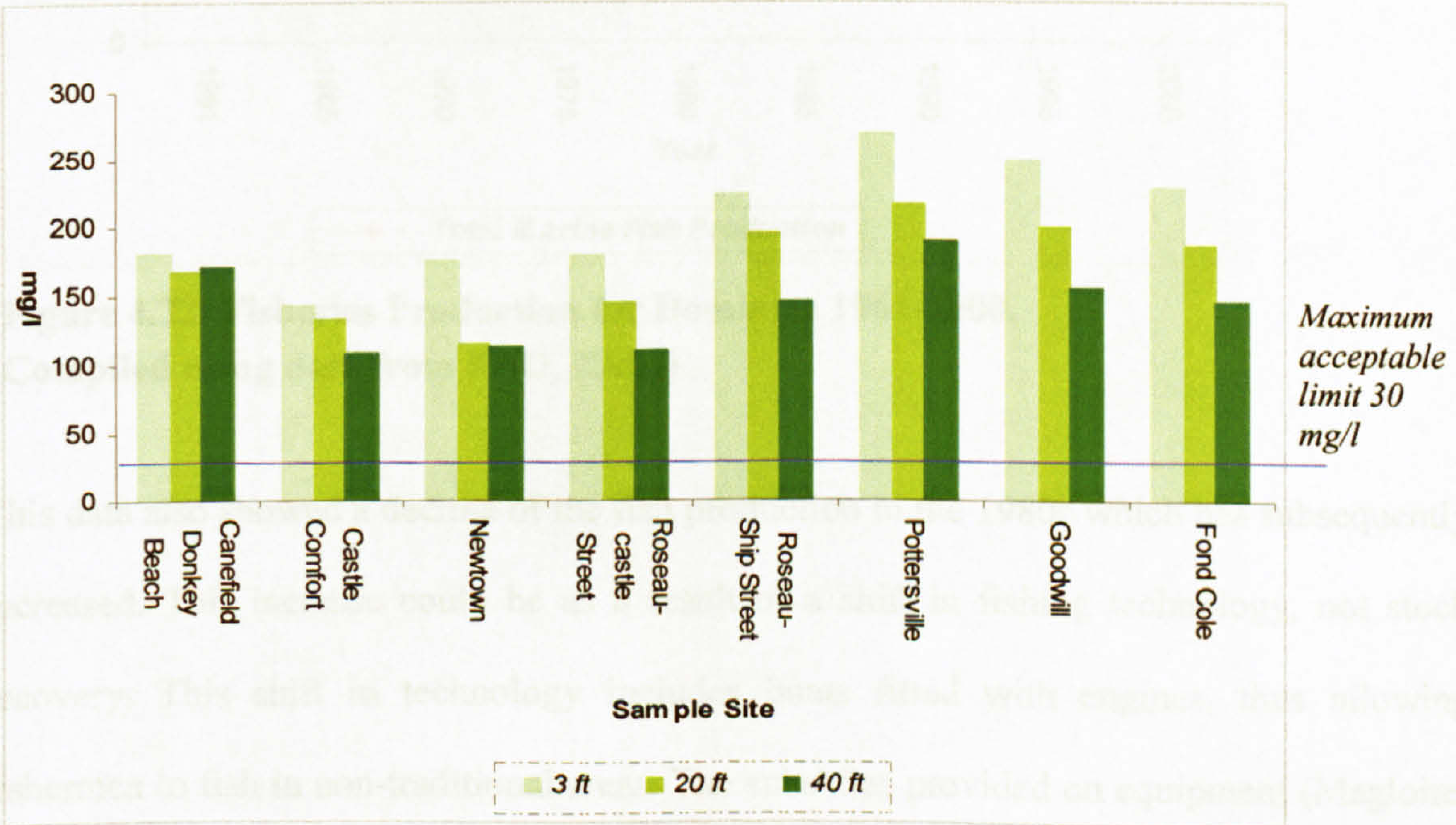


Figure 4.21: TSM Measurements for Dominica in 2001
Compiled using data from Dominica Ministry of Health, (2001)

Extraction of marine resources such as fishes has increased the pressure on fish stock. Fish landings for the period of 1960 to 2000, has shown that the marine production has fluctuated with the highest landings been recorded in 1980 as shown in Figure 4.22. According to Laya and Weidner (2001a), no fisheries official can ascertain the reason for this high catch statistic for 1980. However, the data in this study has indicated a possible link between crop production and fish landings for that year. 1980 recorded the lowest crop production (previously shown in Figure 4.10), in this year, the agricultural sector was affected by a hurricane event. Correspondingly, the fish production was the highest in that year. Therefore, it is possible that there was a higher reliance on fish to supplement the diet caused by lack of agricultural crops.

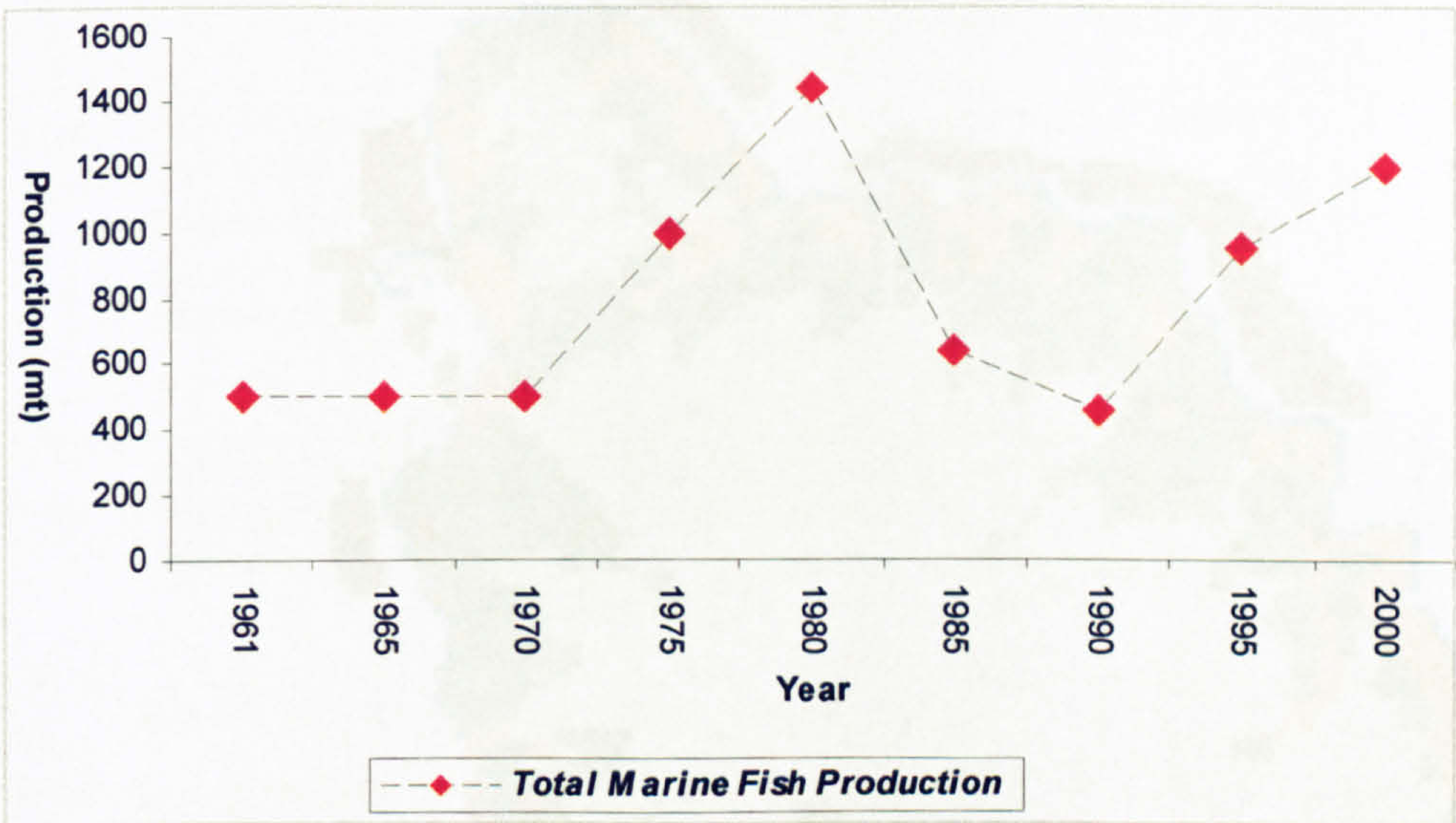


Figure 4.22: Fisheries Production for Dominica 1961-2000. Compiled using data from FAO, (2002)

This data also showed a decline of the fish production in the 1980s which has subsequently increased. This increase could be as a result of a shift in fishing technology, not stock recovery. This shift in technology includes boats fitted with engines, thus allowing fishermen to fish in non-traditional areas. The subsidies provided on equipment (Magloire, *pers. comm.*) and the placing of fish aggregating devise (FADs) in offshore areas (Sebastein, 2001) are evidence to suggest that non traditional fishing areas are being targeted in Dominica. Overall, it is evident that fishing activities are placing pressure on the biodiversity of the marine environment. The absence of stringent management programmes and increased fishing subsidies, can likely help to increase the rate of fisheries exploitation.

Further, the use of spatial information can demonstrate the pressures on the marine environment from land based activities. The economic sectors shown from land use information in Figure 4.23 can provide clues of likely areas of pressures and the possible sources. The spatial pressures of the identified areas are explained in Table 4.11.

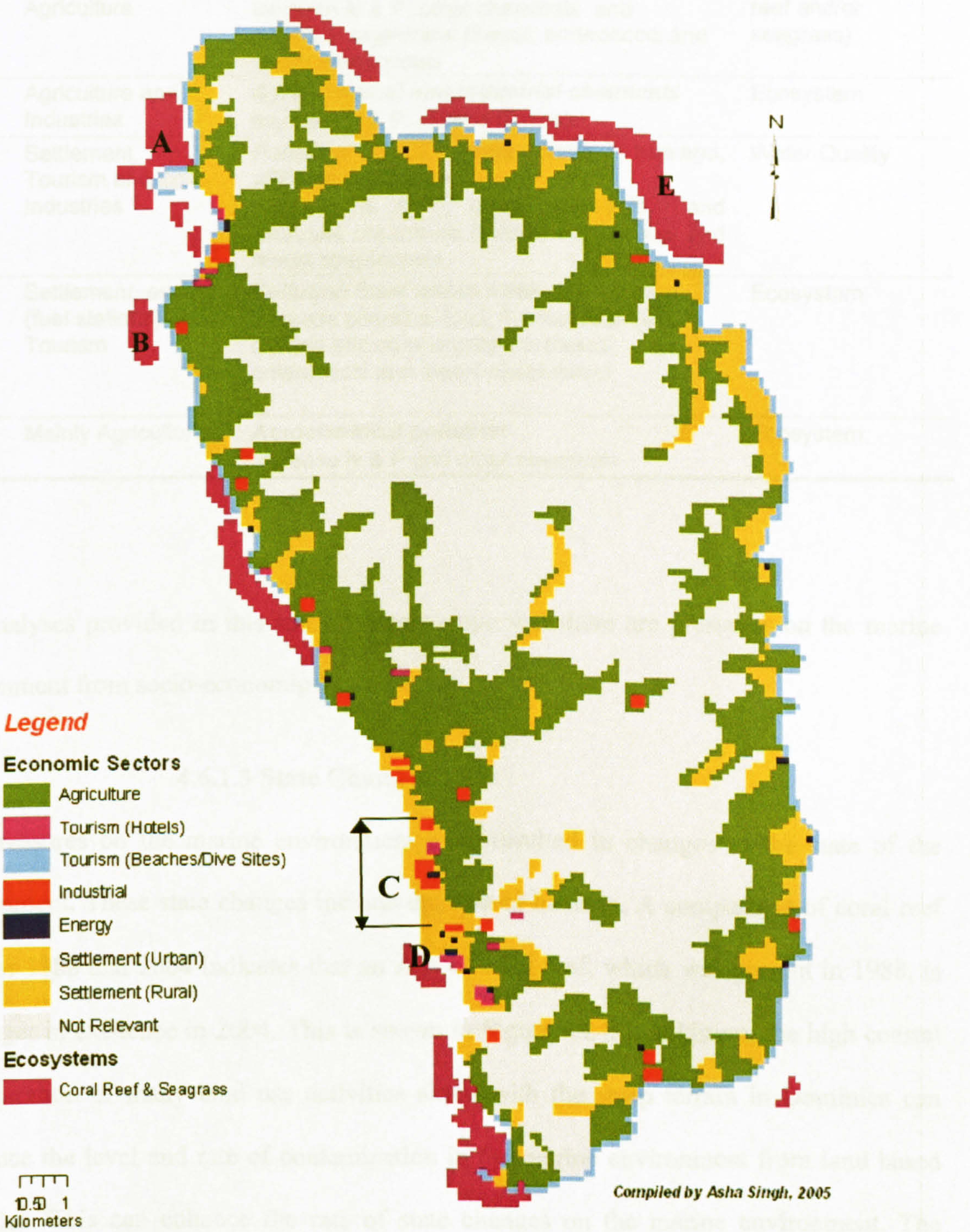


Figure 4.23: A Map showing the Economic Sectors of Dominica using land use information as a proxy to determine spatial pressure. The map was derived using information from Ministry of Planning, (2002 b), Ministry of Fisheries, (2000), Drigo, (2002). Areas A, B, C, D and E are further expanded in Table 4.11.

Table 4.11: Identifying the Drivers, likely Pressure and affected areas highlighted in Figure 4.23

Area	Driver (Activities)	Likely Pressure	Likely Feature to be Affected
A	Settlement Agriculture	***Agrochemical pollution and Sewage*** Increase N & P, other chemicals and microbial organisms (faecal, enterococci and faecal streptococci	Ecosystem (coral reef and/or seagrass)
B	Agriculture and Industries	***Agrochemical and Industrial chemicals*** Increase N & P, other chemicals	Ecosystem
C	Settlement, Tourism and Industries	***Pollution from waste water, sewage, effluent discharge*** Increase N & P, other chemicals and microbial organisms (faecal, enterococci and faecal streptococci	Water Quality
D	Settlement, energy (fuel stations) and Tourism	***Pollution from waste water and Sewage*** Increase chemical load, hydrocarbon (waste oil) and microbial organisms (faecal, enterococci and faecal streptococci	Ecosystem
E	Mainly Agriculture	***Agrochemical pollution*** Increase N & P and other chemicals	Ecosystem

The analyses provided in this section demonstrate that there are pressures on the marine environment from socio-economic drivers.

4.6.1.3 State Changes

The pressures on the marine environment have resulted in changes to the state of the environment. These state changes include the loss of habitats. A comparison of coral reef data for 1988 and 2004 indicates that an area of coral reef, which was present in 1988, is no longer in existence in 2004. This is shown in Figure 4.24. In addition, the high coastal concentration of many land use activities along with the steep terrain in Dominica can influence the level and rate of contamination in the marine environment from land based activities. This can enhance the rate of state changes on the marine environment. The spatial location of the land based activities and the terrain are also illustrated in Figure 4.24.

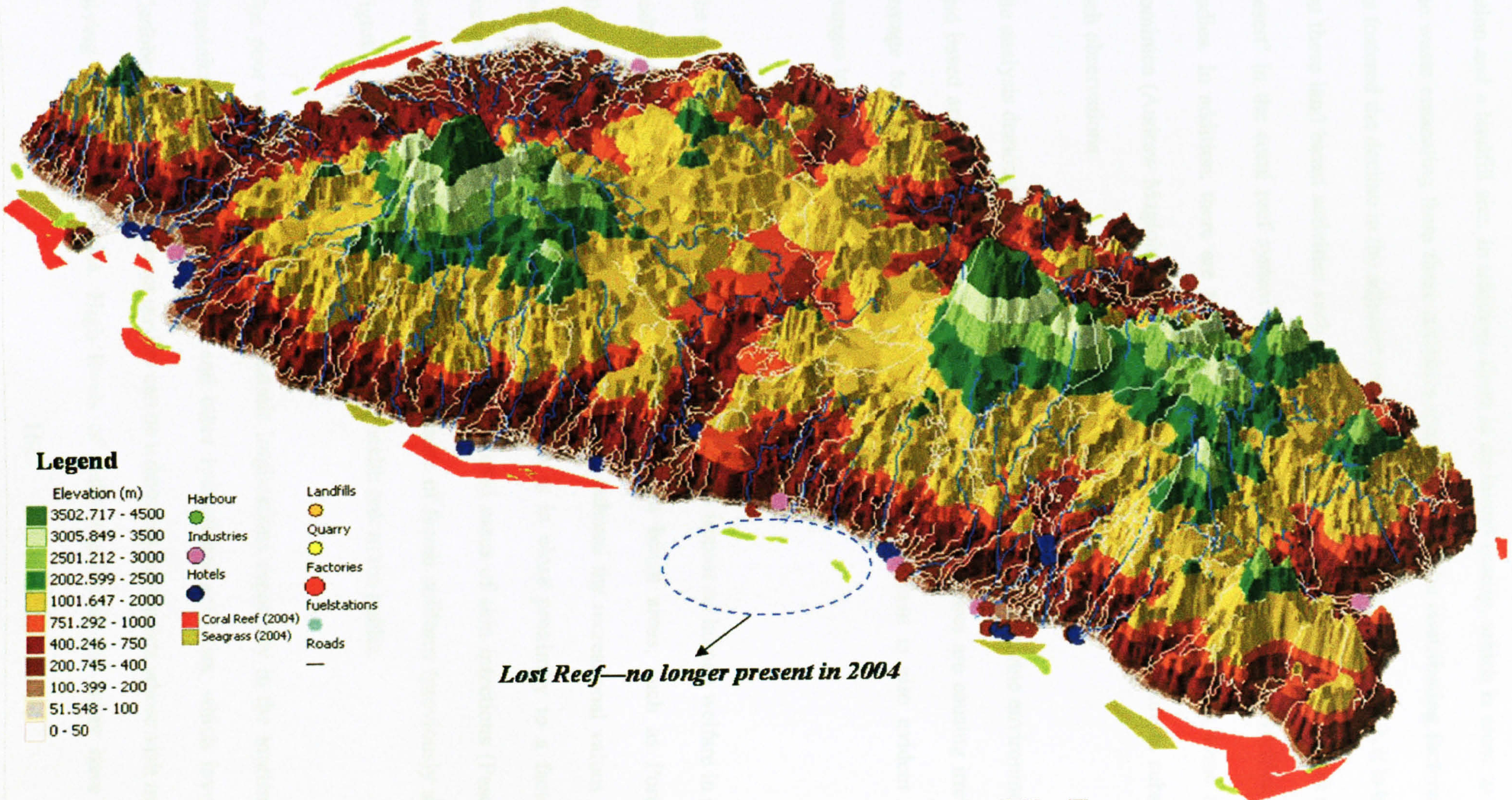


Figure 4.24: A 3D Map of Dominica showing the lost reef and location of other land use activities. The map demonstrates that most of the activities in Dominica are on the West Coast of Dominica. Compiled using data from Ministry of Planning, (2002), GPS Coordinates, Dominica Fisheries Department, (2004)

Compiled by Asha Singh, 2004

The lost reef shown in Figure 4.24 is in close proximity to settlements, factories, fuel station and a landfill site. In addition, there is an inland quarry, which is close to a river. The waste emanating from these activities may be among the contributing factors, which has fostered the decline in the adjacent reef. According to Pascal (*per comm.*), it is believed that these land based activities such as increased sediment load and pollution are causing 'desert' in the coral reef system in Dominica. This claim has not been verified by any studies. In addition, there are frequently observed short algal blooms in some areas in Dominica (Andrew Magloire *pers. comm.*). However, there is no literature to substantiate such observations.

The analysis demonstrates that state changes are occurring in the marine environment from land based activities in Dominica. It is evident that the pressures are causing irreversible damage to habitats. The pollution of the marine environment is also evident causing changes to the water quality.

4.6.1.4 Impact

The state changes to the marine environment have an impact on human welfare in terms of health and user value. The poor water quality in beach areas, such as Portsmouth, Glanvilla, T Bay, Balati and Donkey Beach has reduced the recreational values of these locations. For example, Donkey Beach, which is in close proximity to a factory, has become unsuitable for bathing because of reported cases of skin infections (Pascal *pers. comm.* and *Rapheal pers. comm.*). The presence of faecal coliform (previously shown in Figure 4.17, pg. 149) in the water is a major health risk to the public.

The poor water quality can have economic implications especially in the tourism sector. Dominica is known for its diving and other recreational activities, which involves the Caribbean Sea. The poor water quality can be a deterrent for tourists whose visit may entail diving and beach activities. High levels of sedimentation in the water have reduced visibility, which in turn will decrease the value of dive sites in Dominica. No information exists on whether this has already occurred in Dominica. However, these impacts have affected other popular vacation destinations such as Jamaica (refer to Jamaica profile in Appendix One). Poor water quality curtailed diving in Jamaica and lead to a substantial reduction in visitors (Dixon *et. al.*, 2001). Therefore, the possibility of a reduction in visitors to Dominica and loss of tourism revenues exist if water quality is not maintained.

The loss of fisheries stock has also affected human consumption choices in Dominica. Species such as jack fish is a delicacy, which is no longer found in abundance (Andrew Magloire *pers. comm.*).

4.6.1.5 Responses

The examination of the existing programmes and legislation has revealed that Dominica has not effectively responded to any of the issues mentioned in drivers, pressures, state changes and impact categories. Overall, the relevant legislation in Dominica is not very effective. Legislation is either outdated or inadequate to deal with issues in the marine environment. Table 4.12 provides a summary of the current relevant legislation.

Table 4.12: A Critique of Relevant Environmental Based Legislation of Dominica. Compiled using information from the relevant legislation and (Pascal, 1999)

LEGISLATION	MANADATES	COMMENTS
The Fisheries Act 1957	Gives the Fishery Department the responsibility to manage the marine resources of Dominica and provides a framework for marine resource management	It is old and outdated. The fines are low which will not act as a deterrent for unsustainable fishing practices
The Fisheries Regulation 1989	Supports the fisheries act and it gives authority to the fisheries division to establish MPAs (Soufriere/Scotts Head Bay Area), fisheries nursery areas and priority areas	There are no active gear restrictions or quotas. There is one MPA (Soufriere/Scotts Head Bay Area), which has an active management plan
The Beach Control Ordinance 1966	Allows for the removal of sand and other materials from the beach with permission from the Physical Planning Division. This Act provides for illegal mining, which if prosecuted, one can be fined.	There is no effective monitoring and enforcement and once permits have been issued, sand can be removed from anywhere including critical coastal areas.
The Public Health Act 1969	Provides the Environmental Health Division with the task of monitoring both drinking water and sewerage	There are no working standards for sewerage hence, this act falls short of effective monitoring.
The Water and Sewerage Act 1989	Implemented for the establishment of a company (DAWASCO) to provide water and sewerage needs of the island. It also dictates responsibility for preventing the pollution of water resources and maintains safe drinking water	This does not include marine environment and does not deal with discharges of sewage effluents into the marine environment.
Solid Waste Act 1992	Allows for the semi privatization of garbage collection	Does not deal with environmentally sound disposal practices of waste.

Other mechanisms to respond to environmental issues in Dominica are through agencies and programmes. The Environment Unit of Dominica was formulated in 1998 out of a cabinet decision to tackle emerging environmental issues. However, it was not given any legal mandate to act. This has crippled its intended purpose of policing the environment. To date, the Environment Unit is only acting in an advisory capacity and oversees the implementation of treaties and conventions that Dominica[37] is party.

Currently, there are no active programmes regarding the marine environment. Dominica does not have any existing coastal zone management plan, policy or programme in place even though most of its economic activities are in the coastal zone. The Environmental Health Department is responsible for monitoring water quality but there is no routine water quality monitoring in existence.

Dominica Solid Waste Management Corporation (DSWMC) handles garbage and other solid waste disposal. Litter wardens ability to enforce the legislation is curtailed because they are not gazetted. This makes it difficult to prosecute offenders. Waste such as, derelict vehicles are being dump at 'The Gemit' on the West Coast of Dominica (Caribbean Sea). This measure, according to the Public Education Officer of DSWMC, is temporary, as efforts will be made to ship the scrap metals to Trinidad for recycling. In 2005, scrap vehicles are still being dumped. Household wastes are being disposed in two abandoned quarries in Portsmouth and Stockfarm. These landfill sites observe no landfill engineering practices or building standards. There have been reported incidences of leaching (Geno Jacobs *pers. comm.*) from both landfill sites. However, a fully engineered landfill to accommodate major waste types is now being built at Fond Cole and is expected to be in operation by 2006 (Jeno Jacobs *pers. comm.*). There is no central collection system for oil waste. This fosters the indiscriminate dumping of oil in nearby drains, which in turn drains into surrounding marine areas.

[37] See Chapter Seven for Relevant Treaties and Conventions for Dominica

To fund environmental programmes, some initiatives have been taken by the Government. For example, all visitors to Dominica are required to pay an environmental levy tax of US$1.50, which goes into a consolidated fund. This fund is intended to assists relevant Environmental Agencies to implement their respective programmes.

In terms of marine extraction, the Department of Fisheries has a mandate to oversee the management of this sector. In general, the fisheries sector operates an open access policy, with a closed season for turtles, lobsters (*Panulirus argus*) and queen conch (*Strombus gigas*). This is a response to stock depletion of some species of the demersal fisheries. In addition, the Fisheries Department of Dominica introduced fish aggregating device (FAD) in offshore areas to ease the fishing pressure on demersal species and nearshore fisheries (Sebastein, 2001).

While efforts are being made by Dominica to respond to environmental issues, it is evident in this section that these responses are inadequate to minimise the pressures and subsequent state changes and impacts that are occurring in the marine environment.

4.6.2 SWOT Analysis for Dominica

A SWOT analysis conducted for Dominica has highlighted the areas where the responses are strong as well as areas where there are weaknesses, as shown in Figure 4.25. These are important issues for Dominica to address in order to minimise the changes to the marine environment from terrestrial activities.

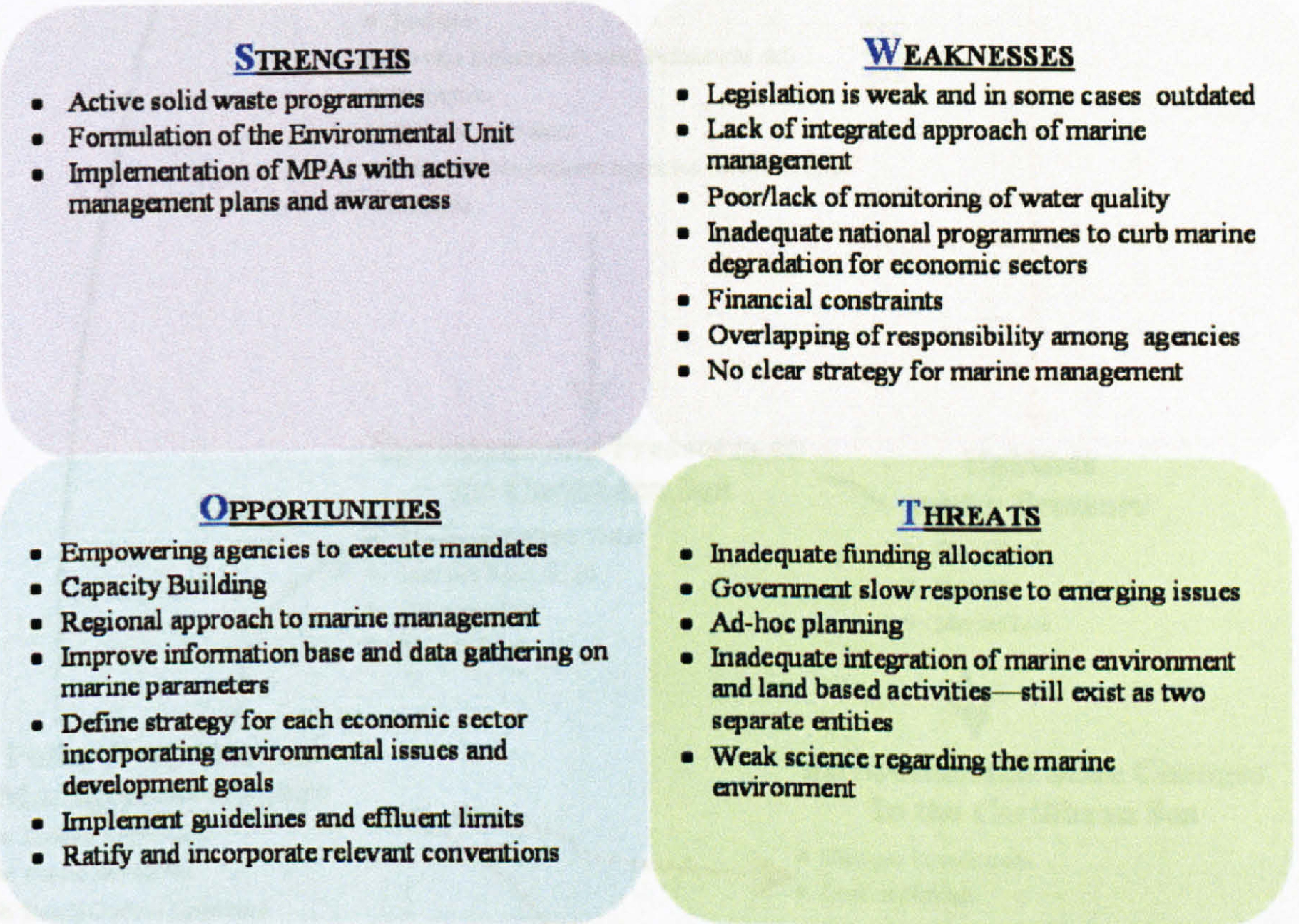


Figure 4.25: SWOT Analysis conducted for Dominica based on the relevant Environmental Responses

In summary, the analyses presented within the DPSIR framework for Dominica have highlighted the links between economic activities and environmental implications for the Caribbean Sea. These issues highlighted in the DPSIR framework are summarised in Figure 4.26.

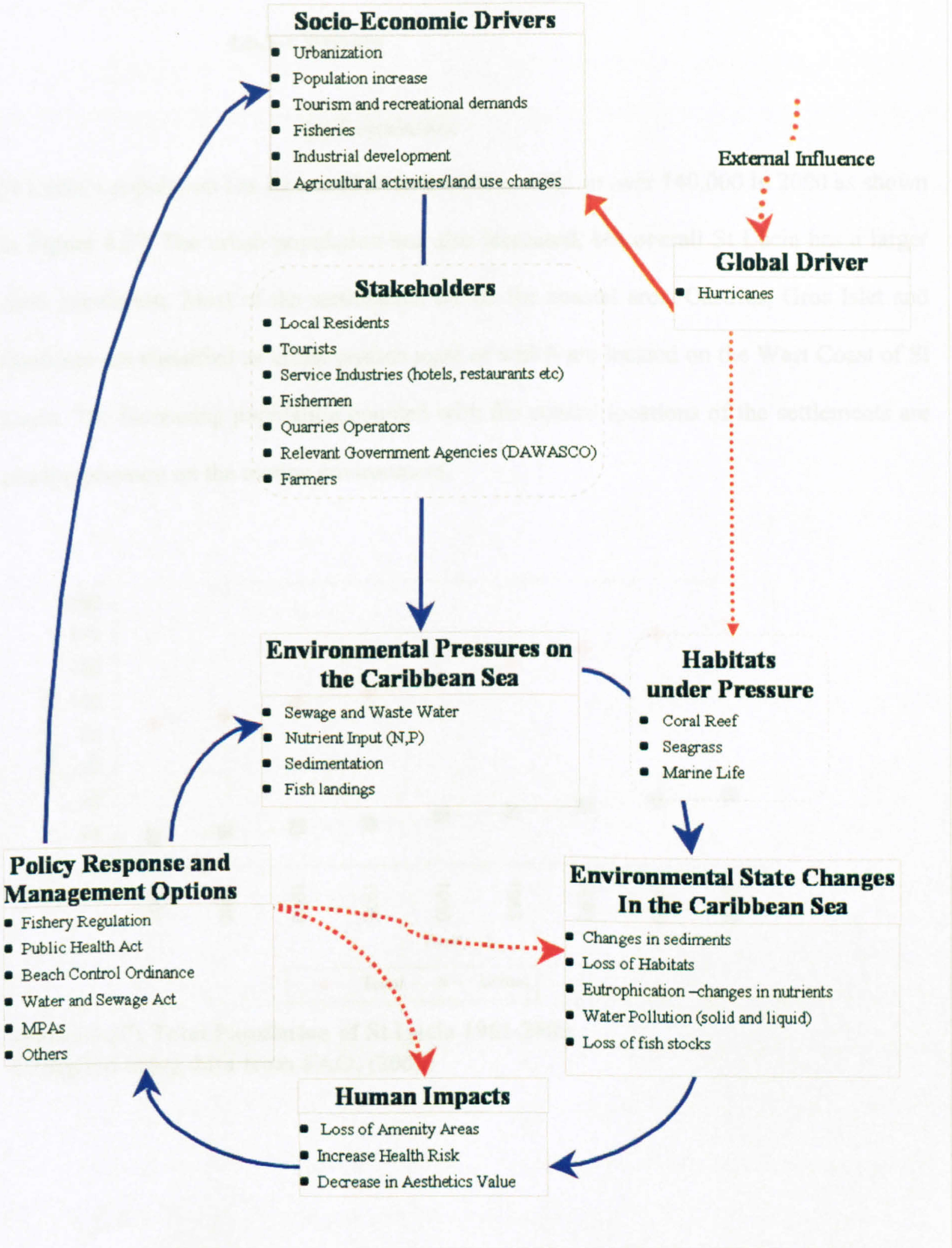


Figure 4.26: Diagrammatic Representation of the DPSIR for Dominica showing the linkages between the various components. It also highlights the stakeholders that are contributing to these pressures also the marine habitats that are under pressure.

4.6.3 ST LUCIA

4.6.3.1 Drivers

(a) Population

St Lucia's population has increased from 84,000 in 1961 to over 140,000 in 2000 as shown in Figure 4.27. The urban population has also increased, but overall St Lucia has a larger rural population. Most of the settlements are on the coastal area. Castries, Gros Islet and Soufriere are classified as urban centres most of which are located on the West Coast of St Lucia. The increasing population coupled with the coastal locations of the settlements are placing pressure on the marine environment.

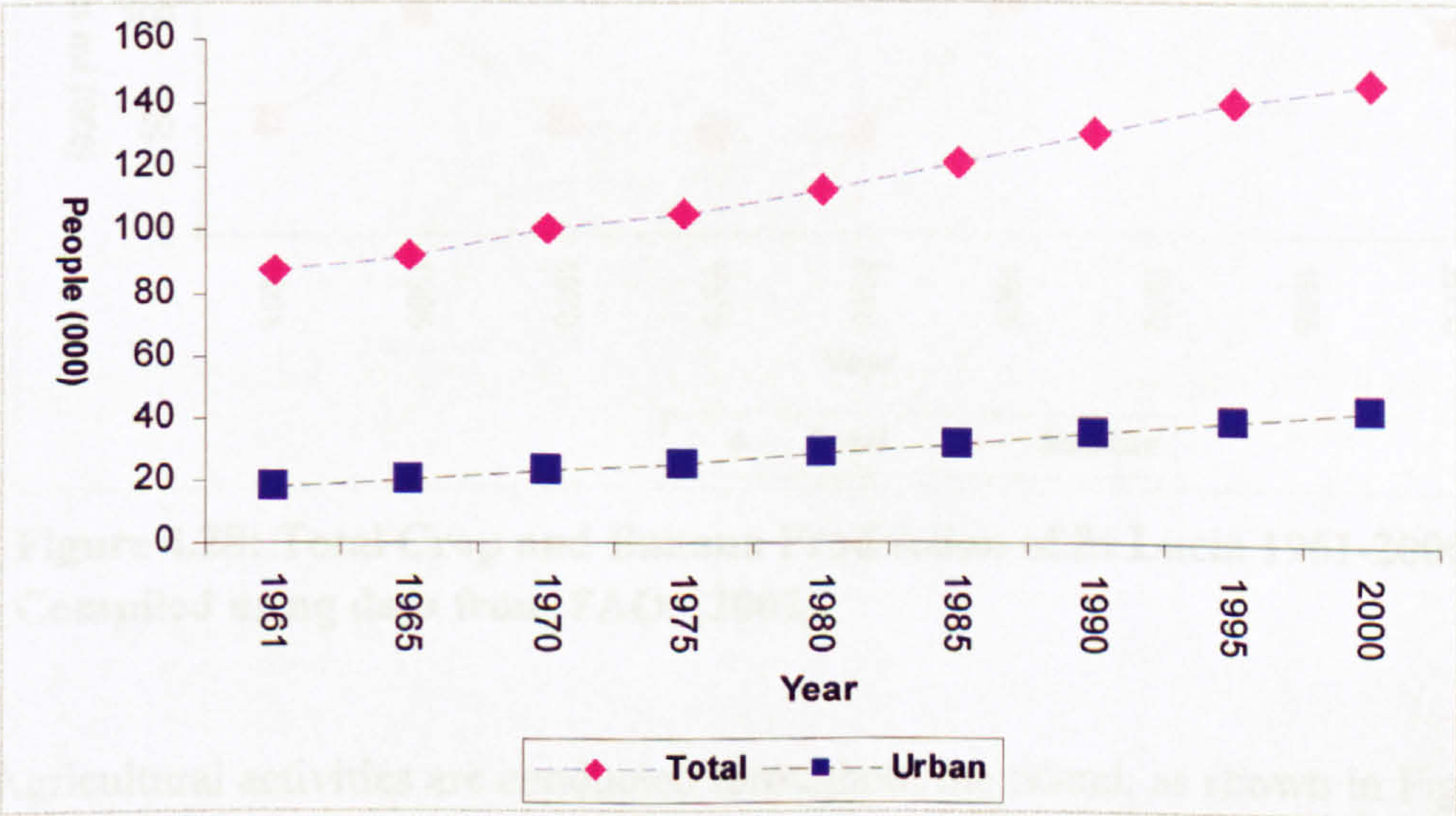


Figure 4.27: Total Population of St Lucia 1961-2000.
Compiled using data from FAO, (2002)

(b) Agriculture Activities

Many different types of crops are grown in St Lucia including tubers and vegetables. The total crop output has fluctuated as shown in Figure 4.28, with the highest output occurring in 1990. Banana is the most widely cultivated crop in St Lucia and shows a similar fluctuation pattern as the total crop production. The sector has also been affected by natural events such as hurricanes. In 1975 Hurricane Allen made landfall in St Lucia severely affected crop production.

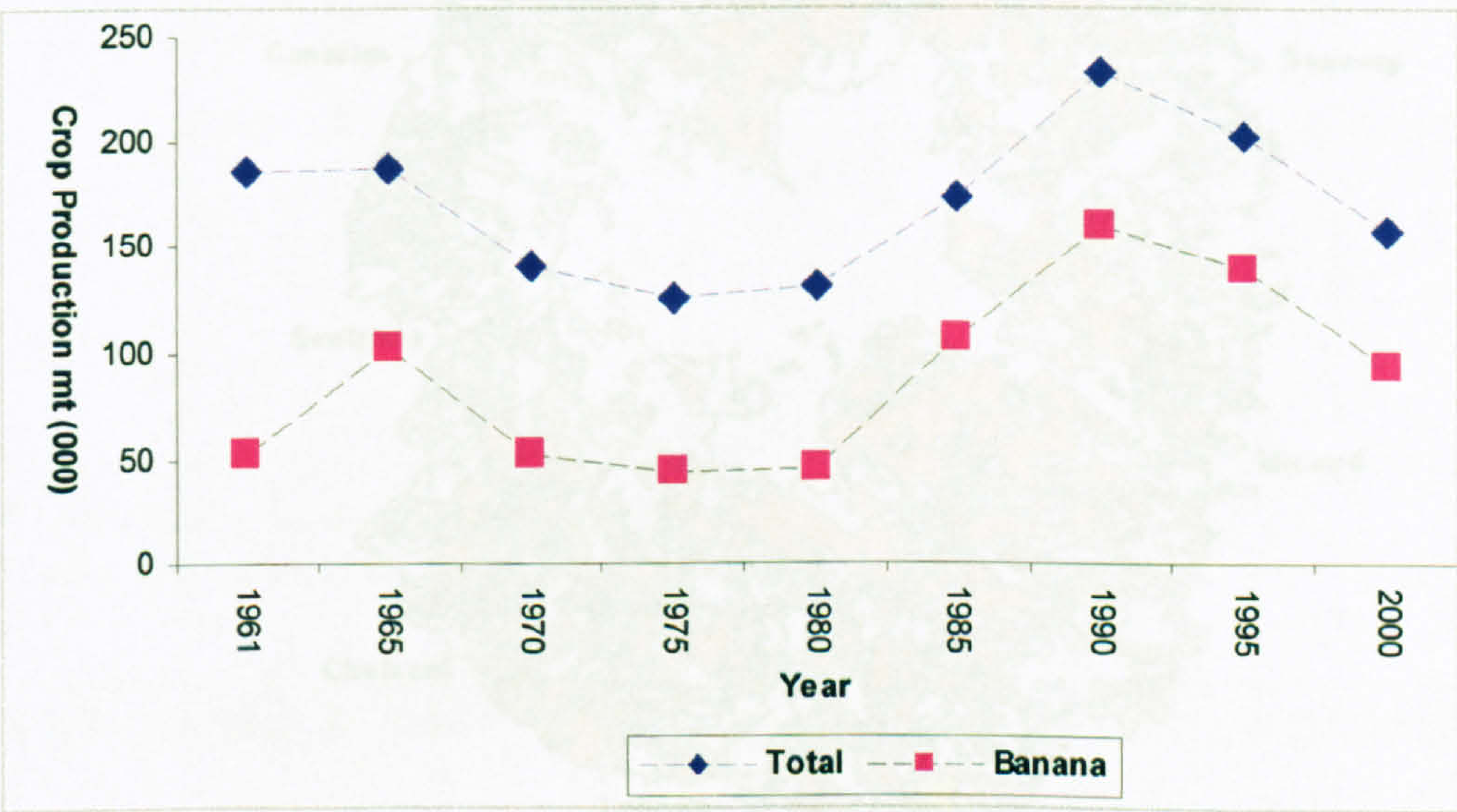


Figure 4.28: Total Crop and Banana Production of St Lucia 1961-2000. Compiled using data from FAO, (2002)

Agricultural activities are conducted throughout the island, as shown in Figure 4.29. Many of the agricultural designated lands are not suitable for banana cultivation and in some areas there are high erosion rates. Cox (2003) showed that areas in St Lucia that are suitable for agricultural cultivation range from 5-45% of the island's land mass, with 5% being the ideal type of soil and topography for farming.

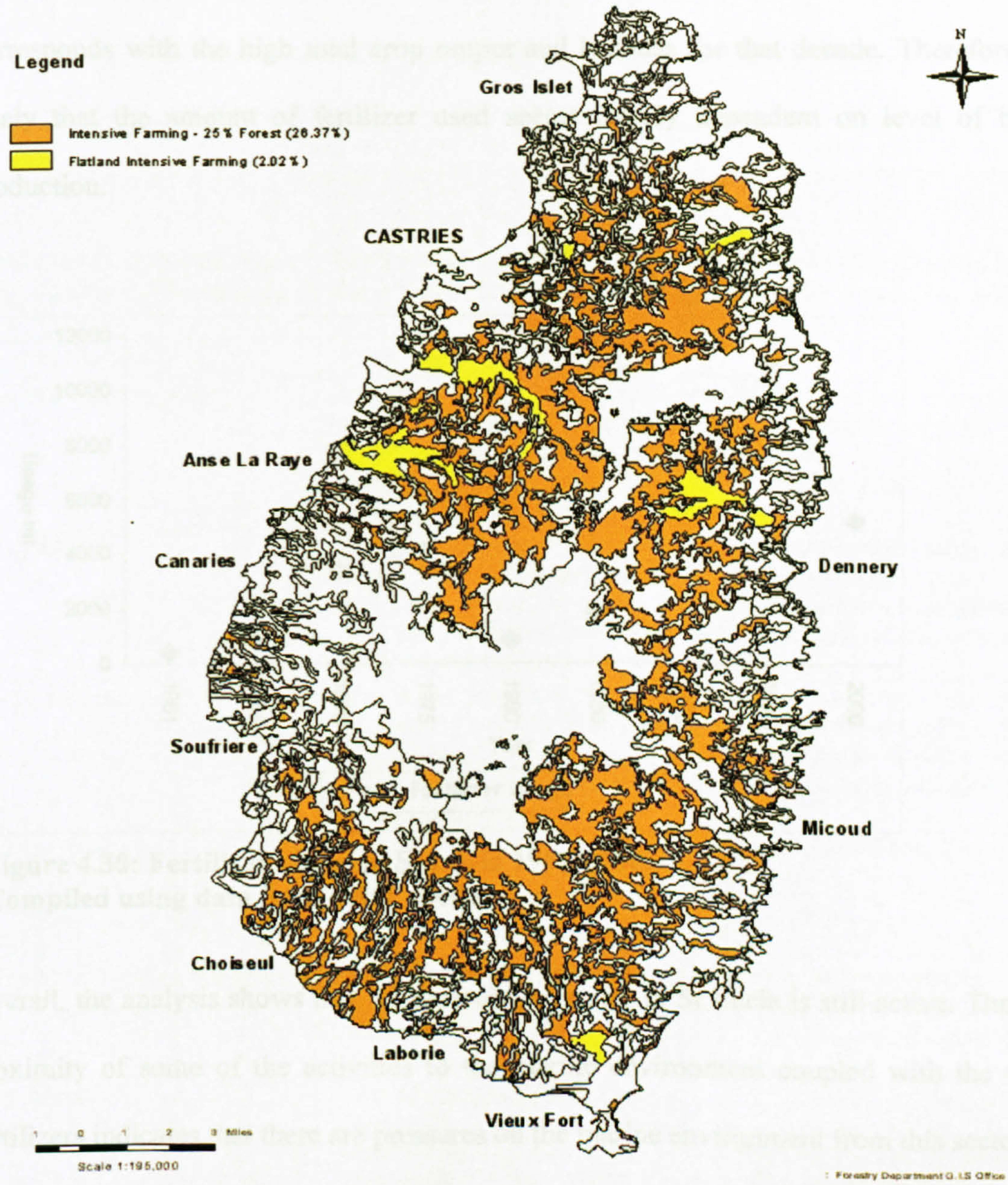


Figure 4.29: A Map showing the Farming Intensity in St Lucia. Intense faming is conducted on steep terrain (Taken from Bushnell *et al*, 2001)

Fertilizer usage in St Lucia was the highest in the 1990s, as shown in Figure 4.30. This corresponds with the high total crop output and bananas for that decade. Therefore, it is likely that the amount of fertilizer used seems largely dependent on level of banana production.

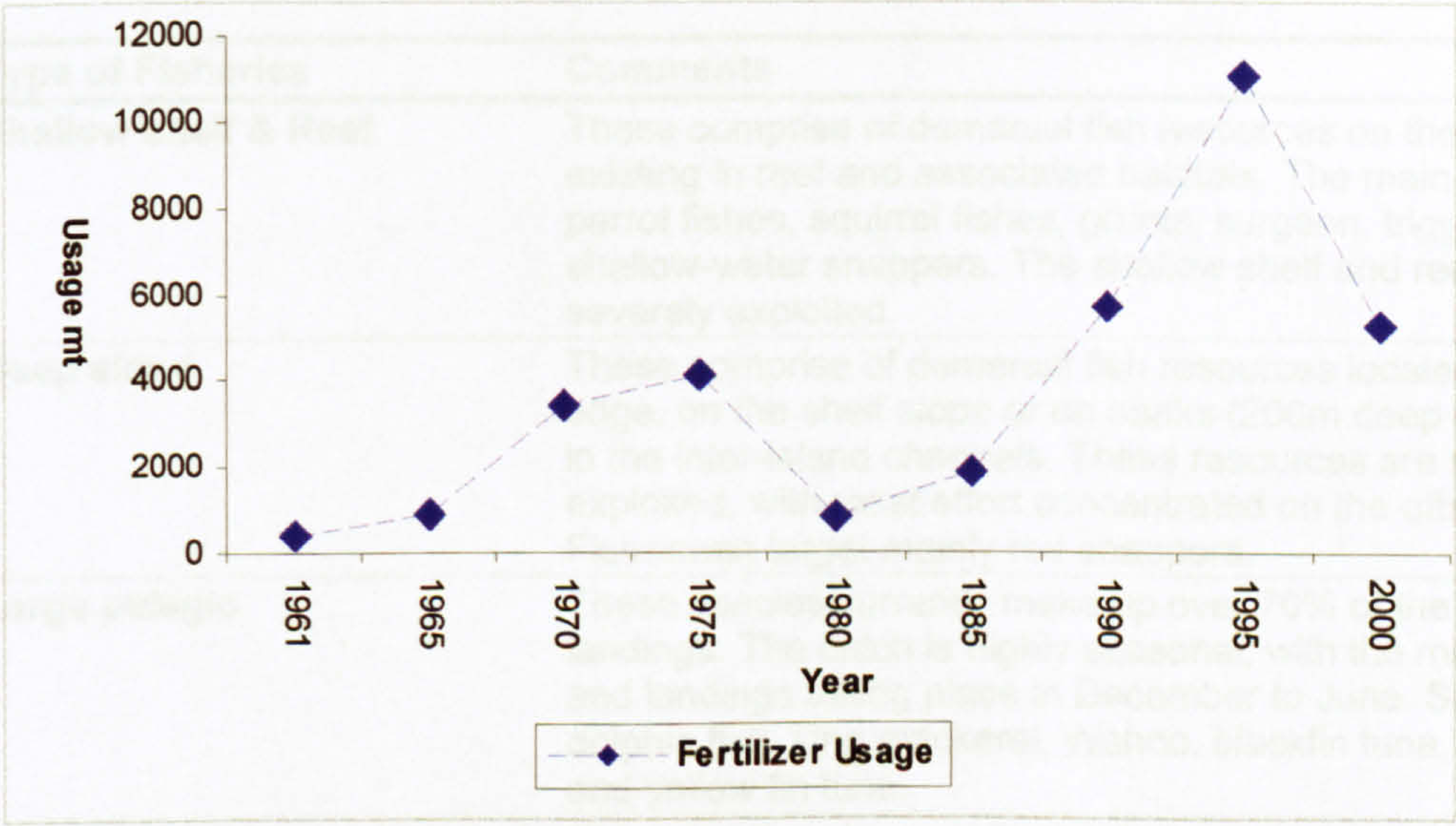


Figure 4.30: Fertilizer Usage in St Lucia 1961-2000. Compiled using data from FAO, (2002)

Overall, the analysis shows that the agricultural sector in St Lucia is still active. The close proximity of some of the activities to the marine environment coupled with the use of fertilizers indicates that there are pressures on the marine environment from this sector.

(c) Fisheries

St Lucia's fisheries is a growing sector with heavy pressure on the coral reef and coastal area (Bushnell *et. al.*, 2001). The state of St Lucia's fisheries sector is summarised in Table 4.13.

Table 4.13: A Summary of the State of the Fisheries Sector in St Lucia. Compiled using information obtained from interviews and St Lucia Fisheries Division, (2001)

Type of Fisheries	Comments
Shallow shelf & Reef	These comprise of demersal fish resources on the island shelf existing in reef and associated habitats. The main species include parrot fishes, squirrel fishes, grunts, surgeon, trigger fishes, and shallow-water snappers. The shallow shelf and reef fisheries are severely exploited.
Deep slope	These comprise of demersal fish resources located at the shelf edge, on the shelf slope or on banks (200m deep or more) located in the inter-island channels. These resources are moderately exploited, with most effort concentrated on the offshore banks. Fishermen target mainly red snappers.
Large pelagic	These species currently make up over 70% of the annual fish landings. The catch is highly seasonal, with the majority of activity and landings taking place in December to June. Species include dolphin fish, king mackerel, Wahoo, blackfin tuna, skipjack tuna and yellow fin tuna.
Coastal pelagic	The catch largely comprises a limited number of species including ballyhoo and small schooling jack species.
Lobsters	The landings mainly comprise the spiny lobster.
Conch	The main species harvested is the Queen Conch. The fishery is controlled through a limited entry system via an exclusive license issued to conch divers who are authorised to use SCUBA gear for the fishing. This fishery was heavily overfished in the past, efforts are now made to advocate stock recovery.
Sea Urchin	The White Sea Urchin, once a popular resource, declined considerably in the early 1980s due to over harvesting. A 3-year ban imposed by the Department of Fisheries (mid 1990s) and regular monitoring of stocks allowed it to recuperate. The fisheries is now controlled by a collaborative management arrangement between the harvesters and management authorities. However, unknown factors, not believed to be associated with harvesting activities, have caused a markedly low recruitment of juveniles over the past decade. Illegal harvesting of this resource is still posing a threat to its recovery.
Flying fish	This fishery is seasonal and is targeted by fishers during October to July. Although there are several species of flying fish in the Caribbean, the four-winged flying fish (*Hirundicthys affinis*) is the most common and comprises the bulk of the catch (over 95%).
Algae sea moss	A variety of marine algae is harvested for making a variety of traditional drinks and porridges. Harvesting of wild stocks is generally discouraged.
Turtle	Traditionally the main species targeted were the Hawksbill, Green and Leather Back turtles.

There has been an increase in the number of fishermen and fishing vessels, as shown in Figure 4.31. The increase in fishing vessels indicates a more modern approach to fishing in St Lucia and a possible shift from nearshore fishing activities to other offshore areas. This increase in fishermen and vessels show a growing sector. This growth will place additional pressure on fisheries stock in St Lucia.

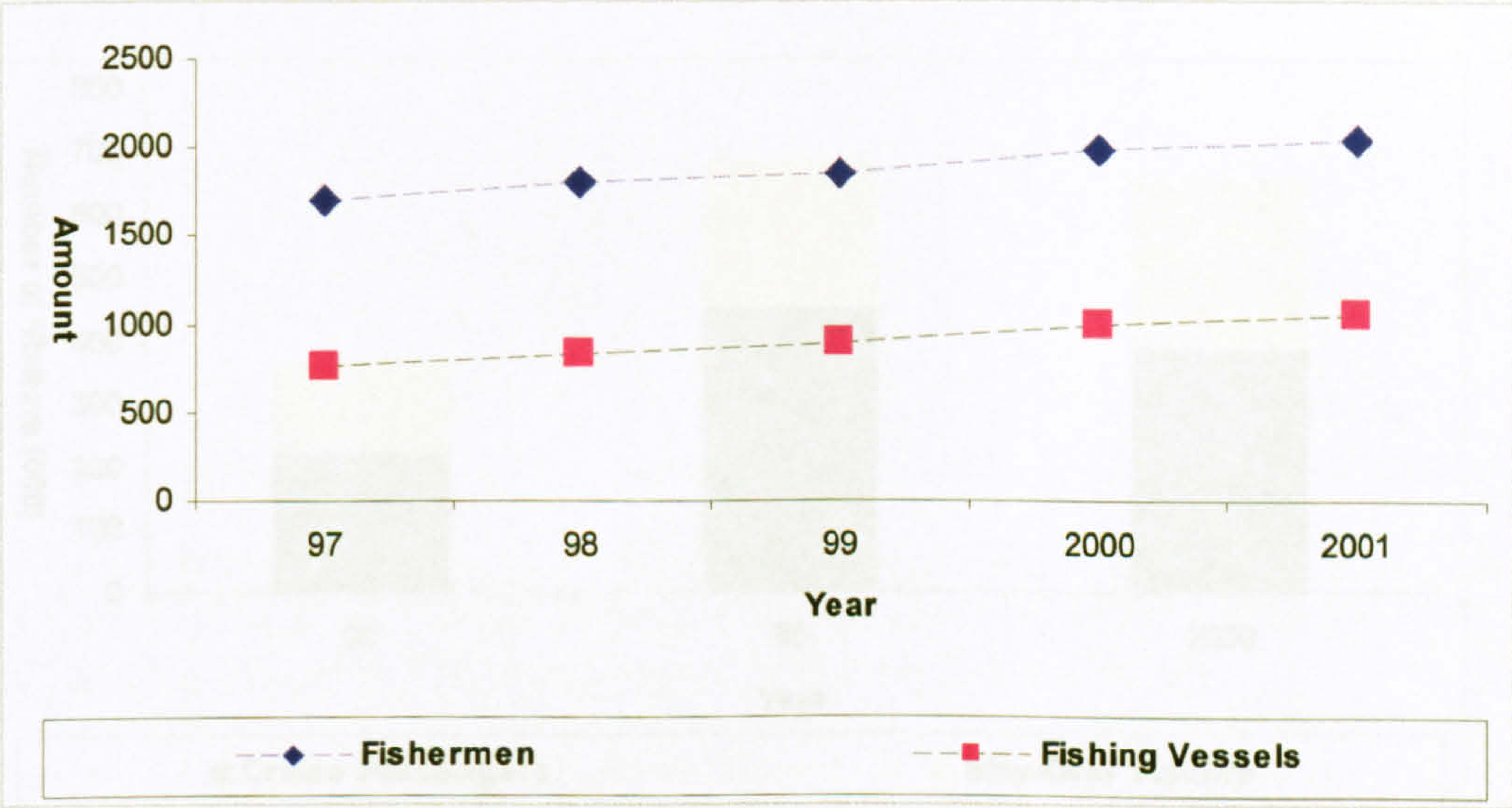


Figure 4.31: Fishermen and Fishing Vessels in St Lucia 1997-2000. Compiled using data from St Lucia Fisheries Division, (2001)

(d) Tourism and Recreational Activities

The tourism sector is emerging steadily in St Lucia. It has been the major economic sector overtaking agriculture since 1997 (UK Trade and Investment, 2003). St Lucia caters for both cruise passengers and stay-over visitors. The cruise sector consists of an average of 3-4 cruise ships per week during the peak season (Deepa Gadjadari *pers. comm.)*. During the off season, St Lucia receives an average of 1 cruise ship per week. There are sixteen dive sites in St Lucia, which are in the Caribbean Sea and two golf courses on the coastal area bordering the sea. In addition, there are fifty-one large hotels of which fifty are in the coastal area bordering the Caribbean Sea (Anonymous, 2003d).

The number of cruise arrivals decreased in 2000, as shown in Figure 4.32. According to Deepa Gadjadari (*pers. comm.*), this decrease is a result of increased competition in the region. This tourism officer noted that fewer cruise ships are coming to the island. Overall, the tourism sector has increased the pressure on the marine environment with activities such as waste disposal and re-engineering of the coastal area.

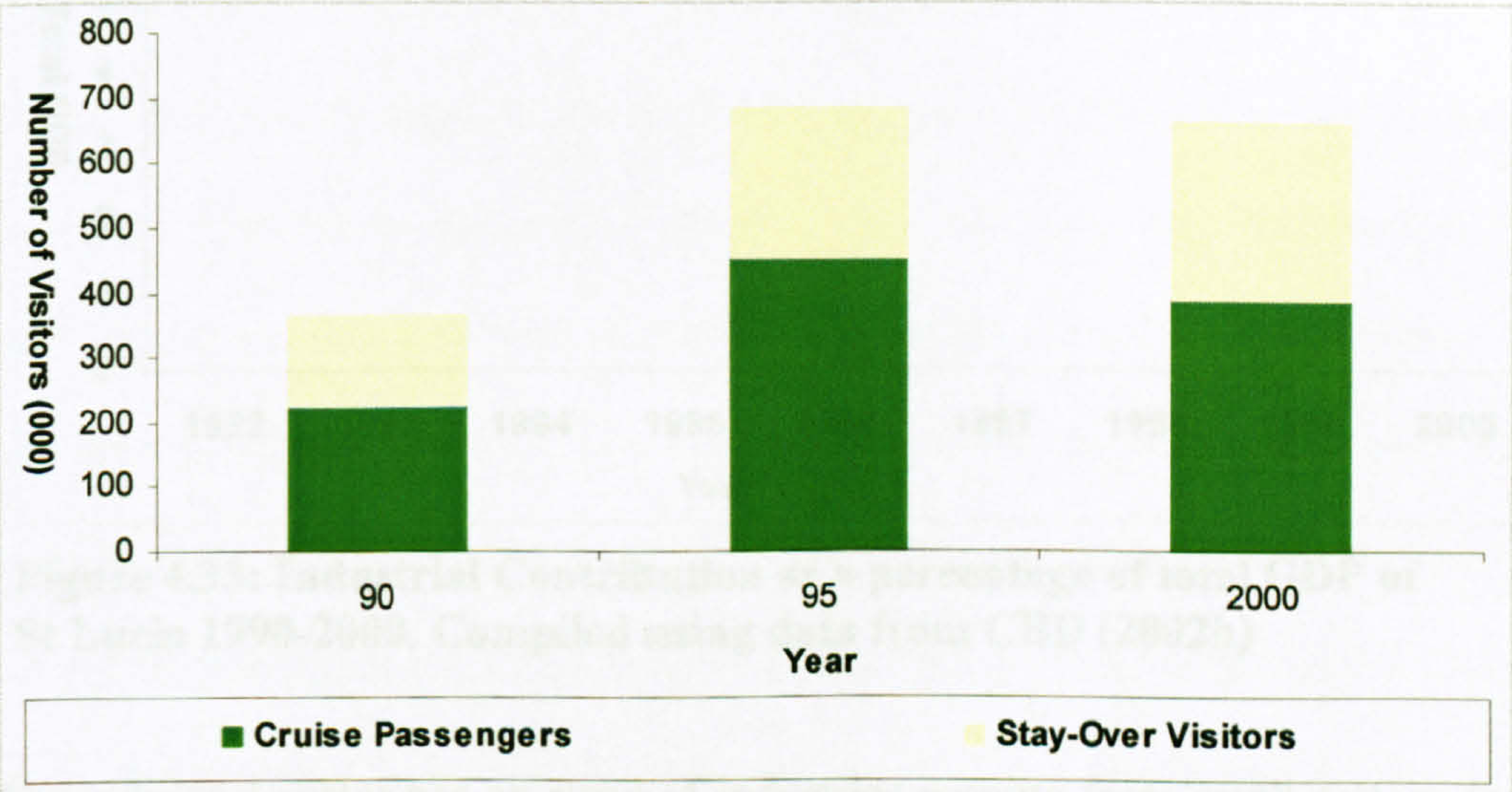


Figure 4.32: Total Cruise and Stay-Over Visitors to St Lucia 1990-2000. Compiled using data from CTO (2002); WTO (2004)

(e) Industrial Activities

The industrial sector contributes between 5-7% of the total GDP. The contribution declined progressively from 1995 onwards as shown in Figure 4.33.

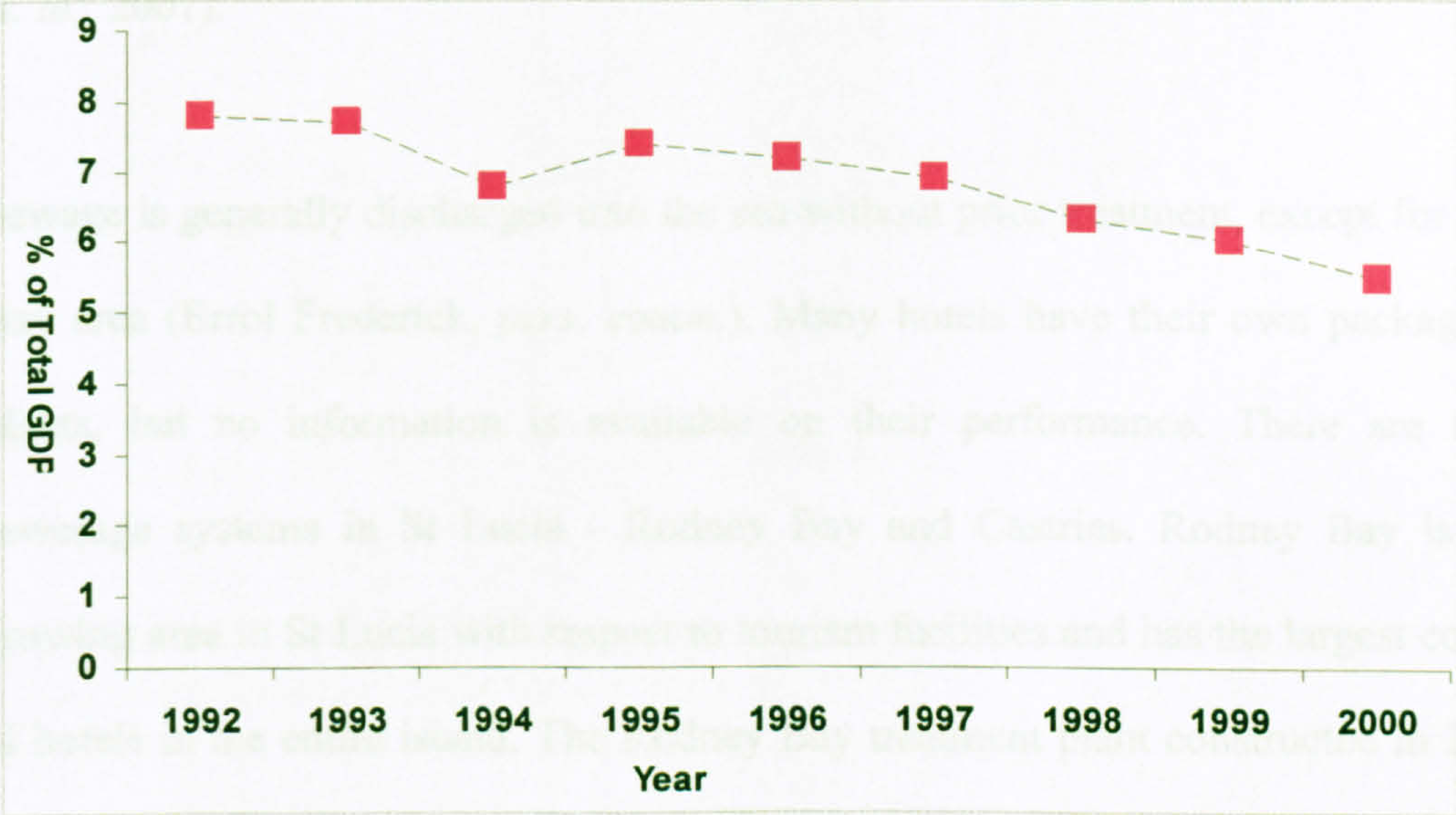


Figure 4.33: Industrial Contribution as a percentage of total GDP of St Lucia 1990-2000. Compiled using data from CBD (2002h)

The industrial sector has an array of industries ranging from small cottage industries such as, processed foods and beverage manufacturing. There are three major industrial zones, namely Cul de Sac, Gros Islet and Vieux Fort, however a large number of factories and industries are still sited in an ad-hoc manner.

There are no discharge limits for wastewater, hence most of the factories dispose their effluents into nearby waterways. The inadequate treatment of waste prior to disposal has added to the pressures on the marine environment.

4.6.3.2 Pressures

Pressures are placed on the marine environment from sewage, agrochemicals, solid waste and petroleum. These are regarded as serious environmental issues in St Lucia (Bushnell *et. al.*, 2001).

Sewage is generally discharged into the sea without prior treatment, except for the Rodney Bay area (Errol Frederick, *pers. comm.*). Many hotels have their own package treatment plants, but no information is available on their performance. There are two central sewerage systems in St Lucia - Rodney Bay and Castries. Rodney Bay is the fastest growing area in St Lucia with respect to tourism facilities and has the largest concentration of hotels in the entire island. The Rodney Bay treatment plant constructed in 2000, offers service to all hotels and homes in the Gros Islet area. Other hotels between Castries and Gros Islet periodically use the Rodney Bay sewerage plant to dispose the sludge collected from their respective in-house treatment plants (Errol Fredericks *pers. comm.*). Rodney Bay conducts secondary treatment of the sewage prior to discharge into the Trou Salee River. The treatment prior to disposal reduces immensely the pressure from sewage on the marine environment.

The Castries sewerage system was built in the 1950s and no upgrades were ever done. This system collects the sewage from Castries City, Castries Suburbs and Castries Rural. Sewage collected by the Castries sewerage plant is not treated and is discharged via an outfall (WASCO) into the Castries Harbour. As shown in Figure 4.34 the faecal coliform level in the Castries area is higher than the acceptable guideline levels in the WHO, LBS Protocol and Blue Flag.

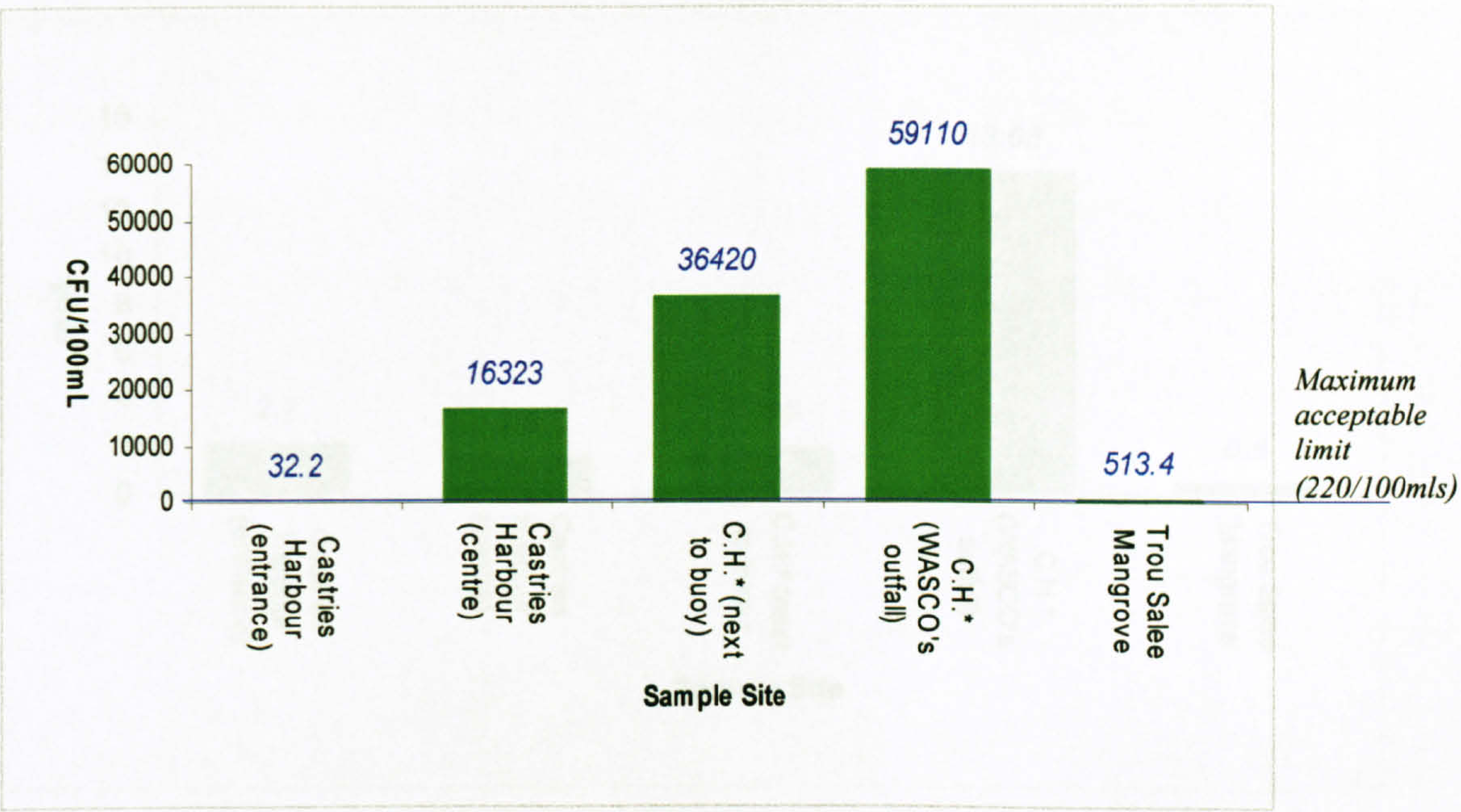


Figure 4.34: Faecal Coliform Measurements for St Lucia in 2004. Compiled using data from CEHI, (2004).

Not all households and businesses are connected to the system in the city and most use sceptic tanks. On many occasions, this has resulted in leaching and foul smells in some parts of the city (John Pierre *pers. comm.*). The other method of sewage disposal in Castries is via pit latrines. In the island of St Lucia, only an average of 16% of the total population is connected to the sewerage systems (Errol Frederick *pers. comm.*).

The nitrates and phosphates measurements shown in Figures 4.35 and 4.36 are particularly high at the WASCO outfall. The elevated level indicates the pressure from sewage, which emanates from the Castries Sewerage Plant. The phosphate level at the True Salee site is higher than the other sample sites. Trou Salee is the exit point for waste from the Rodney Bay sewerage plant and the high phosphate content may be as a result of the type of treatment applied to the sewage prior to discharge.

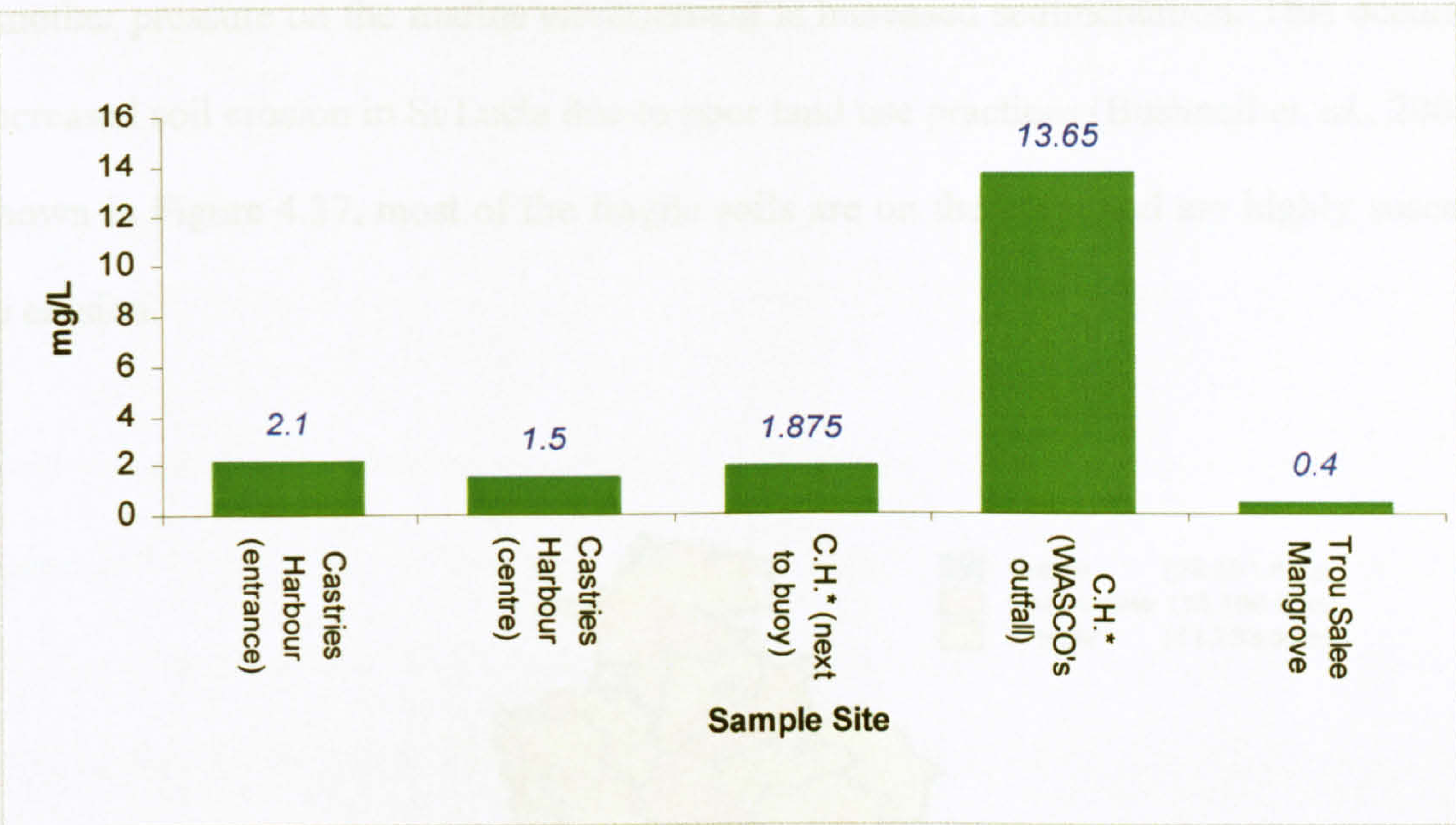


Figure 4.35: Nitrates Measurements for St Lucia in 2004. Compiled using data from CEHI, (2004)

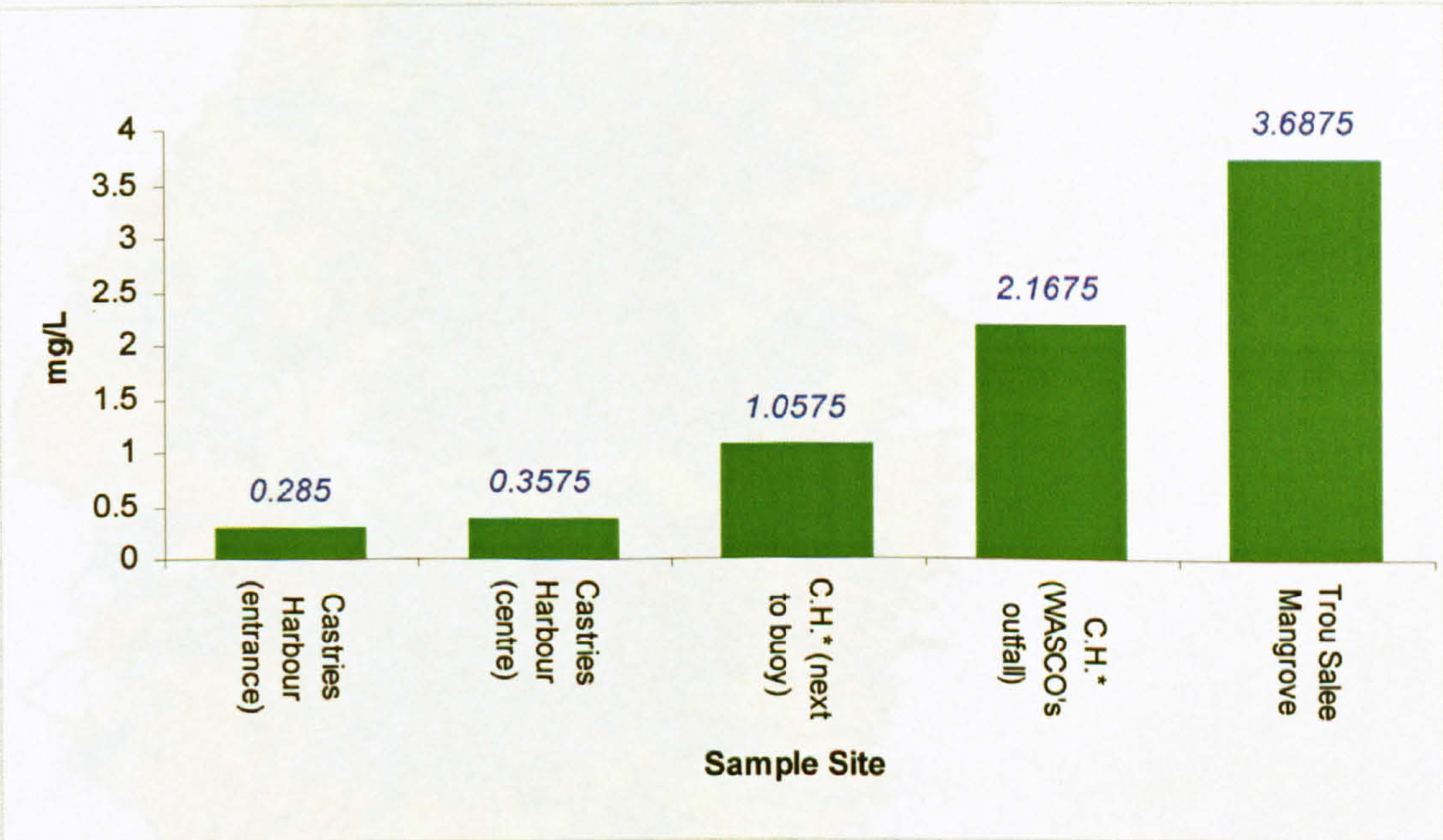


Figure 4.36: Phosphates Measurements for St Lucia in 2004. Compiled using data from CEHI, (2004)

Another pressure on the marine environment is increased sedimentation. This occurs from increased soil erosion in St Lucia due to poor land use practices (Bushnell *et. al.*, 2001). As shown in Figure 4.37, most of the fragile soils are on the coast and are highly susceptible to erosion.

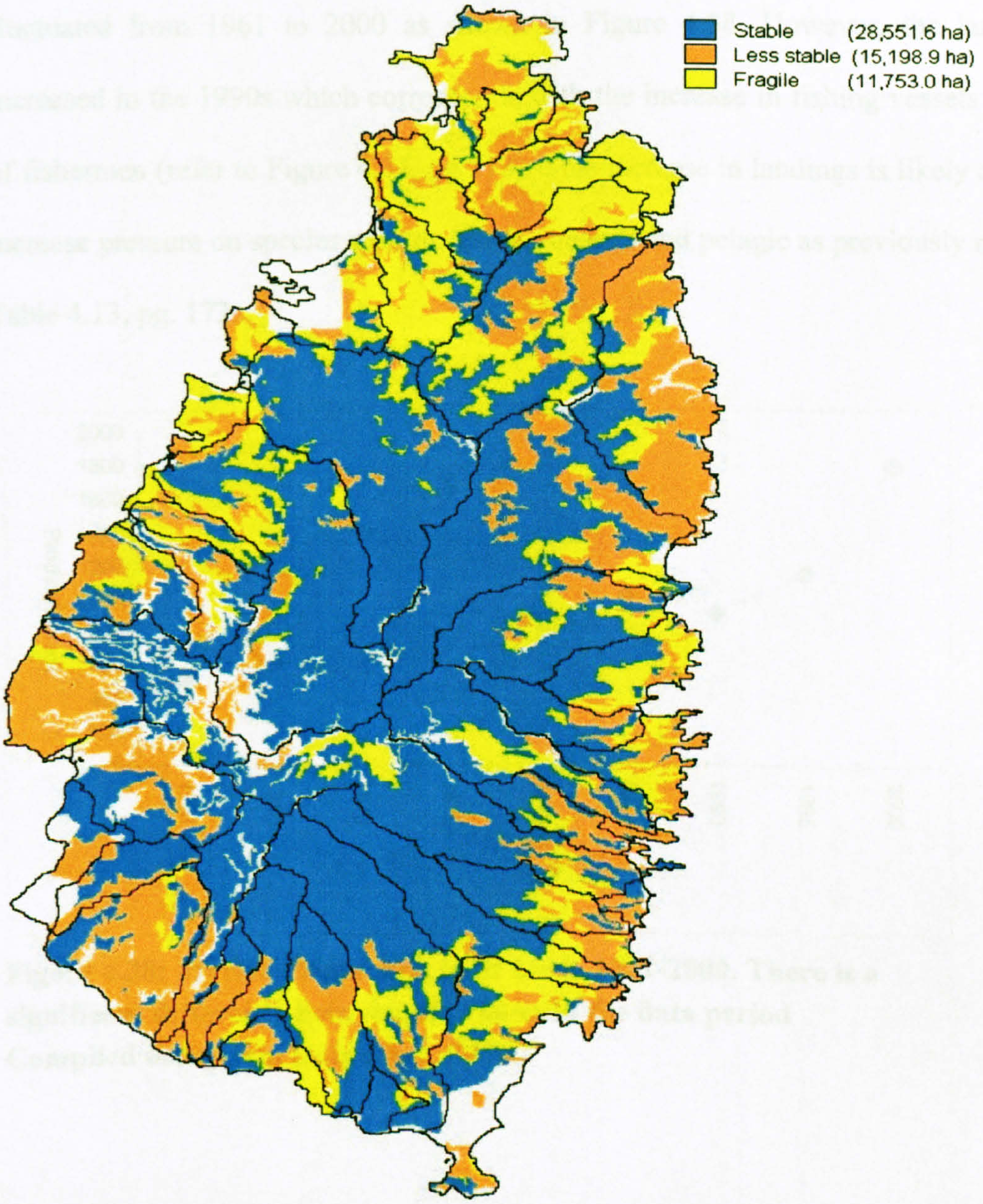


Figure 4.37: Map showing the Level of Erosion in St Lucia (Taken from Bushnell *et. al.*, 2002)

It is estimated that soil loss in St Lucia ranges from 25 to 63 t/ha/yr (Hunting Technical Services Ltd, 1984). According to Bushnell *et. al.* (2001) land based activities such as deforestation and poor land use management have led to high sediment levels in coastal waters.

Fisheries stocks are also under pressure in St Lucia. Fisheries production has generally fluctuated from 1961 to 2000 as shown in Figure 4.38. However, the landings have increased in the 1990s which corresponds with the increase in fishing vessels and number of fishermen (refer to Figure 4.31, pg 173). This increase in landings is likely as a result of increase pressure on species such as conch, lobsters and pelagic as previously mentioned in Table 4.13, pg. 172.

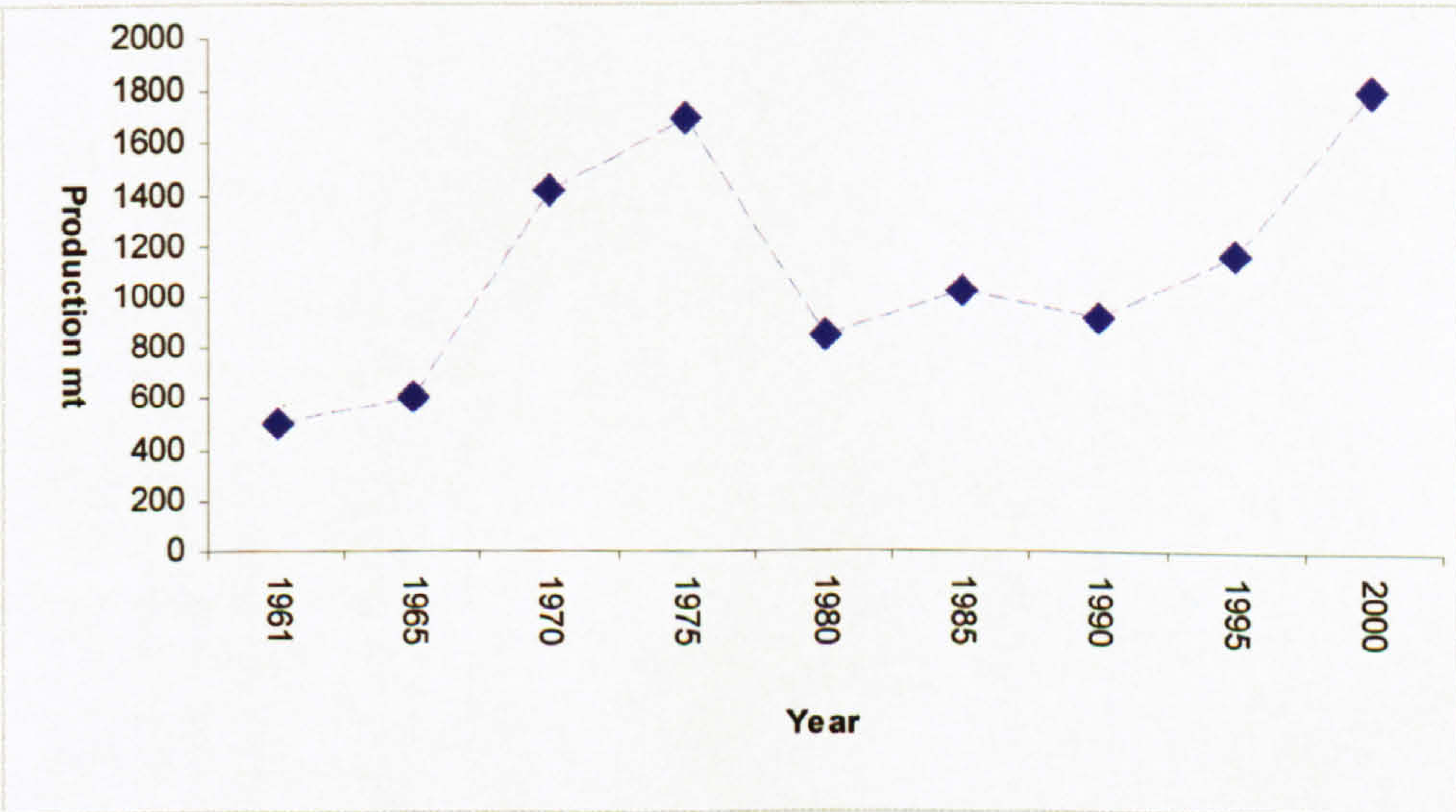


Figure 4.38: Marine Production in St Lucia 1961-2000. There is a significant difference between the values in the data period Compiled using data from FAO, (2002)

There is also pressure from industrial activities such as effluent discharge. For example, St Lucia's distillers currently dispose of waste containing yeast and other materials into the Roseau Bay (Bushnell *et. al.*, 2001). This area is a prime fishing site for seine fishers. Overall, it is evident that the land based activities are causing pressure on the marine environment.

Further, the use of spatial information can indicate the pressures on the marine environment from land based activities in St Lucia. The economic sectors shown from land use information in Figure 4.39 can provide clues of the likely areas of pressures and the possible sources. The sample areas shown in Figure 4.39 are further explained in Table 4.14.

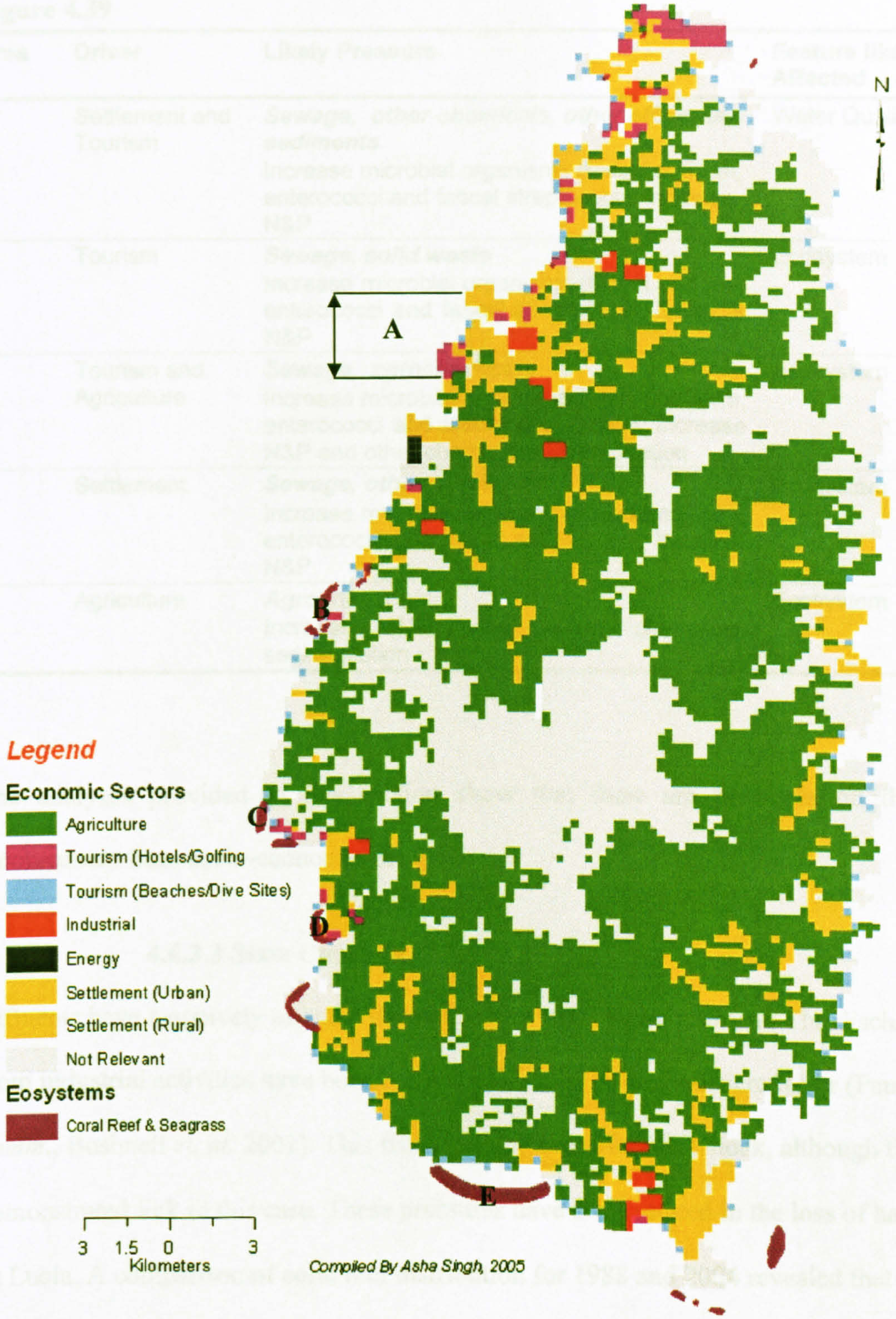


Figure 4.39: A Map showing the Economic Sectors of St Lucia using land use information as a proxy to determine spatial pressures. The map was derived using information from Ministry of Planning, (2002a) and reconnaissance field survey. Areas A, B, C, D and E are further expanded in Table 4.14

Table 4.14: Identifying the Drivers, likely Pressures and affected areas highlighted in Figure 4.39

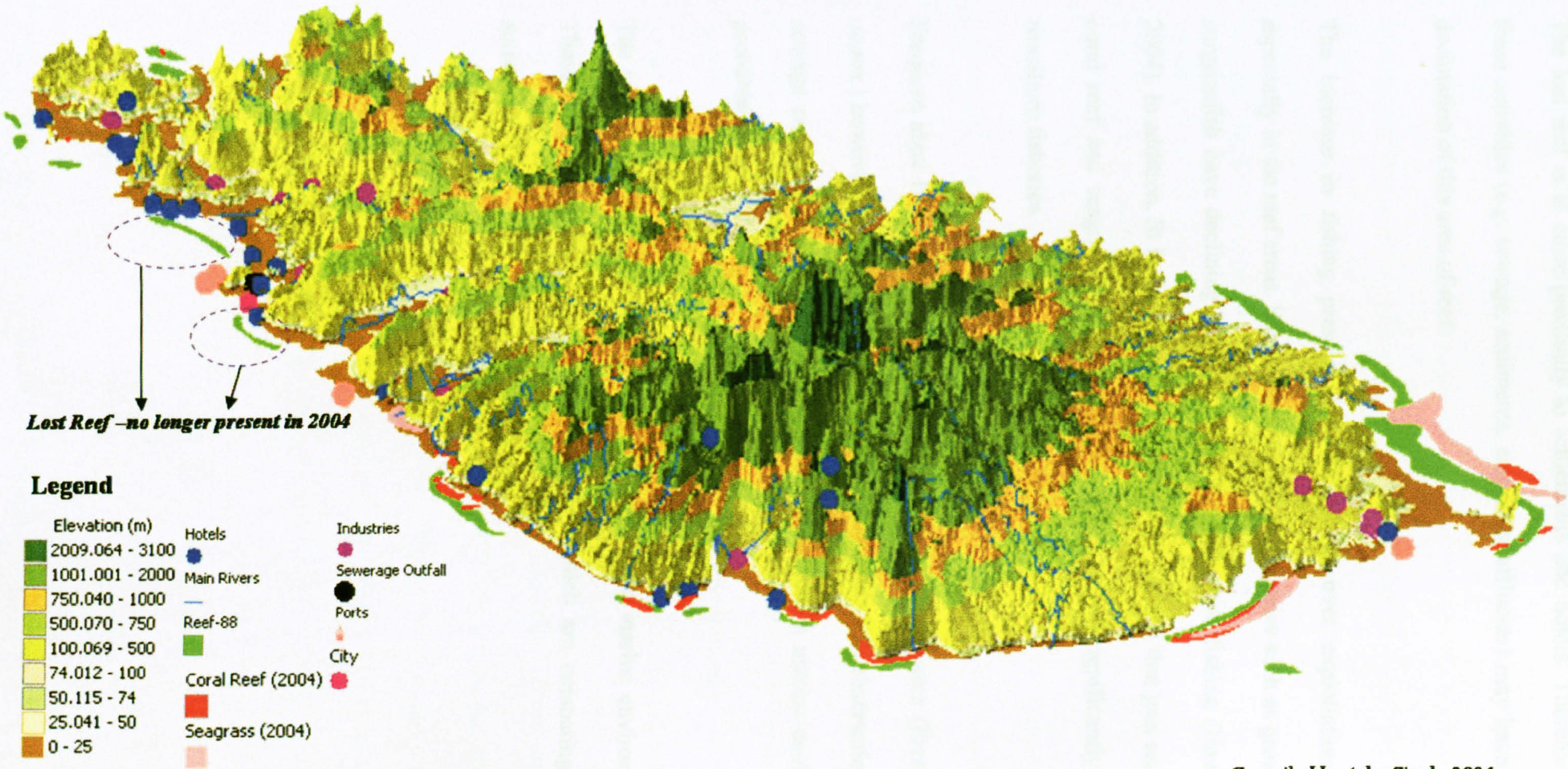
Area	Driver	Likely Pressure	Feature likely to be Affected
A	Settlement and Tourism	***Sewage, other chemicals, other effluents, sediments*** Increase microbial organisms (faecal coliform, enterococci and faecal streptococci. Increase N&P	Water Quality
B	Tourism	***Sewage, solid waste*** Increase microbial organisms (faecal coliform, enterococci and faecal streptococci. Increase N&P	Ecosystem
C	Tourism and Agriculture	***Sewage, agrochemicals*** Increase microbial organisms (faecal coliform, enterococci and faecal streptococci. Increase N&P and other chemicals, sedimentation	Ecosystem
D	Settlement	***Sewage, other waste*** Increase microbial organisms (faecal coliform, enterococci and faecal streptococci. Increase N&P	Ecosystem
E	Agriculture	***Agrochemicals*** Increase N&P and other chemicals, sedimentation	Ecosystem

The analyses provided in this section show that there are pressures on the marine environment from socio-economic drivers.

4.6.3.3 State Changes

Effluents have negatively affected the state of the marine environment. The discharges from industrial activities have been linked to fish kills in the Soufriere River (Paul, *pers. comm.*, Bushnell *et. al.* 2001). This fish mortality can affect fish stock, although there is no demonstrated link in this case. These pressures have also resulted in the loss of habitats in St Lucia. A comparison of coral reef distribution for 1988 and 2004 revealed that some coverage of reef areas were lost in some areas. This is shown in Figure 4.40.

The high coastal concentration of many land used activities along with the terrain in St Lucia can influence the level and rate of contamination in the marine area from land based activities. This can enhance the rate of state changes on the marine environment. The spatial location of the land based activities and the terrain is also illustrated in Figure 4.40.



Compiled by Asha Singh, 2004

Figure 4.40: A 3D Map of St Lucia showing the lost reef and location of other land use activities. The map demonstrates the most of the activities in St Lucia are on the West Coast of the Island. Compiled using data from St Lucia Ministry of Planning, (2004), GPS Coordinates.

The lost reef is in close proximity to settlements and hotels. Therefore, pressures from these activities (e.g. sewage, sediments, and other effluents) may have contributed to the decimation of this area of reef.

The increase in fishing pressure has resulted in over exploitation of some species especially in the reef areas. Studies have shown that species such as groupers, snappers and surgeonfish have declining biomass because of increased fishing (Hawkins and Roberts, 2004). In addition, St Lucia Fisheries Division (2001) noted that past and continued loss of coral reef and seagrass habitats have likely contributed significantly to the decline in nearshore fisheries.

Frequent algal blooms are observed in the Castries harbour area (Errol Fredericks, *pers. comm.*) however, there are no studies conducted to verify this observation. The presence of sewage and other chemicals shows that eutrophication in marine environment is highly probable.

The analyses in this section show that the state of the marine environment is changing. These changes are being caused by pressures, which are emanating from land based activities.

4.6.3.4 Impact

The poor water quality in the marine environment has decreased its recreational value and contributed to the loss of amenity areas. For example in Castries Harbour, the high bacterial count caused by sewage discharge has polluted the water rendering it a prohibited area for swimming and fishing (see picture in St Lucia profile in enclosed CD).

Another impact is the social discomfort to residents. In some settlement areas, the foul smells emanating from nearby marine areas have caused discomfort. According to Paul (*pers. comm.*), this have resulted in constant complaints by residents.

The decrease of fish stocks has negatively influenced the consumers' choices and preferences. Species such as Conch is a delicacy in St Lucia which it is not readily available because of declining stocks.

4.6.3.5 Responses

St Lucia has much legislation, which responds to some aspects of the marine environment. Since 1998, the policy makers in St Lucia have attempted a more integrated approach to resource planning. This approach has evolved from the St Georges Declaration on the Principles for Environmental Sustainability. This declaration was signed in 2000 and it covers all of the islands within the Organisation of Eastern Caribbean States[38]. For the purpose of this study, the legislation that influences the marine spectrum is reviewed, to determine whether they are adequate to deal with the issues in the marine environment. The legislation is summarised and presented in Table 4.15. Most of the information provided with regard to the legislation was taken from a review by OECS (OECS NRMU, 2002).

[38] OECS Countries are Anguilla, Antigua & Barbuda, BVI, Dominica, Grenada, Montserrat, St Lucia, St Kitts & Nevis, St Vincent & Grenadines

Table 4.15: Relevant Environmental Based Legislation in St Lucia

LEGISLATION	COMMENTS
Oil In Navigable Water 1929	Addresses pollution in coastal and marine waters and discharge of oil. It provides a penalty of EC$ 480 (£94) for discharge of oil, but has no provision towards oil spills and the cost of environmental clean up.
Litter Act 1993	Establishes a penalty for littering
Beach Protection Act 1967	Deals with sand mining as an offence and beach littering. This act overlaps with the Litter Act.
Public Health Act 1975	Most of the act deals with waste as an issue to human health and well-being and not as an environmental issue. Part of this act deals with public and private water supplies and establishes standards for drinking water from both storage tanks and chlorinated water.
St Lucia National Trust Act 1975	Responsible for promoting and preserving areas of natural aspects in St Lucia, including both marine and terrestrial space.
Public Health Regulation 1978	Prohibits the discharge of any industrial waste into the coastal water without permission from the Public Health Board. This is not fully enforced.
Wildlife Protection Act 1980	Protects coastal flora and fauna by designation of status for endangered species.
Fisheries Act 1984	Provides the Fisheries Department with the authority to supervise the fishing industry in St Lucia.
Fisheries Regulation 1994	Establishes as an offence for anyone caught releasing any poisonous substance, or other pollutant into the estuaries and marine environment. Such actions incur a fine of EC$5000 (£1,015) in addition to any cost incurred by the Fisheries Department for remedial action. All the cost must be borne by the polluter. The act establishes conservation measures for some marine species such as the sea urchin (*Strongylocentrotus spp.)*, Queen Conch *(Strombus gigas)* and turtles *(Lepidochelys olivacea, Dermochelys coriacea, Caretta caretta, Eretochelys imbricata)* but in February 2005, the government lifted the moratorium on turtles. Under this act, there is a licensing requirement for sport fishing vessels (anglers) and tournament activities, foreign fishing vessels and fish processing facilities. In addition, there are restrictions on certain traps and a prohibition on interfering with fish in its natural habitat.
Merchant Shipping Act 1996	Provides measures to regulate oil pollution incidents from shipping. This legislation also makes a provision with respect to civil liability of pollution in coastal and marine water by merchant ships.
Solid Waste Management Authority Act 1996	Controls the collection and disposal of solid waste but falls short of establishing standards for treatment and disposal of waste.
Water and Sewerage Act 1999	Deals with the formation of a water and sewerage commission to control the sewerage and water supplies of the islands. However, there are no required standards for the treatment and discharge of sewage.
National Conservation Act 1999	Provides measures to assist in the protection of flora and fauna also the coastline. It does not contain any measures to control anthropogenic factors that may harm species or the ecosystems.
National Conservation Authority Act 1999	Establishes the NCA and includes management of activities that may affect the beach area and the designation of MPAs and parks.
Pesticides and Toxic Chemicals Control Act 2002	Repeals the Pesticides Control Act of 1975. It provides a framework for the regulation of pesticides and other toxic chemicals in order to protect humans and other species in the environment. It establishes a licensing system to control the importation of pesticides and toxic chemicals. This deals with control of sale, storage, importation and use of pesticides in St Lucia, but has no measures to control or limit pesticide disposals or prevent contamination of water sources. It has no safeguard against excessive use and the impact it may have on the marine environment.

In addition to the different legislation, there are agencies within St Lucia that are given the mandate to execute the legal requirements of the legislation and promote environmental management within programme areas. However, there is no legislation to facilitate comprehensive management of pollution of the marine environment from the various land based sources.

Sewage is under the jurisdiction of the Water and Sewerage Company (WASCO). This company is responsible for the sewage and water supply in St Lucia. However, WASCO operates without any discharge guidelines.

The Environmental Health Department is responsible for water quality monitoring. No routine monitoring is conducted and there is no monitoring system in place. A personnel in this unit contended that the coastal water is of poor quality by any standard (Edwin Pierre *pers. comm.)*. The data such as faecal coliform used in this analysis substantiates this claim especially in the Castries Harbour.

Solid Waste is the responsibility of the Solid Waste Management Authority (SWMA), a privately controlled agency. The SWMA is mandated to provide an integrated system of waste management and collection. The management of Solid Waste is effective in terms of collection but environmentally sound disposal practices are lacking. There is no system in place to sort the waste prior to disposal into the landfill. The current landfill is located in Deglos, which began operation in 2003. It is fully engineered to modern standards however, it was built on weak subsoil and requires ongoing monitoring to avoid leaching and ground water contamination (Geraldine Lenor *pers. comm.*).

Solid waste disposal including plastic into the surrounding marine environment still occurs (Bushnell *et. al.*, 2001). Corbin and Singh (1993), found that plastics were the most common debris collected on the coastal area in St Lucia between 1992-1993.

In terms of oil waste, St Lucia has a national waste oil policy, which promotes reuse and recycle of oil waste. This policy targets garage owners because these individuals tend to dispose of their waste oil into drains, which eventually pollute the marine environment. As part of the policy, each garage owner must have a waste management plan. However, many offenders are not prosecuted because enforcement capabilities are inadequate to effectively implement this policy (Geraldine Lenor, *pers. comm.*). Small niches of private businesses are emerging in the waste management arena. For example, one business deals with the collecting and shipping of discarded vehicle batteries to Venezuela for recycling. These small but favourable responses to these problems can assist in minimising the effects of land based activities on the Caribbean Sea.

St Lucia has a consolidated fund to assist in the implementation of environmental programmes. For example, the SWMA receives 30% of funding from the consolidated fund to implement a solid waste programme. Funding sources include an environmental tax of $1.50 US charged to tourists.

In 2004, St Lucia developed a coastal zone management policy and a National Environmental Strategy, both aimed at integrating and promoting environmental management. Currently, these policies are not enforced due to the lack of complimentary legislation.

Overall, the information provided in this section shows that St Lucia has much legislation to reduce land based emissions. However, most of the legislation has not addressed emissions into the marine environment. In some cases, the laws are outdated or sectoral and do not embrace integrated management of the environment. Responsibilities for the management of coastal and marine issues are dispersed among agencies. The Sustainable Unit, which was created to centralised environmental management, does not have the decision-making powers to be very effective.

4.6.4 SWOT Analysis for St Lucia

The SWOT analysis conducted for St Lucia has shown major strengths and weaknesses of the current responses. There are many opportunities for improvement to the responses, which is vital in reducing the pressures and subsequent state changes on the marine environment. The identified strengths, weaknesses, opportunities and threats are shown in Figure 4.41.

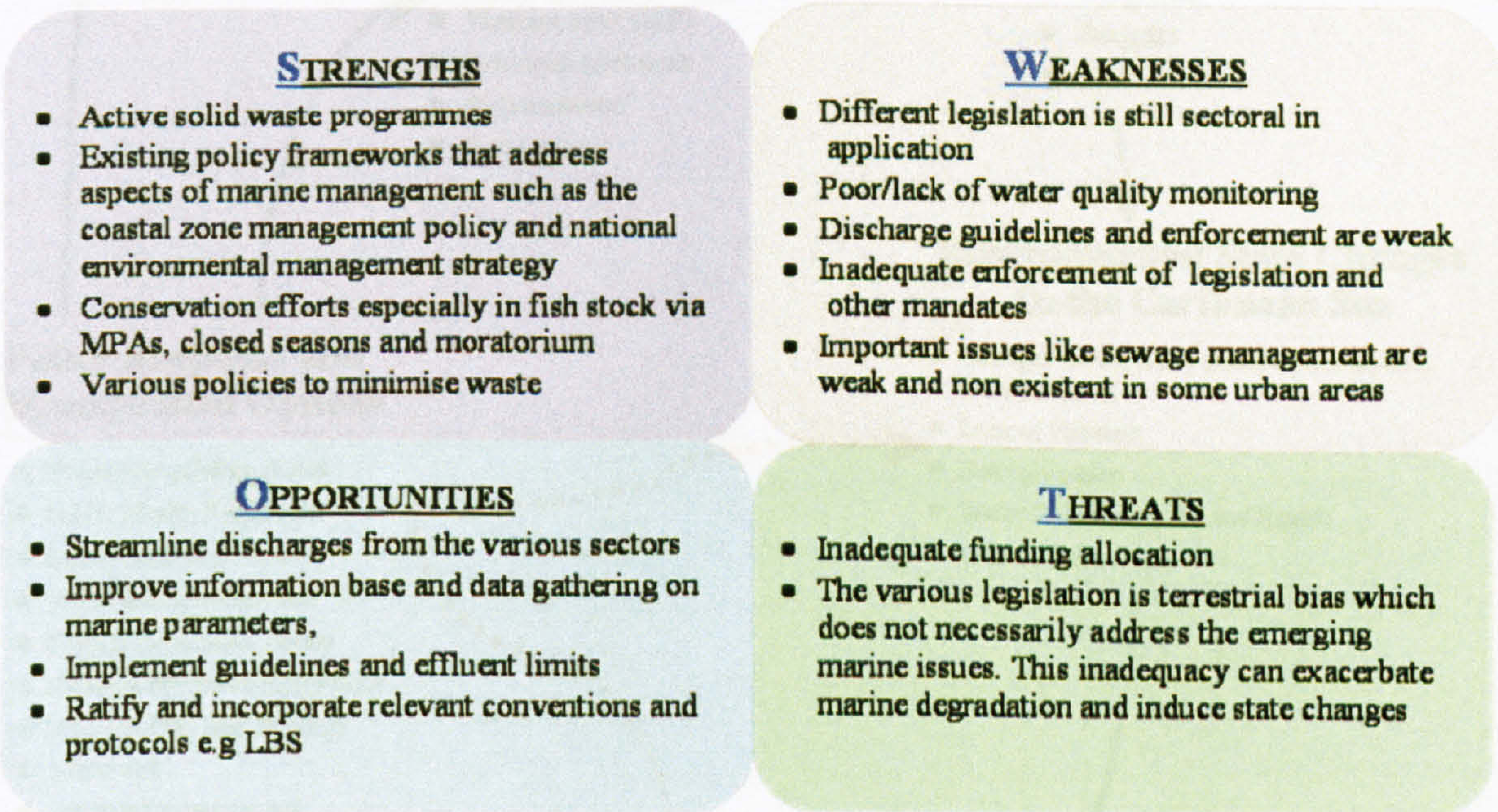


Figure 4.41: SWOT Analysis conducted for St Lucia based on the relevant environmental responses

In summary, the analyses presented within the DPSIR framework for St Lucia have highlighted the links between economic activities and environmental implications for the Caribbean Sea. These issues highlighted in the DPSIR framework are summarised in Figure 4.42.

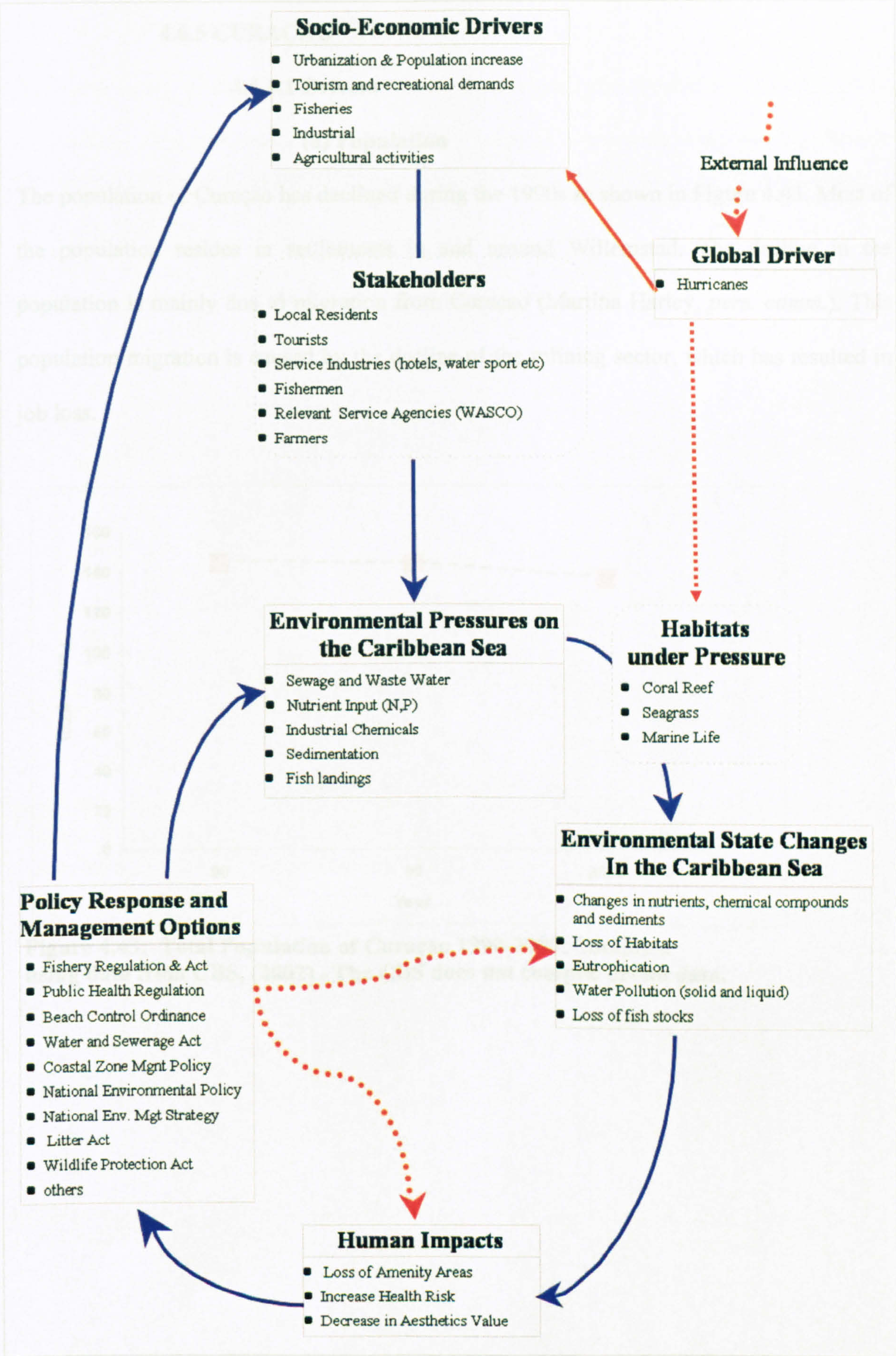


Figure 4.42: Diagrammatic Representation of the DPSIR for St Lucia showing the linkages between the various components. It also highlights the stakeholders that are contributing to these pressures also the marine habitats that are under pressure

4.6.5 CURAÇAO

4.6.5.1 Drivers

(a) Population

The population of Curaçao has declined during the 1990s as shown in Figure 4.43. Most of the population resides in settlements in and around Willemstad. The decline in the population is mainly due to migration from Curaçao (Martina Harley, *pers. comm.*). This population migration is caused by the decline of the refining sector, which has resulted in job loss.

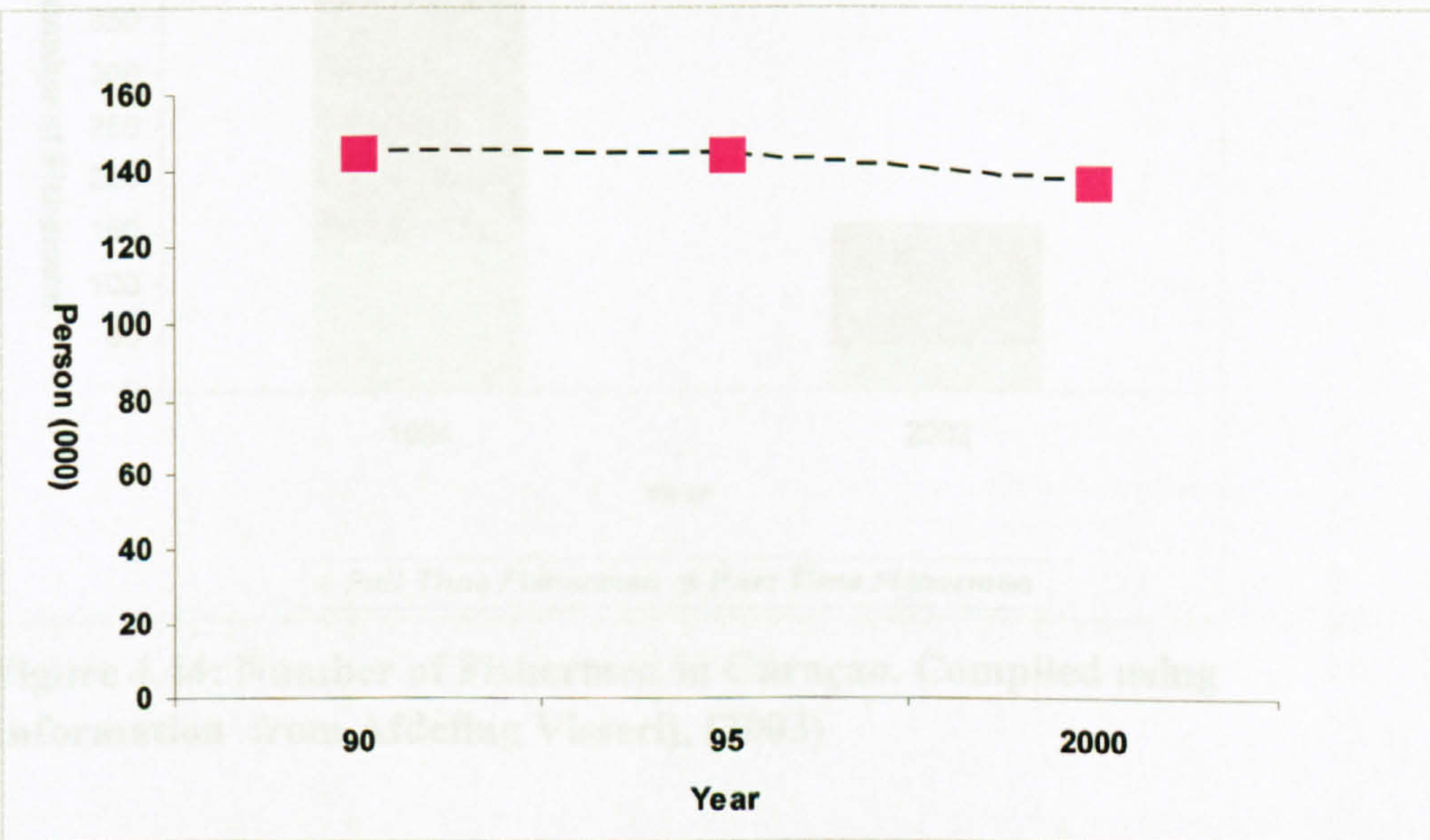


Figure 4.43: Total Population of Curaçao 1990-2000. Compiled using data from CBS, (2002) . The CBS does not compile urban data.

(b) Fisheries

The fisheries sector in Curaçao is small and targets mostly pelagic with an estimated catch of 90-180 mt/yr (Woodley *et. al.*, 1997). Among the species targeted are Wahoo (*Acantocybium solandri*) and Sword Fish *(Xiphias gladius)* and they collectively comprise over 85% of the total catch in 2002-2003 (Afdeling Visserij, 2003). Available data indicate a decrease in the number of fishermen, as shown in Figure 4.44.

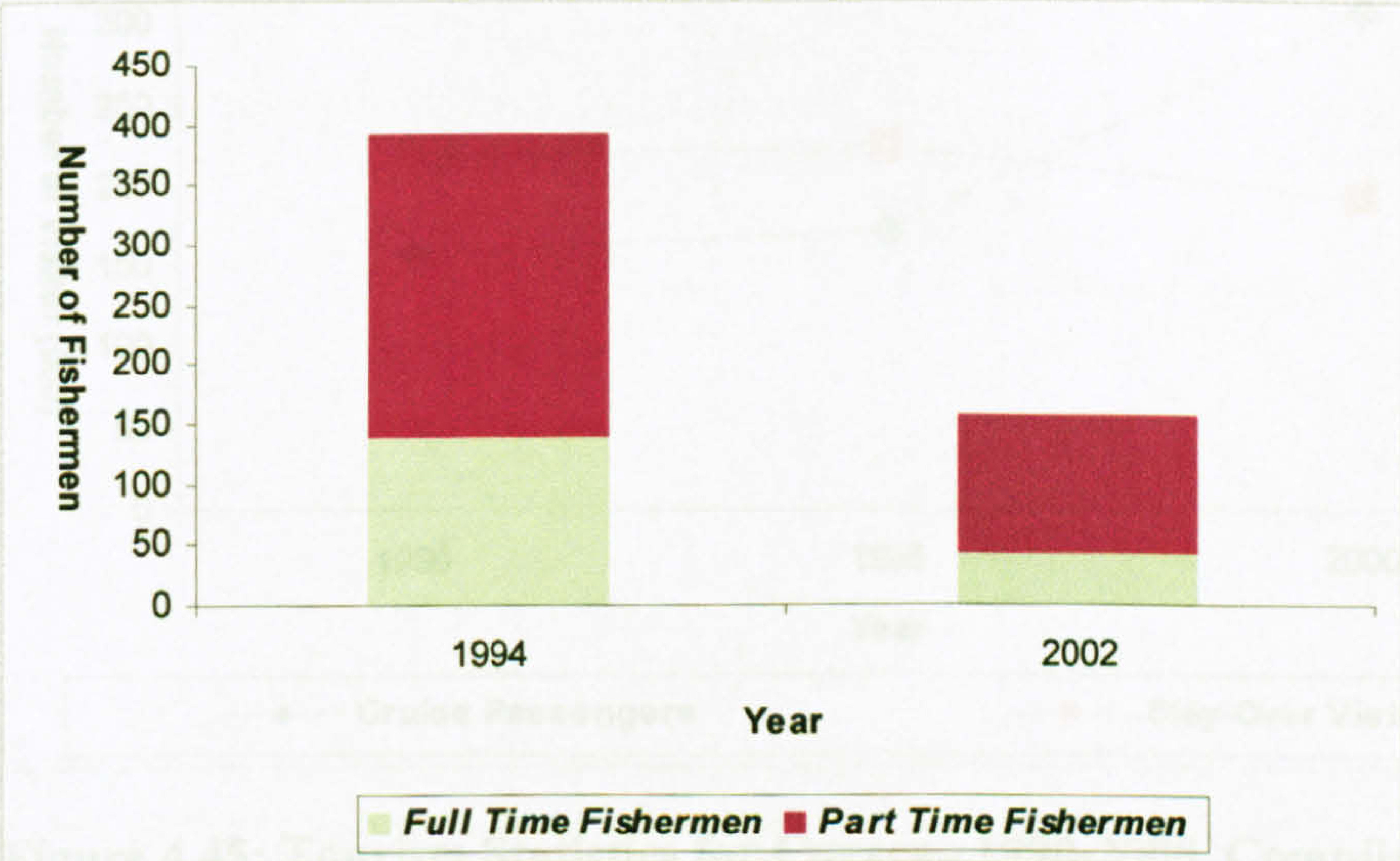


Figure 4.44: Number of Fishermen in Curaçao. Compiled using Information from Afdeling Visserij, (2003)

(c) Tourism and Recreational Activities

Tourism is a growing sector in Curaçao. Diving in the Underwater Park and other beach activities are the major attractions of this island; hence, most of the activities are in the coastal areas. Cruise arrivals have increased and in 2000 have exceeded the number of stay-over visitors, as shown in Figure 4.45.

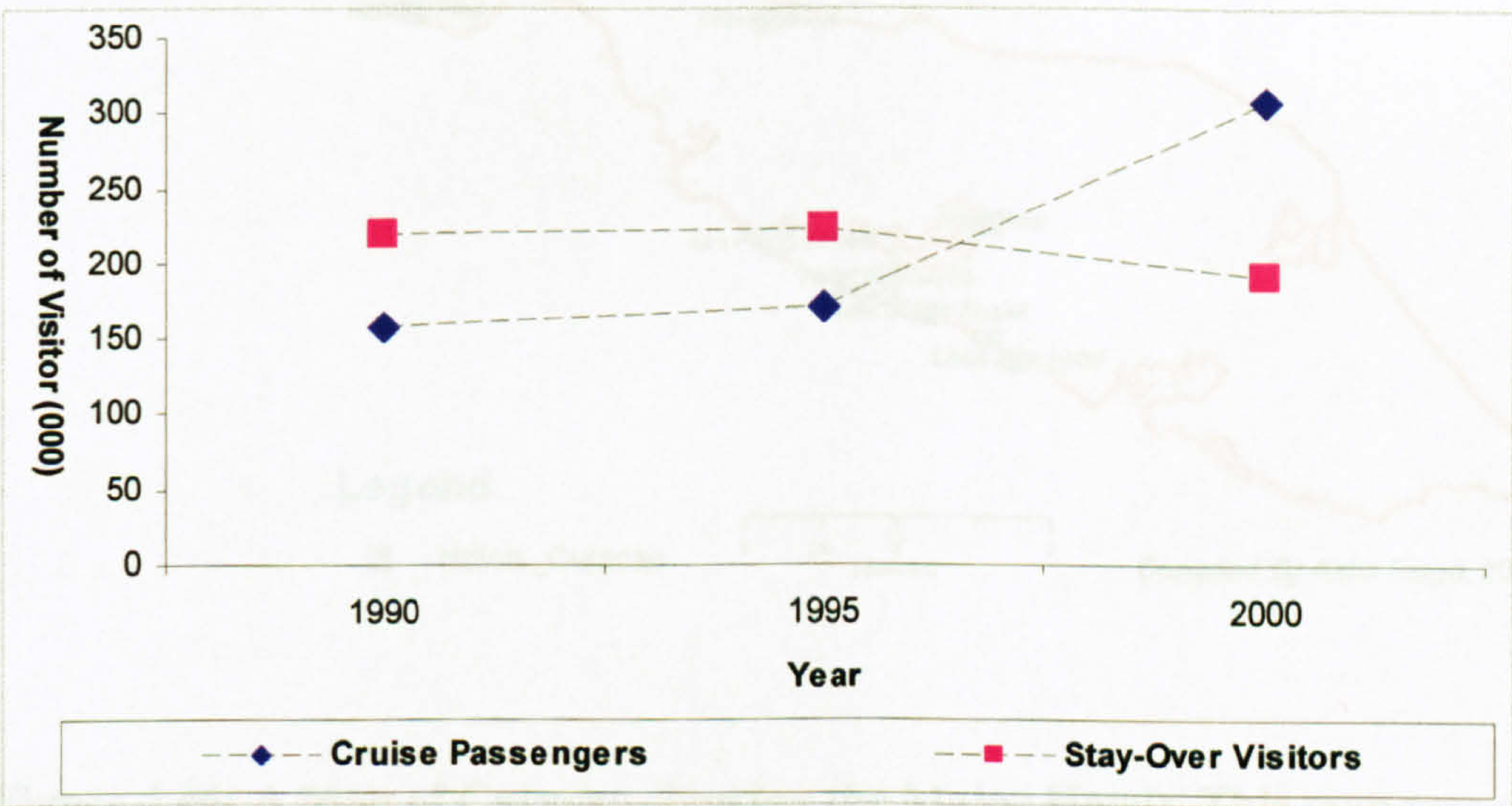


Figure 4.45: Tourism Statistics for Curaçao 1990-2000. Compiled using data from CTO, (2002) and WTO, (2005)

There are over twenty-five hotels and thirty-six apartments which cater for tourists (Curaçao Hospitality and Tourism Association). Most of the hotels and other amenities are located on the coast, as shown in Figure 4.46. In an effort to increase recreational attractions, many artificial beaches were constructed. These include beaches such as Seaquarium, Princess Beach and Avila.

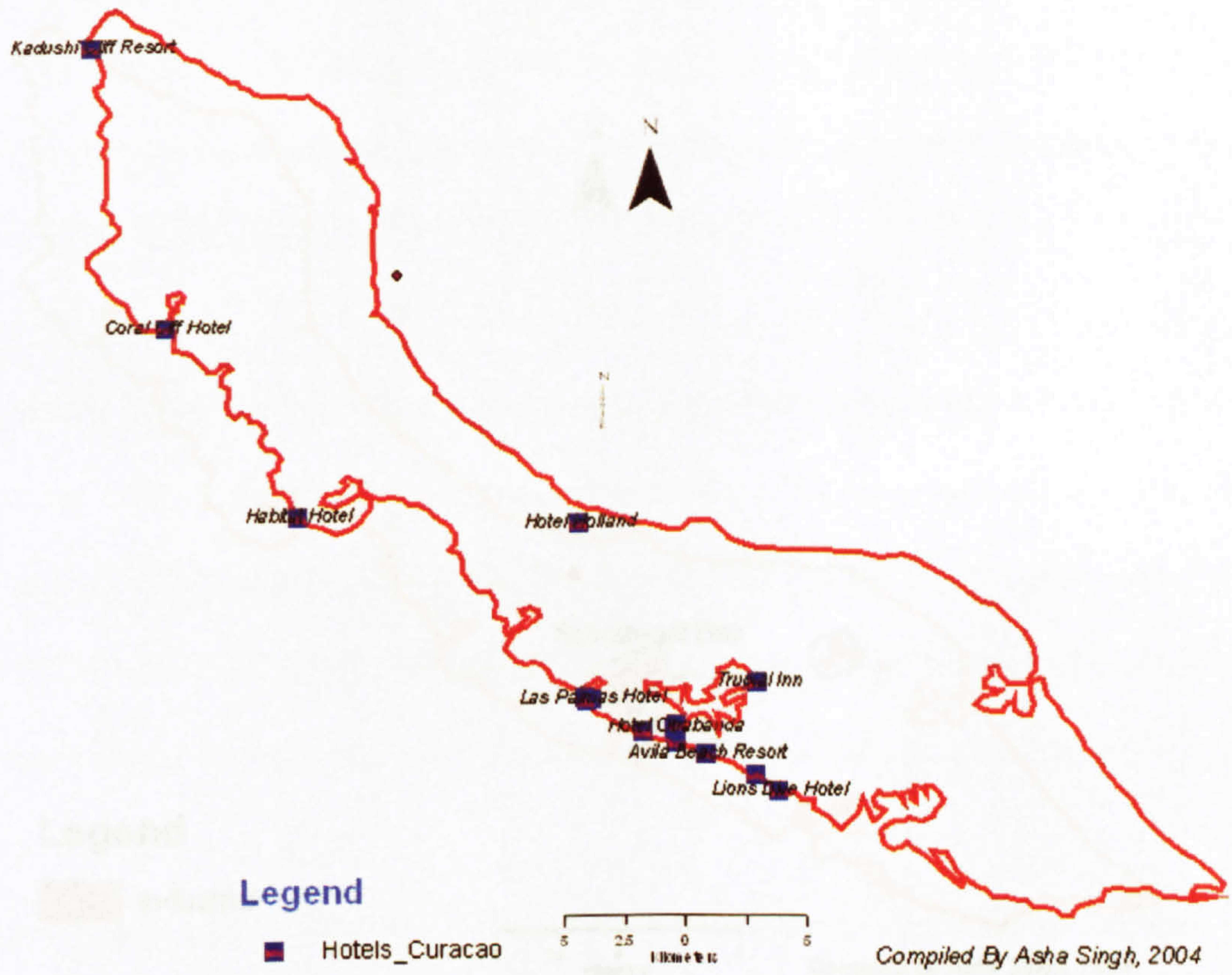


Figure 4.46: A Map of Curaçao showing the Major Hotels. This map was derived using data from reconnaissance survey (GPS coordinates) and Curaçao Road Map (2003)

(d) Industrial Activities

Curaçao has the largest industrial sector of the Netherlands Antilles. Industrial activities include oil refining and a vibrant manufacturing sector. Schottegat Bay is the most important industrial area in Curaçao as most of the factories are located in this area. This is shown in Figure 4.47. Industries in the Schottegat Bay include Isla Refineria, slaughterhouses, brewery and beverage companies and harbours. The effluents from these activities are discharged into the marine environment. The refinery in Schottegat Bay is one of the largest in the world and contributes on average over 60 % of the total earnings of Curaçao (Margaret Magda, *pers. comm.*).

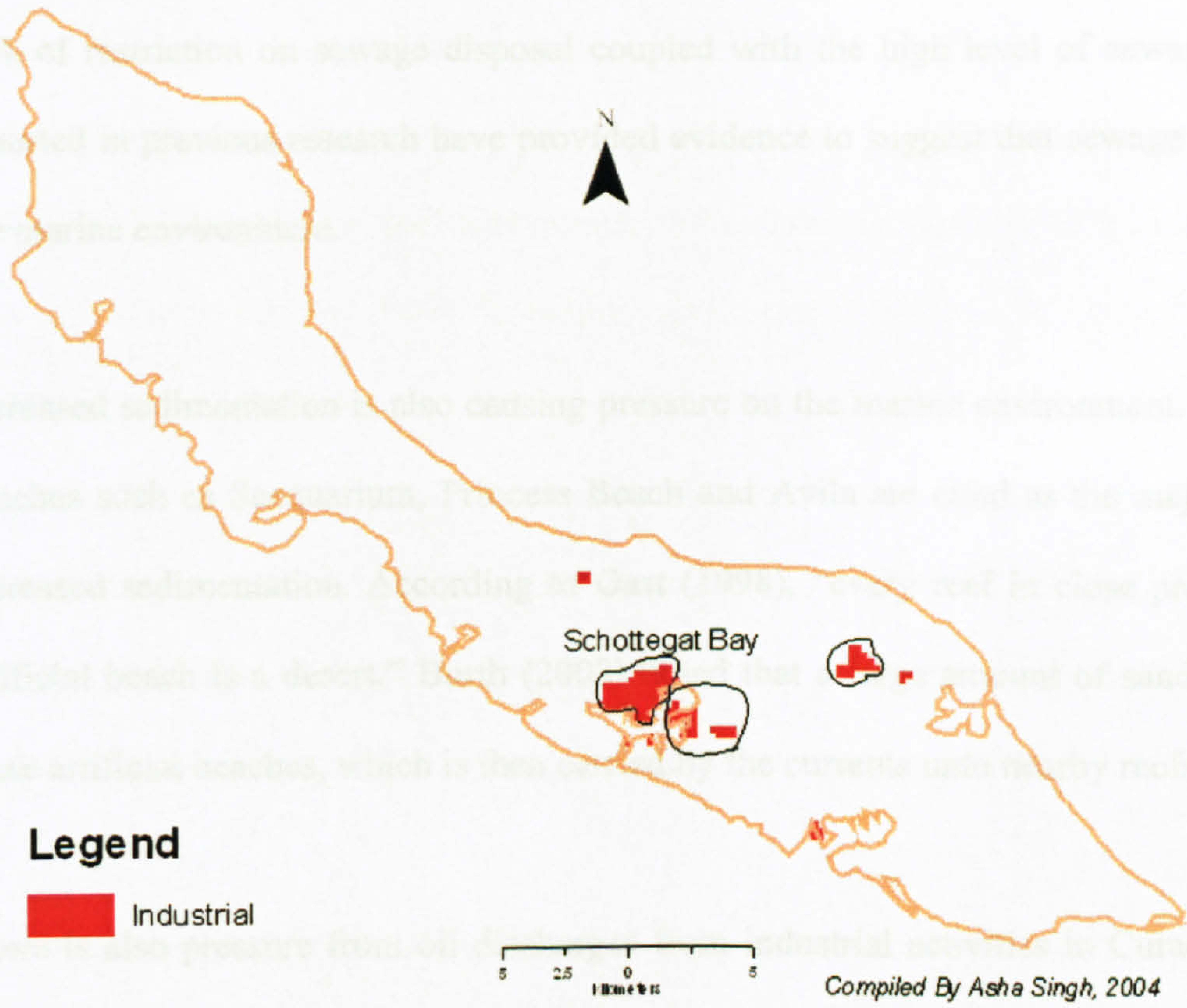


Figure 4.47: A Map of Curaçao showing the Major Industrial Areas. This map was derived using information from Curaçao Road Map, (2003)

4.6.5.2 Pressures

Sewage and wastewater discharges into the marine environment are placing pressure on the system. Presently, only residents in Willemstad have access to a central sewerage system. However, not all residents are connected to the sewerage plant, as it is not mandatory by law to do so. In 1998, only 38% of the households in Curaçao were connected to the sewerage system (Gast, 1998). Most residents that live on the coastal belt, sewer their untreated sewage directly into the marine environment (Eric Newton *per comm.*). Many hotels have their own sewerage treatment facilities on site, but no information is available on their efficiency. The disposal of waste has resulted in nutrient enrichment in the marine environment. Gast (1998), found high levels of phosphates, nitrates and nitrites in the St Anna Beach which is in close proximity to sewage pipes. In addition, untreated sewage discharges in some areas like Marie Pompoen can amount to 1,000 m^3 (Gast, 1998). This lack of restriction on sewage disposal coupled with the high level of sewage discharges reported in previous research have provided evidence to suggest that sewage is an issue in the marine environment.

Increased sedimentation is also causing pressure on the marine environment. The artificial beaches such as Seaquarium, Princess Beach and Avila are cited as the major sources of increased sedimentation. According to Gast (1998), "every reef in close proximity to an artificial beach is a desert." Burth (2002) noted that a large amount of sand is placed on these artificial beaches, which is then carried by the currents unto nearby reefs.

There is also pressure from oil discharges from industrial activities in Curaçao. Constant seepage of oil from the Isla refinery enters the marine environment. Reports by Buth and Ras (1992) and Bhairo-Marhe (1996) both concluded, that high levels of oil are escaping into the marine environment but stop short of commenting on the impacts. There are many reports of oil slicks and tar pollution on the coastal areas (Richardson *et. al.*, 1987; Debrot *et. al.*, 1995).

Another pressure is untreated industrial wastewater from factories, which enters the marine environment. For example, the paint company discharges its waste at Brievengat into the sea (Buth and Ras, 1992; Eric Newton *pers. comm.*). The desalination plant discharges its brine into the sea via the Schottegat Bay and often there are reports of seepages and contamination (Brian Leysner *pers. comm.).* Bhairo-Marhe (1996) conducted samples in Schottegat Bay and found high levels of BOD (40-50 mg/l), nitrogen (N), phosphates (P), low oxygen levels and high levels of heavy metals.

Fishing activities in Curaçao have also resulted in pressure on the fish stock. According to Buurt, (2002), the nearshore fisheries stocks are depleted. There are no annual fish landing statistics for Curaçao. However, a study was conducted in 2003 by the Fishery Department, and it was estimated that the current annual fish landing in Curaçao was approximately 193mt (Afdeling Visserij 2003). Sampling conducted in 2001 to 2002 showed that landings of reef fish makes up approximately 13.9% of the total catch (Burth, 2002; Afdeling Visserij, 2003). Wahoo (*Acantocybium solandri*) is the most important species accounting for 38% of the landings in 2002 compared to 25% in 1977-1980 (Buurt, 2002). Although there are increased landings of Wahoo, there is a decrease in other species (Burth 2002). Overall, the human activities in Curaçao are placing pressures on the marine environment.

Further, the use of spatial information can indicate the pressures on the marine environment from land based activities in Curaçao. The economic sectors shown from land use information in Figure 4.48 can provide clues to the likely areas of pressure and the possible sources. Examples of some areas of pressure are indicated on Figure 4.48 and further explained in Table 4.16.

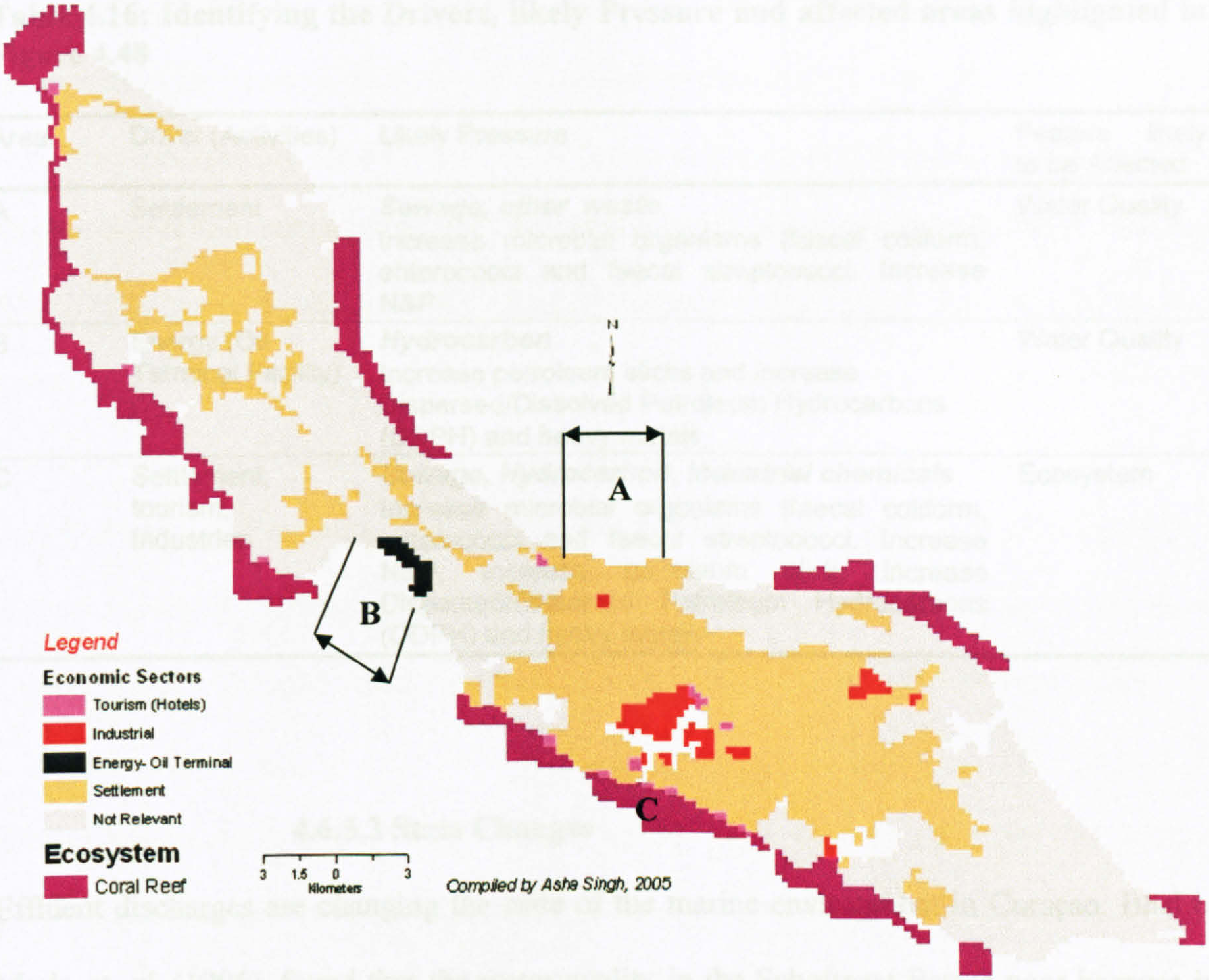


Figure 4.48: A Map showing the Economic Sectors of Curaçao using land use information as a proxy to determine spatial pressure. This map was derived using information from Ministry of Planning, (2002a), reconnaissance field survey and UNEP/WCMC[39]. Area A, B and E are further expanded in Table 4.16

[39] the abundance of coral reef shown in this map was disputed by many officials during my field visit to Curaçao. Many believed that the actual abundance of reef is less than what is measured by UNEP/WCMC, 2004. No other reef distribution data are available for Curaçao

Table 4.16: Identifying the Drivers, likely Pressure and affected areas highlighted in Figure 4.48

Area	Driver (Activities)	Likely Pressure	Feature likely to be Affected
A	Settlement	***Sewage, other waste*** Increase microbial organisms (faecal coliform, enterococci and faecal streptococci. Increase N&P	Water Quality
B	Energy (Oil Terminal Facility)	***Hydrocarbon*** Increase petroleum slicks and increase Dispersed/Dissolved Petroleum Hydrocarbons (DDPH) and heavy metals	Water Quality
C	Settlement, tourism, Industries	***Sewage, Hydrocarbon, industrial chemicals*** Increase microbial organisms (faecal coliform, enterococci and faecal streptococci. Increase N&P, Increase petroleum slick, increase Dispersed/Dissolved Petroleum Hydrocarbons (DDPH) and heavy metals	Ecosystem

4.6.5.3 State Changes

Effluent discharges are changing the state of the marine environment in Curaçao. Bhairo Marle *et. al*. (1996), found that the water quality in the Schottegat Bay is poor because it intercepts waste from Salina (sewage), the beer brewery, slaughterhouses, soft drink factories, the outfalls of the refinery and leakages and spills from the refinery. It was further noted that these discharges are negatively altering the state of the marine water quality.

The fishing pressure placed on the fisheries in Curaçao has resulted in the loss of species and reduction in stock abundance. Fisheries studies conducted by Nagelkerken (1974; 1977; 1980; 1981) in Curaçao, showed that many commercially important species such as groupers, snappers, grunts, hogfish *(Lachnolaimus maximus)* and other species were common on some coral reef areas. However, Bruckner and Bruckner (2003) found that many of these species are absent or have low abundance. According to Buurt (2002), fishing data in 1977-1980 showed that landings of rainbow runner (*Elagatis bipinnulata*) constituted approximately 10-15% of total catch, but in 2000-2001, there was no recorded landings of this species. This observation led Buurt (2002) to conclude that this species no longer exists in Curaçao. Sea Urchins (*Didema antillarum*) are also absent in Curaçao. Sampling conducted by CARICOMP in 1995, found no representation of this species in the Spanse Water Reef (CARICOMP, 2002). This species was reported to be on the decline since 1984 (Bak and Carpay, 1984). Reef fishing still exists, though the stocks have been severely depleted. Species such as conch and lobsters are also severely depleted (Gerard Buurt *pers. comm.*). This decrease in the fisheries stock in Curaçao is attributed to the heavy artisanal fishing pressure and the use of spear guns, fish traps, and gill nets (Van't Hof *et. al.*, 1995). Bruckner and Bruckner (2003) found that there is a loss in important nursery areas in Curaçao which are causing low fish stock and abundance in the reefs.

Eutrophication is another issue, which are causing state changes in the marine environment. According to Gast (1998), there are many areas especially coral habitats that are eutrophic which is caused mainly by land based activities. These activities include sewage and industrial waste disposal and groundwater seepage. Eutrophication has contributed to low coral recruitment, a reduction in the coral abundance and species loss. According to Gast (1998), species of coral such as *Acropora palmate, A. cervicornis* and *Porites porites* no longer exist in some areas including St Anna Bay.

Overall, it is evident in this section that the pressures from land based activities and fishing have resulted in state changes in the marine environment. This included the reduction or loss of fish species (sea urchin, rainbow runner) and habitats areas in Curaçao.

4.6.5.4 Impact

Poor water quality has decreased the recreational value of some areas in Curaçao. Some areas are prohibited for swimming and other recreational activities. An example of one such area is the Schottegat Bay. In addition, the decline in habitats such as coral reefs can have consequences on the tourism sector because diving is one of the main tourist attractions in Curaçao. No information exists on whether this is already happening.

The lost of fish species, frequency of fish kills (Schottegat Bay) and the reduction in abundance due to overfishing has influenced human consumption preferences. This is due to the unavailability of certain species. The collapse of the nearshore fisheries has also had an economic impact to the subsistence of fishermen and in 2000 the number of fishermen has decreased in Curaçao (refer to Figure 4.44, pg. 190).

4.6.5.5 Responses

Curaçao is a dependent island unlike Dominica and St Lucia. Curaçao, along with Saba, St Maarten, Bonaire and St Eustatius comprise the Kingdom of the Netherlands Antilles. These islands are classified as overseas territories of The Netherlands. The Netherlands must sanction major decision-making, which include legislation and other legal mandates. In Curaçao, the system of governance is a two-tier approach. The Central Authority forms the higher level, which is a single entity that is responsible for the entire Kingdom of Netherlands Antilles. The lower level is commonly referred to as the island government or insular level, which manages the internal affairs of its specific island. Every form of governance has to be approved by the central authority, thus in effect these island governments function as implementing bodies.

The legislation and programmes to minimise marine degradation from land based activities and fishing are inadequate. The legislation does not directly target issues regarding the marine environment. Some legislation does contain some elements that are used to address certain issues. These legal instruments are reviewed in Table 4.17.

Table 4.17: Relevant Environmental Based Legislation in Curaçao

LEGISLATION	COMMENTS
Nuisance Act 1980	Deals with nuisance including pubs etc. However, it also requires provision for wastewater discharge, but does not stipulate discharge limits.
Island Regulation of the Netherlands Antilles (Eilanden-regeling Nederlandse Antillen, ERNA) 1998	Regulates the function of the central government. In 1998, a statement regarding the environment was added to this regulation, which is "the management of the environment and the management and conservation of nature, as they derive from treaties."
Reef Control Regulation (1976)	Stipulates policies for managing the reefs. Old and outdated and does not reflect current situation

In addition to these pieces of legislation, there are agencies, which are mandated to deal with various environmental matters.

The Environmental and Conservation Ordinance Unit has the mandate to implement existing laws, legislation and treaty obligations[40]. At present, this unit lacks the necessary legal requirements to enforce these agreements. The Environmental Health Authority, is responsible for upholding the legislation however, not much legislation is very active on the island of Curaçao. Strides are being made with regard to restrictions on air, water and solid waste emissions from the oil refinery through dialogue (Eric Newton *pers. comm.*). These are not legislated and the onus is still largely on the operators of the refinery to limit or treat the emissions prior to releasing them into the surrounding environment.

According to Sybesma, (1988), "the priority is given to stimulate tourism as a major economic source in Curaçao and the island government is handling tourist development on an ad-hoc basis". To address this planning issue, a zonal plan was devised in 1995 (Landsverordening Grondslagen Natuurbeheer en Bescherming) in which the island was divided into 12 zones. To date this document still has not been approved and remains in draft after nearly nine years (Leon Pors, *pers. comm.*).

[40] See Chapter Seven for the Treaties of Curaçao

The non-existence of an EIA process regulation adds to these problems, as it is not mandatory for businesses to conduct EIAs (Eric Newton *pers. comm.*). Two EIAs have been conducted, with little input or review by the relevant authorities (Eric Newton, *pers. comm.*). In addition, there are no standards or discharge limits in Curaçao. In 2003, a Nature and Environmental Policy Plan was devised, to address environmental issues as part of the Island Regulation Act. This is currently in the scoping phase[41].

The fisheries sector operates without any legislation, policy, gear types, limits, size restrictions or quota (Gerard Buurt, *pers. comm.*; Faizal *pers. comm.*) There is draft legislation for gear restriction for conch and lobster fishing, which was conceived in 2001, but still has not been approved for implementation (Faizal, *pers. comm.)*. In 2003, the Fisheries Department of Curaçao drafted a fisheries plan (Afdeling Visserij, 2003). This document is awaiting approval for implementation. In terms of marine conservation, the Curaçao Underwater Park is designated as a park, but it does not have any no-take zones (NTZs)[42]. According to Bruckner *et. al*. (2003) "hook and line" fishing is permitted within park boundaries. Enforcement of the legislation is weak. For example, spearfishing in the coral reef area was prohibited in the Reef Control Act of 1976, but such activities were still prevalent until 1998 (Bruckner and Bruckner, 2003).

Solid waste such as household garbage collection and disposal is managed by SELIKOR. This is a private sector initiative and it has one of the most modern waste disposal facilities in the Caribbean region (Wesley Kook, *pers. comm.*). It is ISO 14,000 certified[43] and has the facility for mechanical sorting of waste (Wesley Kook, *pers. comm.*).

[41] See details at http://www.mina.vomil.an/

[42] no- take zones are areas in which extraction of living and non-living resources are permanently prohibited except for research or monitoring to evaluate effectiveness. (Peter,2005)

[43] ISO 14000 is a certification system governed by the International Standards Organization (ISO), which provides a model for companies to operate in order to minimise environmental impacts

The present landfill, Monplier East, which was opened in 1984 does not accept oil-generated waste and prior notification is required for chemical waste. This method of waste collection has not solved the issue of dumping in the marine environment. There is no legislation in Curaçao that prohibits waste dumping in the marine environment. This loophole has allowed for the continuation of dumping in the Caribbean Sea (Buth and Ras, 1992; Gast, 1998; Buurt, 2002). The most popular area used for dumping is an area called "The Shoot" (Brian Leysner, *pers. comm.*). In terms of hydrocarbon waste, there is a general response in Curaçao. The collected waste oil is currently being exported to Trinidad by SALTEC (Wesley Kook, *pers. comm.*).

Overall, the responses by Curaçao are inadequate to effectively manage the marine environment. Similar sentiments were expressed by Gast (1998, pg. 8), where it was noted, "Curaçao need a long term commitment and realistic plan to counter the effects of the marine degradation which must be enforced by Law." The analysis conducted for Curaçao within the DPSIR framework clearly shows such needs.

4.6.6 SWOT Analysis for Curaçao

The SWOT analysis conducted for Curaçao has shown majors weaknesses of the current responses. There are many opportunities for improvement to the responses, which will foster a more effective management of the marine environment. The identified strengths, weaknesses, opportunities and threats are shown in Figure 4.49.

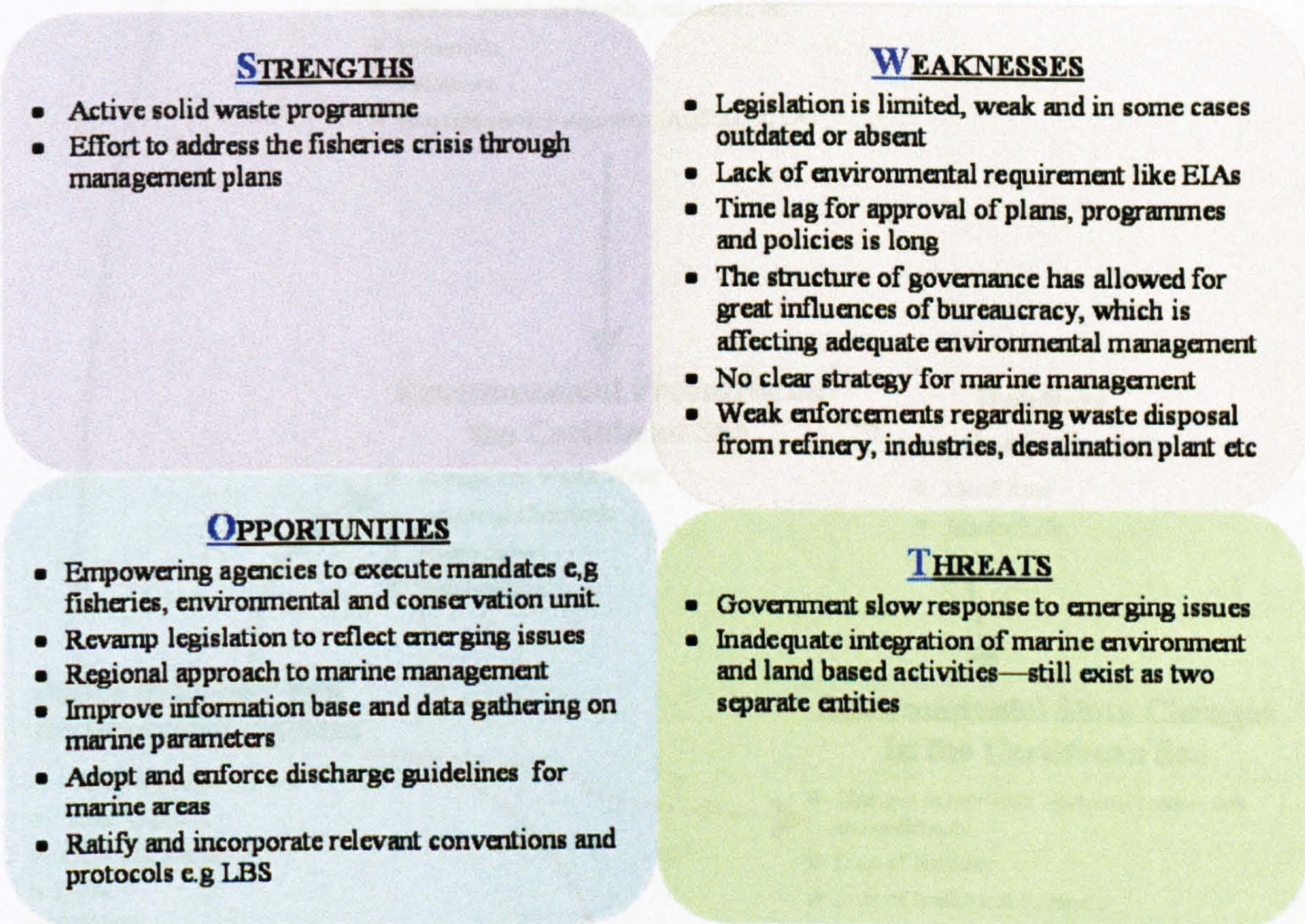


Figure 4.49: SWOT Analysis conducted for Curaçao based on the relevant environmental responses

In summary, the analyses presented within the DPSIR framework for Curaçao have highlighted the links between economic activities and environmental implications for the Caribbean Sea. These issues highlighted within the DPSIR framework are summarised in Figure 4.50.

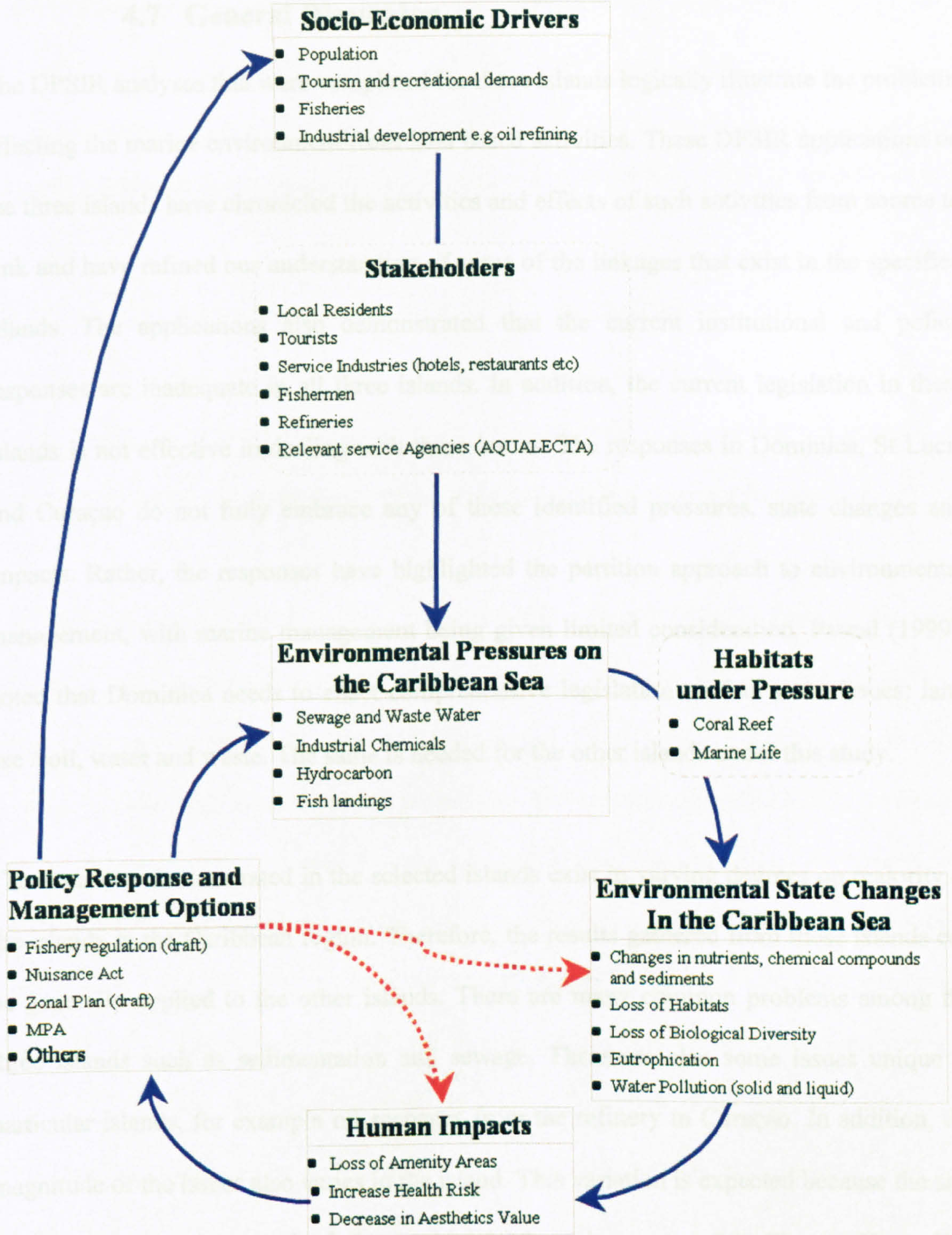


Figure 4.50: Diagrammatic Representation of the DPSIR for Curaçao showing the linkages between the various components. It highlights also the stakeholders that are contributing to these pressures also the marine habitats that are under pressure

4.7 General Discussion

The DPSIR analyses that were completed for these islands logically illustrate the problems affecting the marine environment from land based activities. These DPSIR applications on the three islands have chronicled the activities and effects of such activities from source to sink and have refined our understanding of some of the linkages that exist in the specified islands. The applications also demonstrated that the current institutional and policy responses are inadequate in all three islands. In addition, the current legislation in these islands is not effective in dealing with these issues. The responses in Dominica, St Lucia and Curaçao do not fully embrace any of these identified pressures, state changes and impacts. Rather, the responses have highlighted the partition approach to environmental management, with marine management being given limited consideration. Pascal (1999), noted that Dominica needs to enact comprehensive legislation on four main issues: land use /soil, water and waste. The same is needed for the other islands under this study.

The situations demonstrated in the selected islands exist in varying degrees on majority of the islands in the Caribbean region. Therefore, the results gathered from these islands can be generally applied to the other islands. There are many common problems among the three islands such as sedimentation and sewage. There are also some issues unique to particular islands, for example oil seepages from the refinery in Curaçao. In addition, the magnitude of the issues also varies in the island. This variation is expected because the size of the economic sectors varies between the islands as demonstrated in Chapter Three. The pressures and state changes that are identified in this chapter can increase in magnitude as the economic sectors increase on the islands. As discussed in Chapter Three, there is a high possibility of economic growth occurring, especially in the tourism sector.

The results of the DPSIR have shown that the process of development (drivers), on the islands has manifested itself more at the local level (i.e. the pressures and state changes are evident in the critical coastal and shelf areas). These areas are critical due to the presence of many coral reef and seagrass habitats. This chapter has demonstrated the decimation/degradation of some areas of coral cover within the region and has attempted to demonstrate the spatial pressure and the causes.

The use of GIS within this study, has demonstrated that land use information can be used, to contribute to our understanding of the likely areas of pressure on the surrounding marine areas. In addition, it can provide clues regarding the possible source (s) or economic sector (s) of the pressures along with the possible types of effluent.

Land use information when applied in this manner can provide indicators of the water quality, as suggested by Bowen and Riley (2003). In addition, the land use information when used as indicators of economic sectors can assist policy makers in prioritizing monitoring plans and identify critical parameters. For example, habitats in close proximity to agricultural land use are likely to be affected by increase Nitrogen and Phosphorus loads, therefore any monitoring plans can prioritise water sampling to suit the specific marine area. This use of existing information in such a manner can also reduce the financial cost of monitoring - a factor which impedes efficient water quality monitoring in the Caribbean. This technique of using land use information as an indicator for marine management is applicable to the region because many islands have updated land use information. It can also assist policy makers to incorporate marine management into mainstream land use planning. This incorporation is a necessary requirement to maintain coastal based economic activities (e.g. tourism) in the long term.

Overall, the results illustrate the vulnerability of the marine system to the activities on the island. The drivers (population size, visitors' number) are very important because they can dictate to an extent the magnitude of the pressures and state changes (i.e., the larger the socio economic drivers, the greater the pressure and state change from land based activities). These pressures and subsequent state changes can increase in the absence of adequate response mechanisms. Current trends indicate that economic development is still priority in the islands. In the current scenario economic development will continue to dictate the drivers and pressures on the marine system. Therefore, policy and management responses must be rigorously reviewed and restructured in an effort to minimise the pressures and subsequent state changes from inevitable economic development. If this is not done, anthropogenic activities will continue to trigger changes in the marine systems.

4.8 Conclusion

Most of the pressures and state changes discussed in this chapter require local responses. The local responses must be able to minimize the pressures, which emanate from land based activities. It is evident in this chapter that these pressures and state changes can have implications on the immediate ecosystems and can extend regionally and even globally. For example, the loss of coral reefs and the reduction of fish stocks in any particular area can result in ecosystem changes and functions. The application of the DPSIR/GIS has highlighted the inadequacy of the islands' policies with regard to marine management. It also shows that available information (land use) can be used more effectively to assist in better management of the marine environment in these countries.

The DPSIR has also demonstrated the influence of hurricanes on the economic sectors. However, natural events such as hurricanes and tsunamis can trigger changes in the marine system. These events can impacts on the habitats either directly or indirectly also the economies of the SIDS. In view of their importance to the region, these influences will be discussed in Chapter Five.

CHAPTER FIVE

5.0 EXTERNAL INFLUENCES: NATURAL PHENOMENA IN THE STUDY AREA

5.3 Hurricanes

The Caribbean region experiences an annual hurricane season (June - November). Many studies deal with the number of hurricanes generated in the region over time (Reading, 1990; Elsner *et. al.*, 1999; Goldenburg *et. al.*, 2001; Webster *et. al.*, 2005). However, no studies reported the number of hurricanes that made landfall in the SIDS over any period of time. This information is vital in understanding the actual pressure on the SIDS and nearby ecosystems and habitats. Therefore, the compilation of such data in this study provides an indication of the SIDS vulnerability to the effects of hurricanes. The data for the period 1960 to 2004 showed that the highest number of successive hurricanes that made landfall in the islands occurred between the period of 1994 to 2004. This is shown in Figure 5.1. This data also suggest that for each decade, there is an average of 1[44] hurricane hit per year in the SIDS.

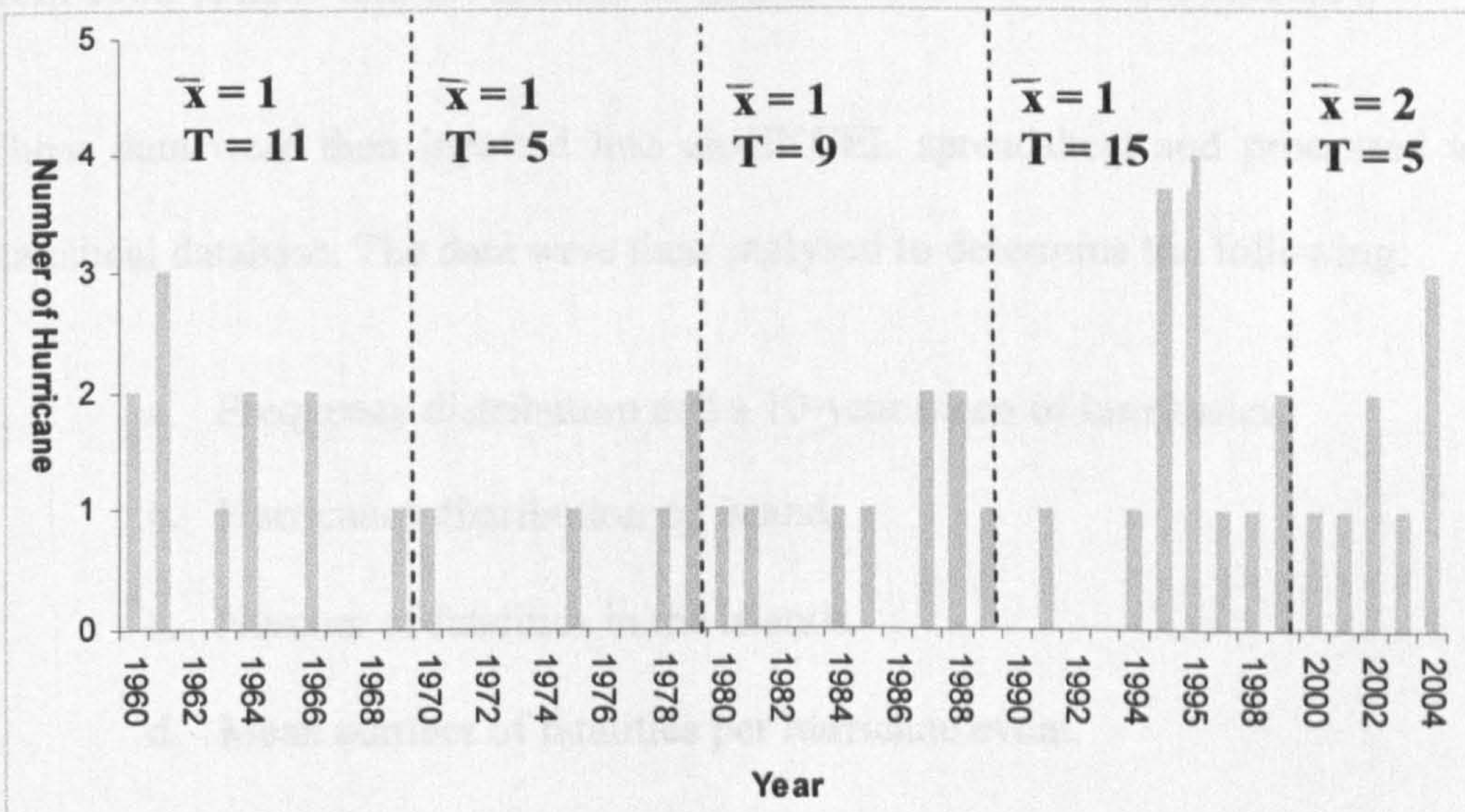


Figure 5.1: Total Number of Hurricanes that made landfall in the Caribbean 1960-2004. $\bar{x}$ = calculated mean, T = total number of hurricanes for that period. Compiled using data from National Hurricane Centre, (2004)

[44] Rounded to the nearest whole number

5.1 Introduction

As demonstrated in Chapter Two, many of the Caribbean islands are crossed by active tectonic boundaries, which can cause events such as tsunamis. In addition, some islands especially those in the archipelago chain are in a geographical area where the majority of the Atlantic hurricanes are generated. These natural events can affect the Caribbean ecosystems, SIDS population and economic activities. In this chapter, the three major natural phenomena of hurricanes, tsunamis and effects of climate change are analysed and discussed within the context of SIDS and the Caribbean Sea.

5.2 Methodology

In order to examine the influence of hurricanes in the Caribbean, data were compiled from the archive of the National Hurricane Centre (2004). Each hurricane that made landfall from 1960 to 2004 and the number of fatalities were isolated and recorded.

These data were then inputted into an EXCEL spreadsheet and processed to produce a statistical database. The data were then analysed to determine the following:

a. Frequency distribution and a 10-year mean of hurricanes.
b. Hurricanes distribution by island.
c. Number of fatalities in the islands.
d. Mean number of fatalities per hurricane event.

Information from existing studies was also used in this analysis to demonstrate the influences of these three natural events in the region.

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Study conducted by Goldenburg *et. al*. (2001) reported that for the period of 1995 to 2000 the highest level of North Atlantic hurricanes was experienced . This can have implications for the SIDS because if the number of hurricanes increases in the region the probability of hurricanes making landfall in the SIDS may also increase. Goldenburg *et. al*. (2001) also noted that this six-year period (1995-2000) has witnessed a 2.5-fold increase in major hurricanes (wind speed $\geq$ 50 meters per second) and a fivefold increase in hurricanes affecting the Caribbean. Goldenburg *et. al*. (2001), has predicted that the present high level of hurricane activity is likely to persist for an additional 10 to 40 years. Webster *et. al*. (2005) found that the number of cyclones[45] in the North Atlantic has increased in the past decade. In general, these studies highlight the increasingly high probability of impacts on the islands in the Caribbean.

From 1960 to 2005, Cuba recorded the highest number of hurricane hits among the islands of the Caribbean, as shown in Figure 5.2. Aruba, Bonaire and Curaçao recorded one hurricane hit each during this period. This number of hurricane hits shows that some islands are more vulnerable than others. Islands in close proximity to the North Atlantic (Cuba, Puerto Rico, Dominican Republic and USVI) are more vulnerable to hurricane hits than islands in the South (Grenada, Barbados). The reason for this disparity is because most of the hurricanes develop in the North Atlantic.

[45] Cyclones is a term used to include both hurricanes and tropical storms

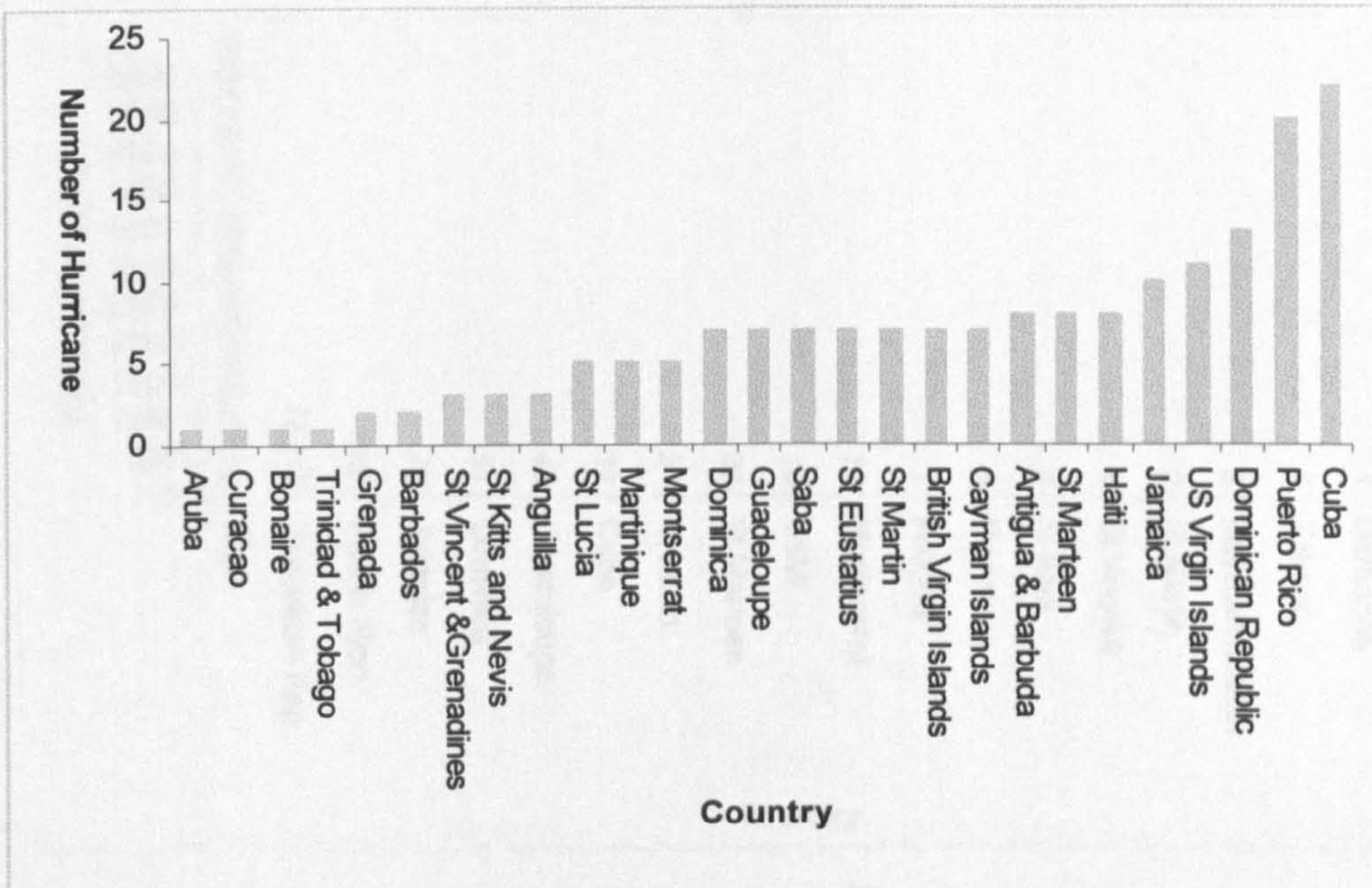

Figure 5.2: Total Number of Hurricanes that made landfall by Island 1960-2004. Compiled using data from National Hurricane Centre, 2004

From 1960 to 2004, Grenada recorded damages from two hurricanes, the most recent being Hurricane Ivan in September 2004. Hurricane Ivan destroyed nearly 90% of the island's infrastructure. The banana industry was severely damaged and more than 90% of the forest lands and watersheds were stripped of vegetation (USDA Forest Service, 2004). According to UNEP, the total loss is estimated at US$ 3 billion which is more than double Grenada's Gross Domestic Product (UNEP, 2005c). The case of Grenada demonstrates how island economies are extremely vulnerable to natural disasters. Economies such as Grenada's which took years to build and develop can be devastated within minutes of a natural disaster.

During the period examined, fatality statistics have demonstrated that Haiti suffered the most deaths between the period 1960 to 2004, as shown in Figure 5.3. Most of the deaths on the islands occurred in the 1990s. The total raised drastically in 2004 when Hurricanes Jeanne and Ivan made landfall.

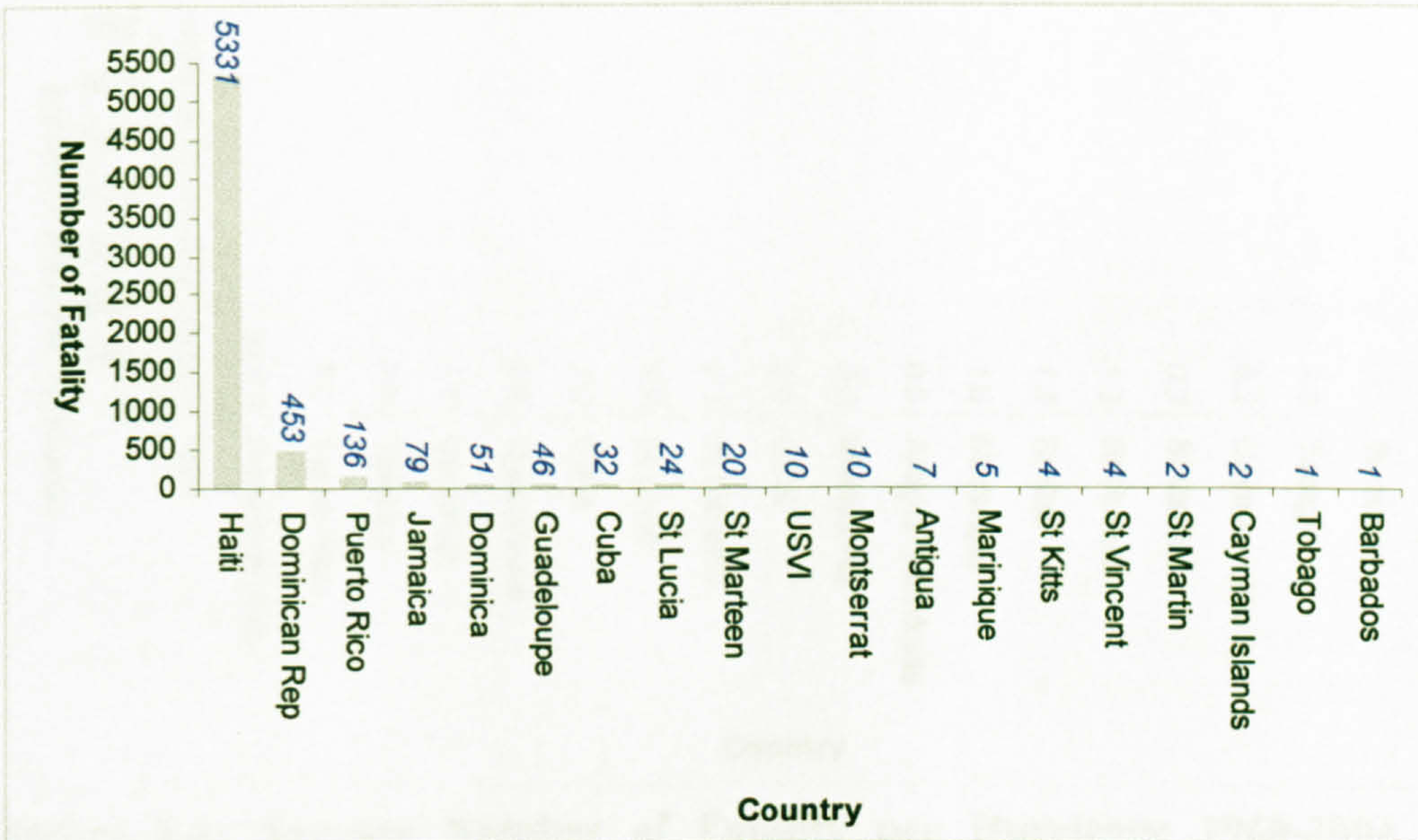

Figure 5.3: Total Number of Fatalities from Hurricanes shown for each island 1960-2004 Compiled using data from National Hurricane Centre, 2004

A comparison between fatalities and number of hurricanes that made landfall in the islands, have shown that Haiti on average suffers more deaths[46] per hurricane than any other island in the region, as illustrated in Figure 5.4. The existing deforestation issue in Haiti (Pelleck, 1990; Ministère De L'Environnement, 2001; Anonymous, 2002a), has increased the island's vulnerability to such events and is the likely underlying cause for the high mortality rate.

[46] Most of the deaths are usually caused by the aftermath of hurricanes such as flooding, however, these are usually regarded as hurricane fatalities

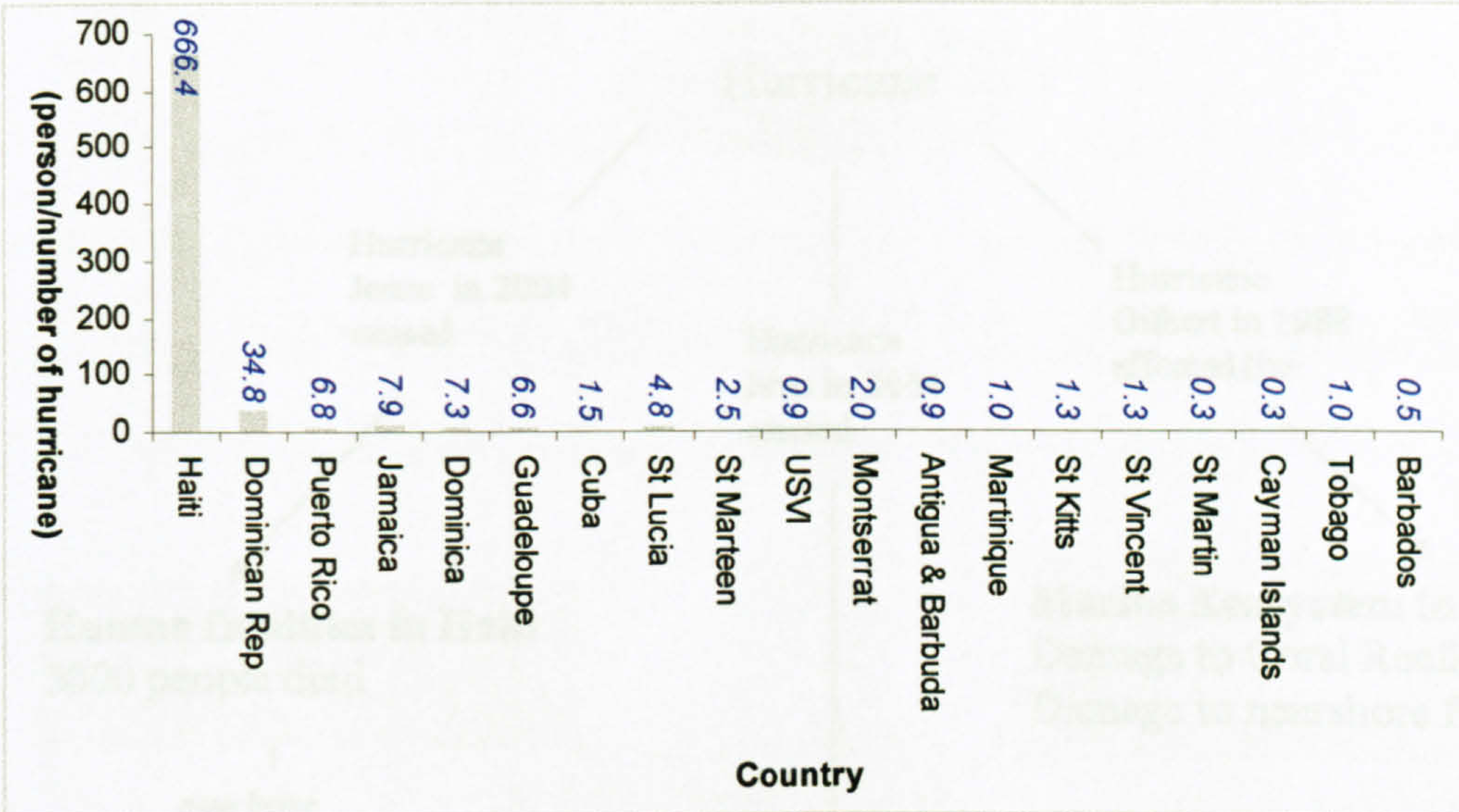

Figure 5.4: Average Number of Fatality per Hurricane 1960-2004. Compiled using data from National Hurricane Centre, 2004

Ecosystems in the region are also vulnerable to hurricane damage. In 1988, Hurricane Gilbert made landfall in Jamaica, which resulted in the destruction of marine habitats. In 1989, a study was initiated to investigate the impacts on the marine resources using Jamaica's reef as a case study. This study concluded that there was severe damage to the coral reefs. Branching corals, sponges and sea fans were destroyed (Woodle, 1989). In another study, it was found that immediately after a hurricane storm in Jamaica, fishes showed changes in behaviour and unusual shoaling due to loss of territories (Kjerfve *et. al.*, 1986). According to Woodley (1989), violent hurricanes reduce the carrying capacity of the reefs by reducing their three-dimensional complexity. Kjerfve *et. al.,* (1986), also found that hurricanes have an effect on nearshore fish nursery areas in Jamaica. Migratory animals such as marine mammals and turtles also suffer the effects of hurricane. In 2005, Hurricane Emily hit the Coast of Mexico where it was estimated that over 84,000 eggs of the endangered Green and Loggerhead turtles were washed away from nesting sites (Quintanilla, 2005). Figure 5.5 shows the casual chain relationship of hurricanes and their effects in the region. It provides examples of known effects in the region from three hurricane events.

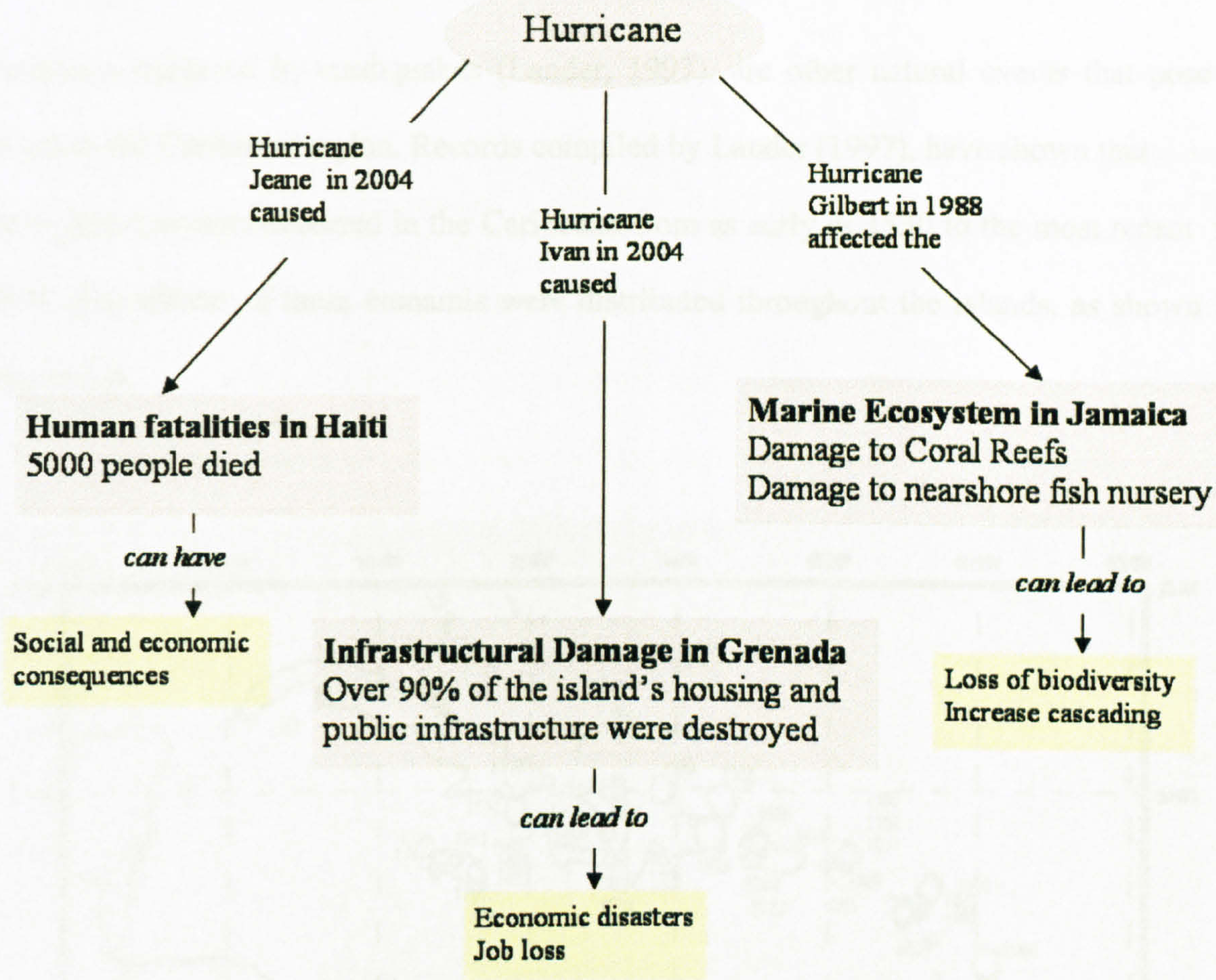

Figure 5.5: Casual Link Representation of Hurricanes in the Caribbean citing examples of recorded hurricanes that made landfall. The link shows that Hurricanes as an external pressure in the region can cause economic, ecological and human loss.

In the long term however, these marine systems must have adapted to sporadic hurricanes. The problem arises when the magnitude and frequency of hurricanes increase steadily which is likely as suggested by Goldenburg *et. al.* (2001). The increased frequency of hurricane events coupled with anthropogenic stress (refer to Chapter Four), can trigger long term changes in the system.

5.4 Tsunamis

Tsunamis triggered by earthquakes (Lander, 1997), are other natural events that pose a threat to the Caribbean region. Records compiled by Lander (1997), have shown that forty-nine tsunamis occurred in the Caribbean from as early as 1530 to the most recent in 1991. The effects of these tsunamis were distributed throughout the islands, as shown in Figure 5.6.

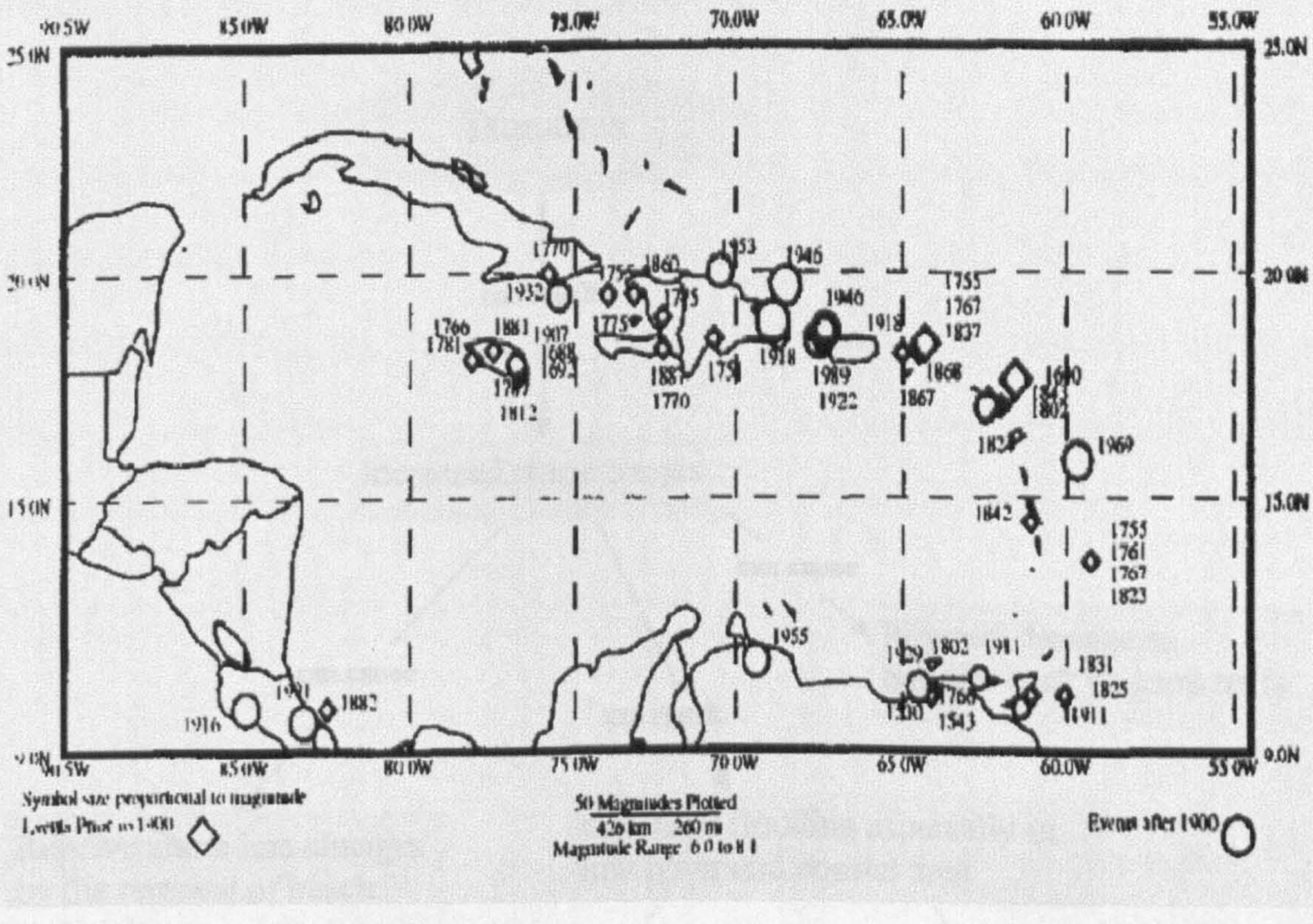

Figure 5.6: Distribution and Year of Tsunamis Occurrences in the Caribbean for the period 1530 -1991. Taken from Lander, (1997)

Previous tsunamis have resulted in human fatalities in the region. According to Woods Hole Oceanographic Institution (2005), the last deadly tsunami occurred in 1979 which claimed the lives of 1,700 people in The Dominican Republic and Haiti. The risks of human fatality and physical destruction from tsunamis are ever present in the region. A recent study conducted by the Woods Hole Oceanographic Institute (WHOI), reported an elevated earthquake risk along the Septentrional Fault Zone, which cuts through the

Dominican Republic. According to the principal scientist, “it is not a question of if it will happen but when” (Ten Brink and Lin, 2004). Such an event if it occurs can place over thirty-five million inhabitants at risk (Grindlay *et. al.*, 2005), together with coastal infrastructures and economic sectors. Marine ecosystems are also at risk of physical damage from such disaster. The literature on effects of tsunamis in the region is sparse and the damages experienced from previous tsunamis in the region are understudied. Figure 5.7 illustrates the potential threats and known effects of tsunami events on the region.

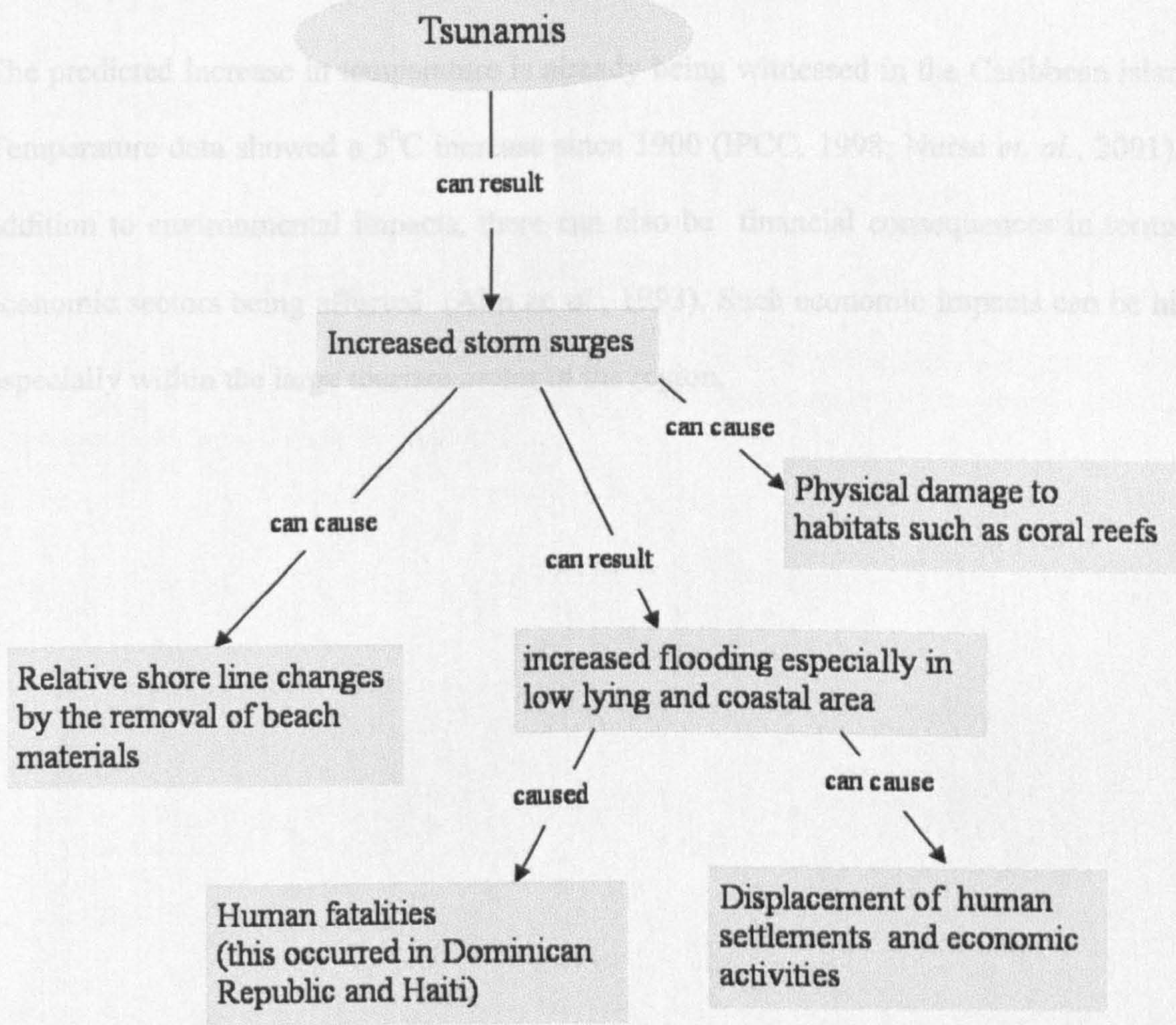

Figure 5.7: A Casual Link Representation of Tsunamis Risk and Effects in the Caribbean. The link shows that Tsunamis as an external pressure in the region can cause economic and ecological losses. Dominican Republic and Haiti were affected in 1979, which resulted in human fatalities

5.5 Climate Change

Climate change, which is anticipated to increase extreme weather events and rising sea levels, is set to aggravate the problems already stated. Numerous studies have demonstrated the vulnerability of the SIDS in the Caribbean. These include events such as increased flooding (Maul, 1993), relative sea level movement causing shoreline changes (Hendry, 1993) and temperature elevation (Gray, 1993), all of which can cause ecological loss, especially to fisheries (Gallegos *et. al.*, 1993). These potential effects of the climate change in a Caribbean context are illustrated in Figure 5.8.

The predicted increase in temperature is already being witnessed in the Caribbean islands. Temperature data showed a 5^0C increase since 1900 (IPCC, 1998; Nurse *et. al.*, 2001). In addition to environmental impacts, there can also be financial consequences in terms of economic sectors being affected (Alm *et. al.*, 1993). Such economic impacts can be high, especially within the large tourism sector in the region.

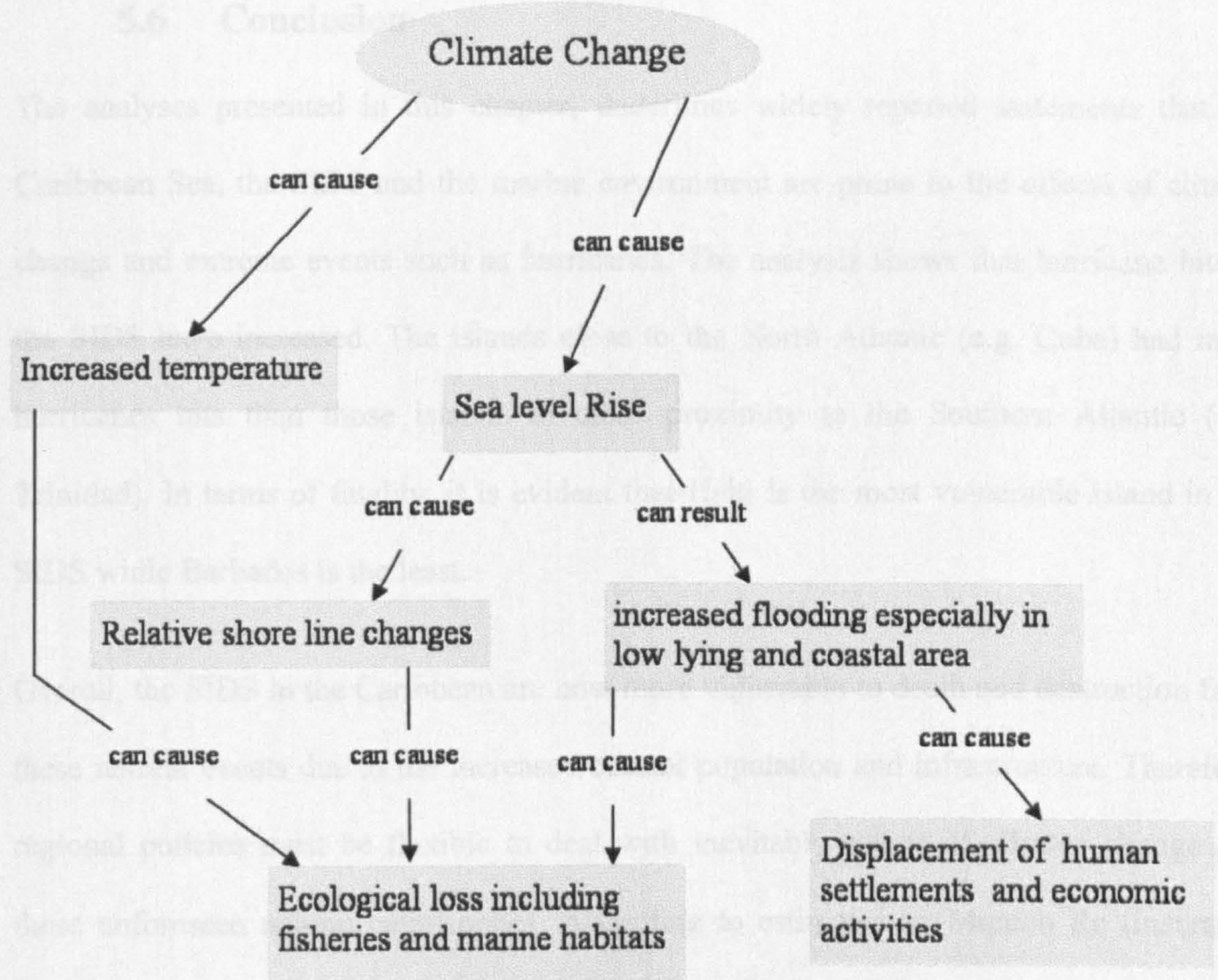

Figure 5.8: A Conceptual Casual Link Representation of Climate Change in the Caribbean. The link shows that the effects of climate change in the region can cause economic, ecological and human loss

5.6 Conclusion

The analyses presented in this chapter, underlines widely reported statements that the Caribbean Sea, the SIDS and the marine environment are prone to the effects of climate change and extreme events such as hurricanes. The analysis shows that hurricane hits in the SIDS have increased. The islands close to the North Atlantic (e.g. Cuba) had more hurricanes hits than those islands in close proximity to the Southern Atlantic (e.g. Trinidad). In terms of fatality, it is evident that Haiti is the most vulnerable island in the SIDS while Barbados is the least.

Overall, the SIDS in the Caribbean are now more vulnerable to death and destruction from these natural events due to the increased coastal population and infrastructure. Therefore, regional policies must be flexible to deal with inevitable events of climate change and these unforeseen natural catastrophes. According to estimates by Munich Re (insurance company), weather-related disasters are on the rise. In the first ten months of 2004, insured losses amounted to some US$ 35 billion - the largest loss ever - with uninsured losses some US$ 90 billion (UNEP, 2005c). Continued (and increasing) financial, human and ecological losses from extreme events in the Caribbean SIDS, suggest that current management systems and development strategies are not taking into full account the frequency and occurrence of these threats. The current responses to climate change and natural disasters in the region are discussed in Chapter Seven.

In addition to extreme natural events discussed in this chapter and land based activities (Chapter Four), the sea habitats and ecosystem are also vulnerable to other coastal and offshore activities such as shipping. These activities can collectively affect the ecosystems in the marine environment (Chapter Two). In Chapter Six, a vulnerability assessment will be conducted to illustrate the stress on the sea from anthropogenic activities (coastal and offshore).

CHAPTER SIX

6.0 ASSESSING THE VULNERABILITY OF THE CARIBBEAN SEA TO HUMAN ACTIVITIES

6.1 Introduction

The Caribbean Sea is a large marine ecosystem, which consists of many habitats. Some of these habitats are within island territories while others are found at a wider geographic scale. Comparatively, there are activities, which crisscross the sea. If these activities are not managed effectively it can lead to undesirable consequences on the ecosystems (UNEP, 1989, 2004a). There have been no previous attempts to ascertain the vulnerability of the entire sea. Therefore, in this chapter, the vulnerability levels of the sea will be assessed through spatial analysis.

6.2 Review of Vulnerability Assessment

Vulnerability assessments are subjective because they do not conform to a rigid methodology in environmental applications. The parameters of vulnerability assessment may vary depending on the objective of the assessment, data availability and the analytical tool used.

This type of assessment has been used to demonstrate impacts in a given area or ecosystem and assist in decision making (Hinkel and Klein, 2003; Vafeidis *et. al.*, 2003). In addition, vulnerability assessment can enable a user to produce information on a range of vulnerability indicators and to analyze a range of mitigation and adaptation policies (Hinkel and Klein, 2003).

Some vulnerability assessment techniques exist for land based areas, such as Environmental Vulnerability Index (EVI) devised by SOPAC (Kaly and Pratt, 2002). The EVI has been applied to many areas such as Tobago (Gowrie, 2003) and is based primarily on measuring the state of the environment against predetermined economic and physical benchmarks. However, the EVI cannot be applied to this assessment because there are no benchmark values for the marine environment.

6.3 Methodology

6.3.1 Application of this Assessment to the Caribbean Sea

A vulnerability assessment is comprised of three phases: susceptibility, risk and vulnerability. In the context of this study, these phases are differentiated using a modified description adopted from Evan and Maidment (1995).

Susceptibility When the marine environment is likely to be affected by anthropogenic activities.

Risk The likelihood or probability that anthropogenic activities can actually affect the marine environment.

Vulnerability When the marine environment is susceptible and there is the presence of anthropogenic activities.

These phases will be shown for the Caribbean Sea using spatial data.

6.3.2 Data Collection

Data were gathered from various sources and are in shown in Table 6.1. These data were used to produce spatial information for the vulnerability analysis.

Table 6.1: Metadata Information of Data Compiled for the Vulnerability Assessment

GIS CODED THEME	THEMES	SOURCE (S)	FORMAT	ATTRIBUTES
CT	Cities	Various literature	Digital data were compiled	Recompiled from data created for analysis in Chapter Two and Three
RF	Refineries	Various literature including Dillion, (1995)		
PT	Ports	Various literature including World Seaport, (2003) and Fairplay, (1999)		
SE	Seagrass	UNEP/WCMC, (2003)	Digital data provided but customised for this study	
MPA	MPAs	UNEP/WCMC, (2004)		
DM	Demersal	IUCN, (1979) Undefined paper maps	Digital data were compiled	species
CR	Crustaceans			species, types (shrimp, lobster etc.)
BF	Billfish			species, season and common names
MS	Mollusc			species *(Strombus gigas)*
TU	Tuna			species
PP	Phytoplankton Productivity			level of productivity
TR	Lightering Areas	Dillion, (1995) Paper maps		assigned identity number
COP	Crude Oil Products			route directions
POP	Processed Oil Products			route directions and destinations
SP	Shipping	Admiralty, (1987) Undefined paper maps		routes
CR	Cruise	Compiled from various cruise companies. Undefined paper maps		routes

6.3.3 Data Analysis

Data collected were inputted into databases and subsequently mapped as points, polylines or polygons in ARC/GIS 8.3. Manipulation was conducted in GIS where various themes were produced. The general procedure followed is diagrammatically illustrated in Figure 6.1.

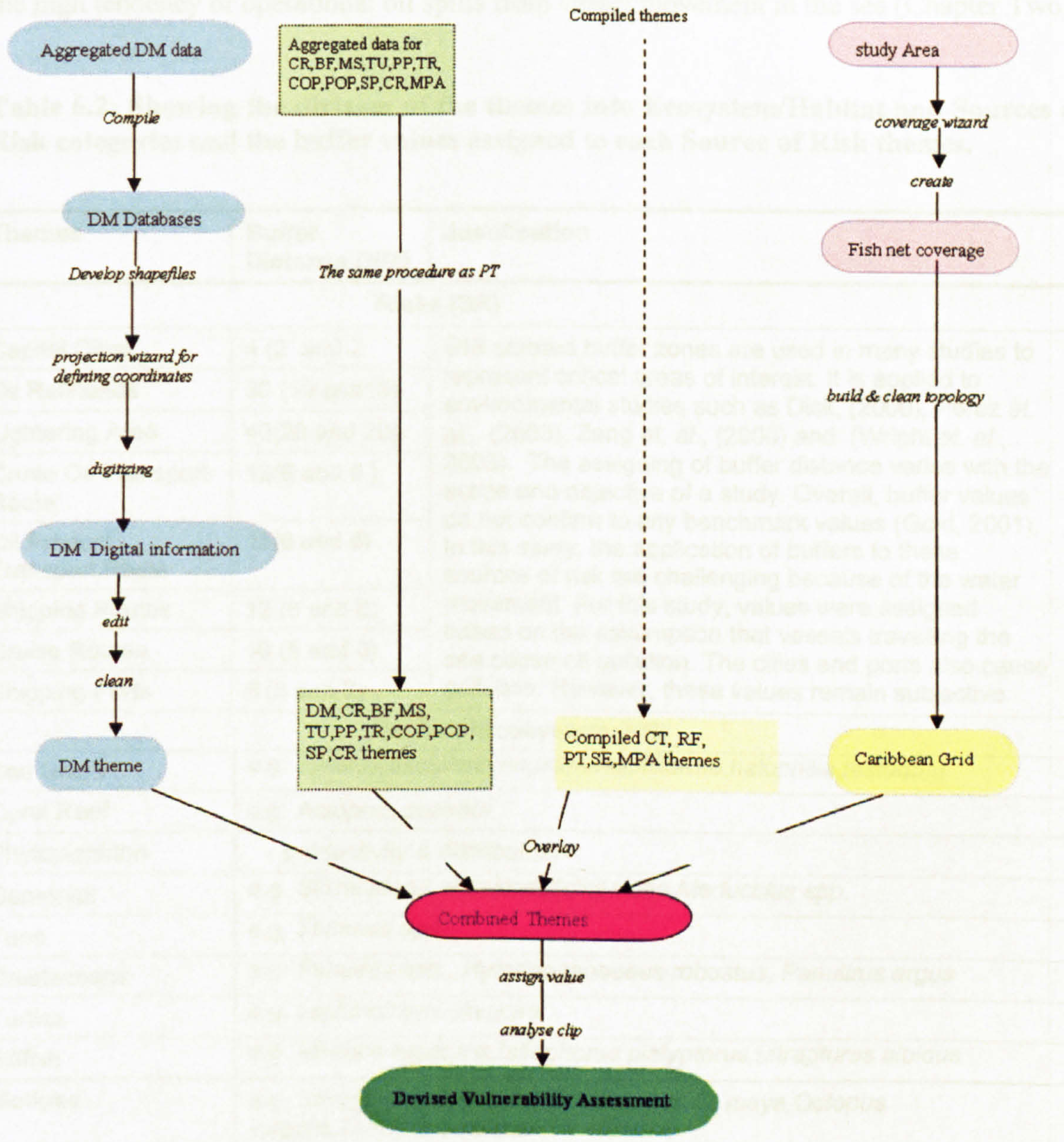

Figure 6.1: Simplified Flow Diagram Representation of Techniques used to derive the Vulnerability Assessment

Each theme was then classified as either "*habitat/ecosystem (HE)*" (habitats and ecosystems that are likely to be affected) or ***"Risks (SR)"*** (activities that are likely to cause environmental impact). This classification is shown in Table 6.2. Each "*SR*" themes were isolated and analyses were performed in GIS to assign buffers of various distances. The assigned values are shown in Table 6.2. The assigning of buffer values was done in order to account for the possible spread of waste, particularly oil. This is necessary because of the high tendency of operational oil spills from vessel movement in the sea (Chapter Two).

Table 6.2: Showing the division of the themes into Ecosystem/Habitat and Sources of Risk categories and the buffer values assigned to each Source of Risk themes.

Themes	**Buffer Distance (NM)**	**Justification**
	Risks (SR)	
Capital Cities	4 (2 and 2	GIS created buffer zones are used in many studies to represent critical areas of interest. It is applied to environmental studies such as Dick, (2000), Perez *et. al.*, (2005), Zeng *et. al.*, (2000) and (Wright *et. al.*, 2003). The assigning of buffer distance varies with the scope and objective of a study. Overall, buffer values do not confirm to any benchmark values (Gold, 2001). In this study, the application of buffers to these sources of risk are challenging because of the water movement. For this study, values were assigned based on the assumption that vessels travelling the sea cause oil pollution. The cities and ports also cause pollution. However, these values remain subjective.
Oil Refineries	30 (15 and15)	
Lightering Area	40(20 and 20)	
Crude Oil Transport Route	12(6 and 6)	
Oil Product Transport Route	12(6 and 6)	
Shipping Routes	12 (6 and 6)	
Cruise Routes	10 (5 and 5)	
Shipping Ports	6 (3 and 3)	
	Habitats/Ecosystem (HE)	
Sea Grass	e.g. *bailonis,decipiens,engelmanni,filiforme,halophilia,testudum*	
Coral Reef	e.g. *Acropora palmate*	
Phytoplankton	*productivity & distribution*	
Demersal	e.g. *Serranidae,Lutjanidae,Sciaenidae,Merluccius spp.*	
Tuna	e.g. *Thunnus spp)*	
Crustaceans	*e.g. Penueus spp., Hymenopenaeeus robustus, Panulirus argus*	
Turtles	*e.g. Lepidochelys olivacea*	
Billfish	e.g. *Makaira nigricans,Istiophorus platypterus,tetrapturus albidus*	
Mollusc	e.g. *Strombus gigas,Octopus macropus,O. maya,Octopus vulgaris,Octopus briareus*	

Further, the "SR" and the "HE" themes were reclassified into categories according to "susceptibility" and "sources of risk" to reflect the phases in the vulnerability assessment (Section 6.3.1). In each of the categories, these themes were subdivided into types depending on their spatial location. These are shown in Table 6.3. These subdivisions were done in order to provide an indication of the likely but not exclusive sources of influence. For example, littoral habitats are likely to be more susceptible to sources of risk from coastal activities.

Table 6.3: Division of the Various GIS Themes into Categories of Susceptibility and Sources of Risk

Categories	Types	Themes
Susceptibility	Littoral	Seagrass, coral reef., turtles nesting sites, MPAs
	Offshore	Mollusc, Crustacea, billfish, tuna, demersal, tuna, phytoplankton productivity
Sources of Risk	Coastal	Cities, refineries, shipping ports
	Offshore	Lightering areas, crude oil route, processed oil route, shipping route, cruise route

The "susceptibility" category is shown in Figures 6.2, 6.3 and 6.4 for littoral, offshore and a combination. The "sources of risk" category is shown in Figures 6.5, 6.6 and 6.7 for coastal, offshore and combined respectively.

To determine the levels of vulnerability, all the themes in both categories were then combined to illustrate the spatial relationship between themes. This is shown in Figure 6.8. A grid of 30 km^2 cell sizes was created in GIS as previously illustrated in Figure 6.2 and overlain onto the combined themes. A numerical ranking system was devised base on the number of "SR" and "HE" themes. This ranking system is shown in Table 6.4.

Table 6.4: Devised Ranking System used in the Vulnerability Assessment

Assigned Value	Description (Vulnerability)	Explanation
0	Not Relevant including Land Area	No data or No combination of "HE" and "SR" themes
1	Low Level	Combination of 1-2 "HE " and 1-2 "SR" themes
2	Medium Level	Combination of 3-4 "HE " and 3-4 "SR" themes s
3	High Level	Combination of 5-6 "HE" and 5-6 "SR" themes
4	Extremely High Level	Combination of > 7 "HE " and > 7 "SR" themes

The number of "SR" and "HE" themes found in each grid cell was then analysed. Each cell was then populated with an assigned value based on the ranking system (Table 6.4). The outcome of this analysis is an assessment map of the Caribbean Sea showing the levels of vulnerability. This is shown in Figure 6.9. This assessment was further manipulated in GIS, by applying bilinear interpolation kriging (ESRI, 2002), to produce a better model of the derived assessment (ESRI, 2002). This is shown in Figure 6.10.

This assessment did not fully take into account the currents and wind dynamics that exist in the Caribbean Sea. Rather, the assessment regarded the Caribbean Sea partially as a stagnant system (only buffer values were assigned). The Caribbean Sea has many passages and is therefore influenced by the current patterns and movement of water into and out of the sea. To incorporate current movement and prevailing winds into this assessment, maps of the current movement (Gyory *et. al.*, 2002) and prevailing winds (Mariano, 1996) were used for comparison with the derived vulnerability assessment. This information was used to speculate the areas in the sea where the wind and current movement are most likely to influence or change the levels of assessment. These areas are shown in Figure 6.11.

6.4 Results and Discussion

The results of the analysis are spatial information, which are presented in categories of susceptibility, sources of risks, vulnerability and influences of current movement and wind pattern.

6.4.1: Susceptibility

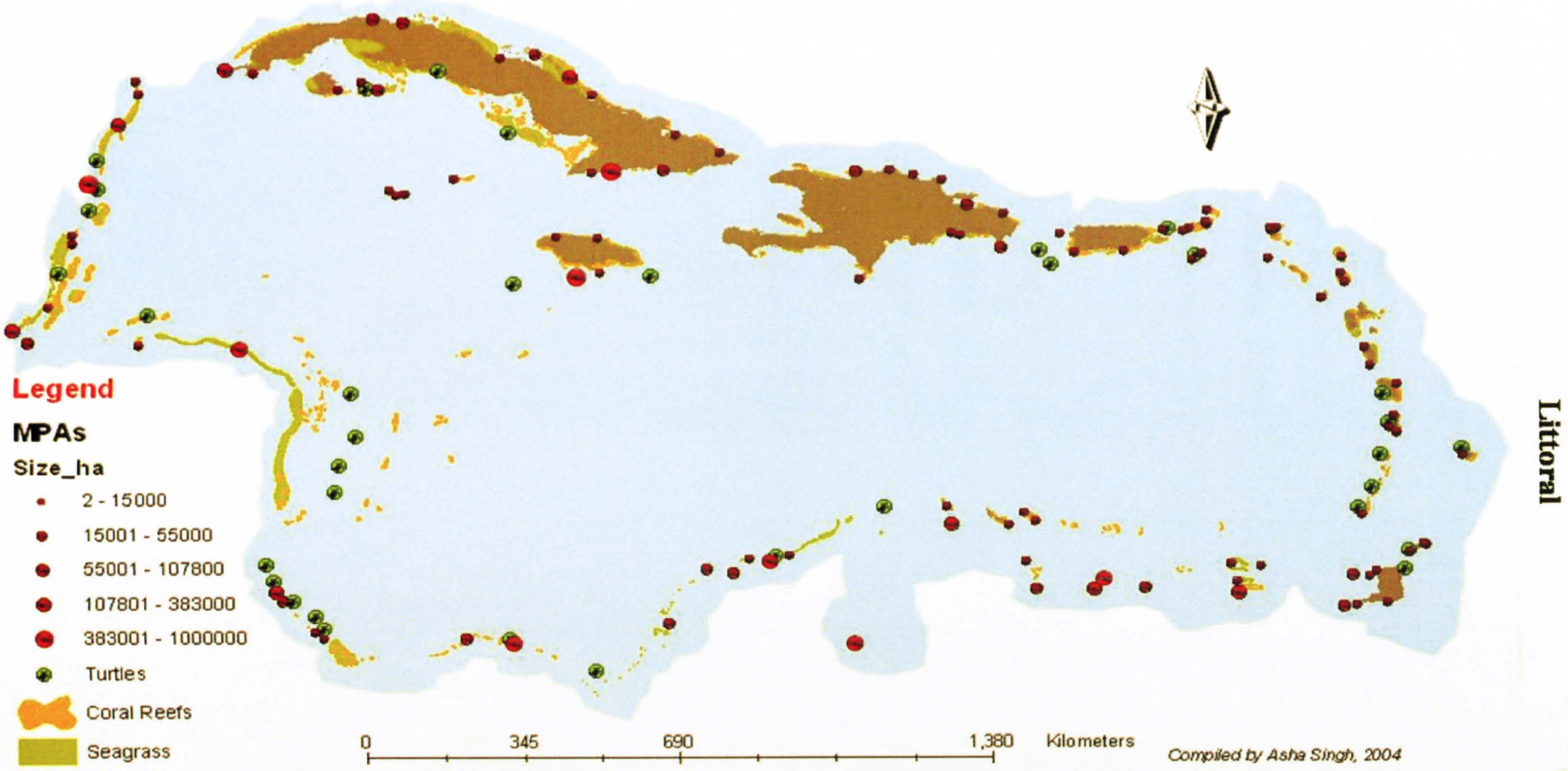

Figure 6.2: A Map of the Caribbean Sea showing Susceptible Littoral Habitats/Ecosystem

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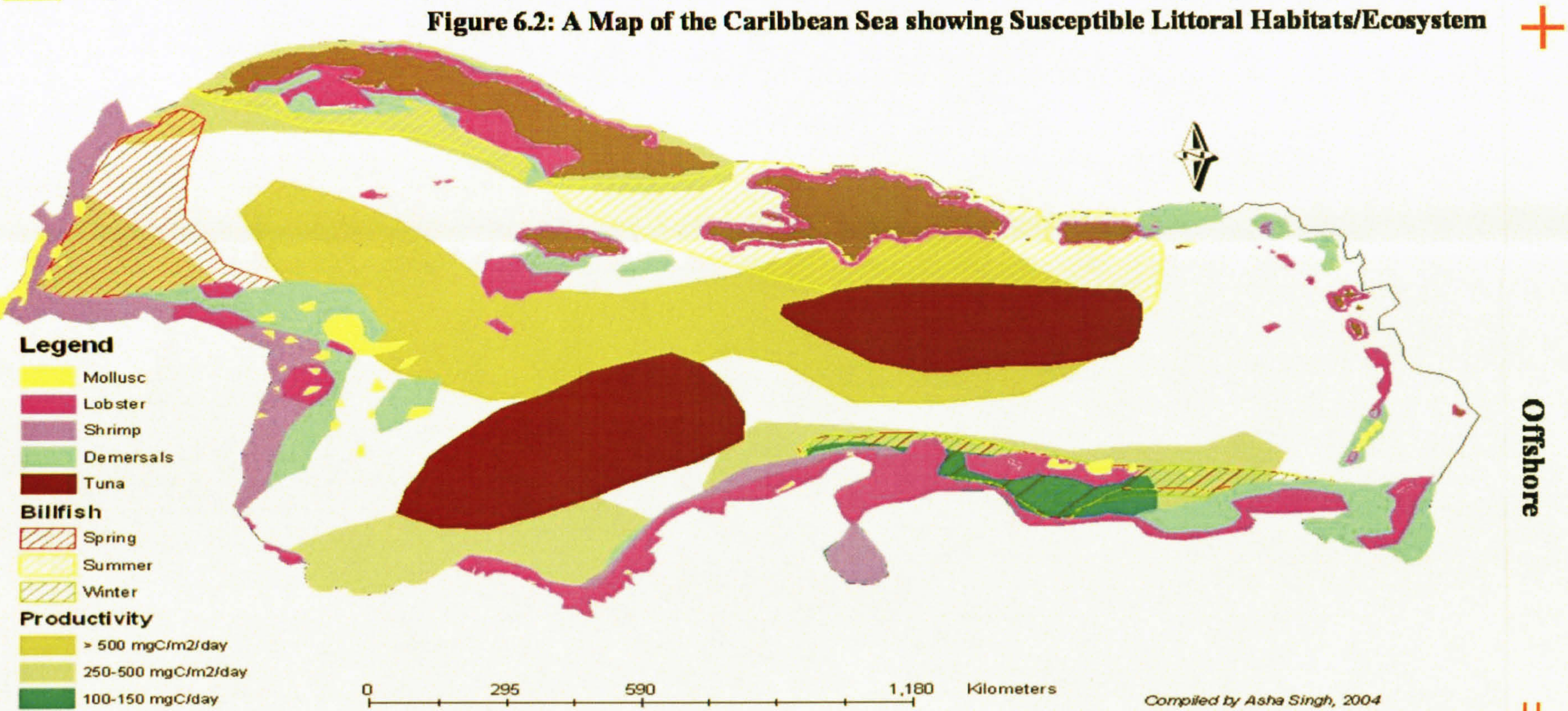

Figure 6.3: A Map of the Caribbean Sea showing Susceptible Offshore Habitats

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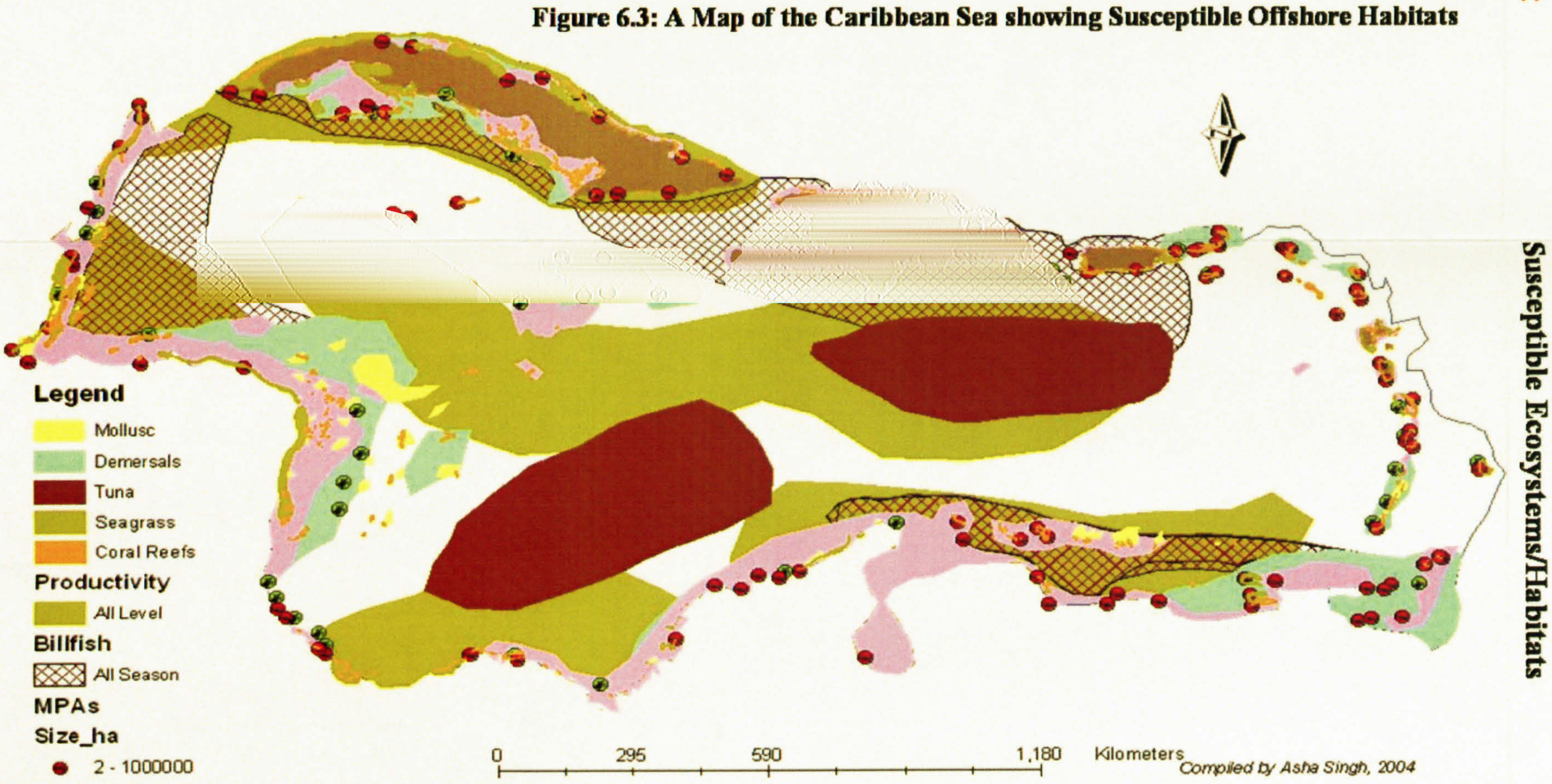

Figure 6.4: A Map of the Caribbean Sea showing all Susceptible Habitats/ Ecosystem

Susceptibility: The susceptibility category showed the presence of many habitats in the Caribbean Sea. Both littoral and offshore habitats are susceptible to land and sea based activities. However, based on the spatial location of the littoral habitats (Figure 6.2), it is likely that they are more at risk from the coastal activities (refineries and ports). In contrast, the offshore habitats (Figure 6.3), such as the demersal and tuna are more likely to be affected by offshore activities such as vessel movement and pollution from maritime traffic. This spatial illustration of habitats in Figure 6.3 provide tangible data, which confirm that there are habitats of certain species, which are found at a Caribbean - wide level.

In terms of connectivity, the littoral habitats may share less and may generally be isolated within a specific geo-political borders. This isolation also makes these habitats more prone to decimation from other land based activities as demonstrated in Chapter Four. Comparatively, some of the offshore habitats, such as tuna, are concentrated in a specific area of the sea and will therefore be more susceptible to large-scale single events. Events such as oil spills, if occur in these habitat areas can affect the population stock.

6.4.2 Sources of Risk

Coastal

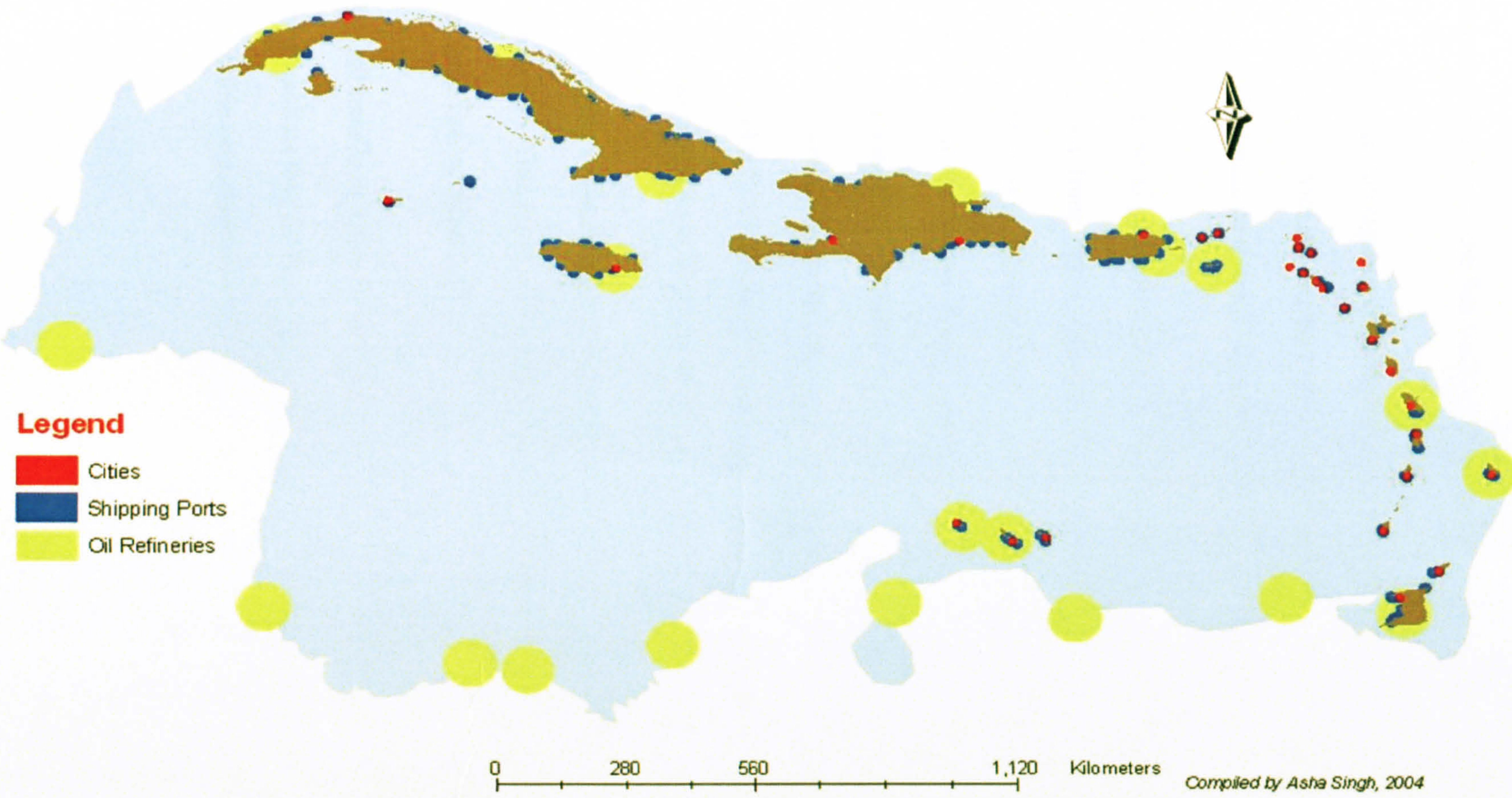

Figure 6.5: A Map of the Caribbean Sea showing the Coastal Sources of Risk

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Offshore

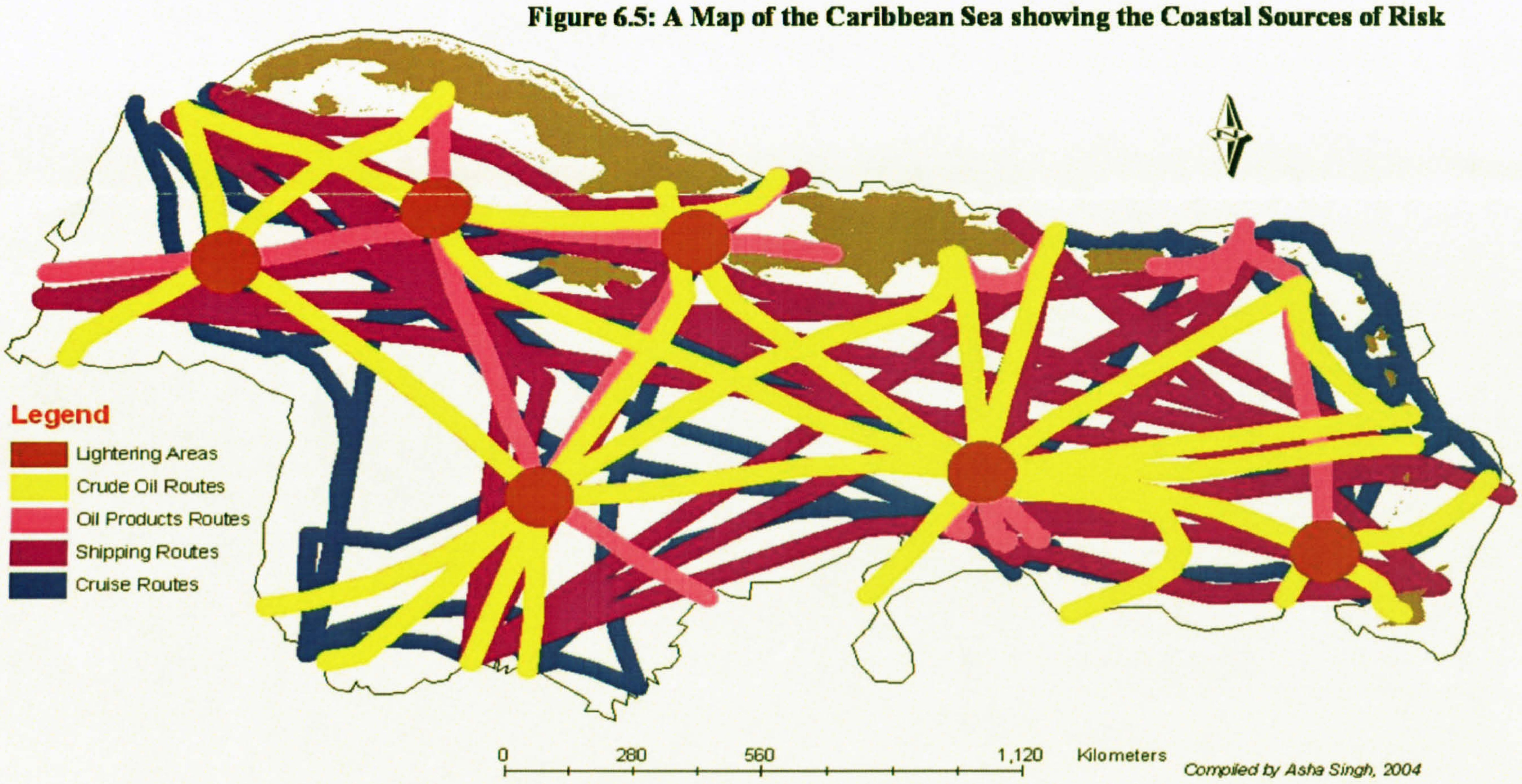

Figure 6.6: A Map of the Caribbean Sea showing the Offshore Sources of Risk

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Sources of Risk

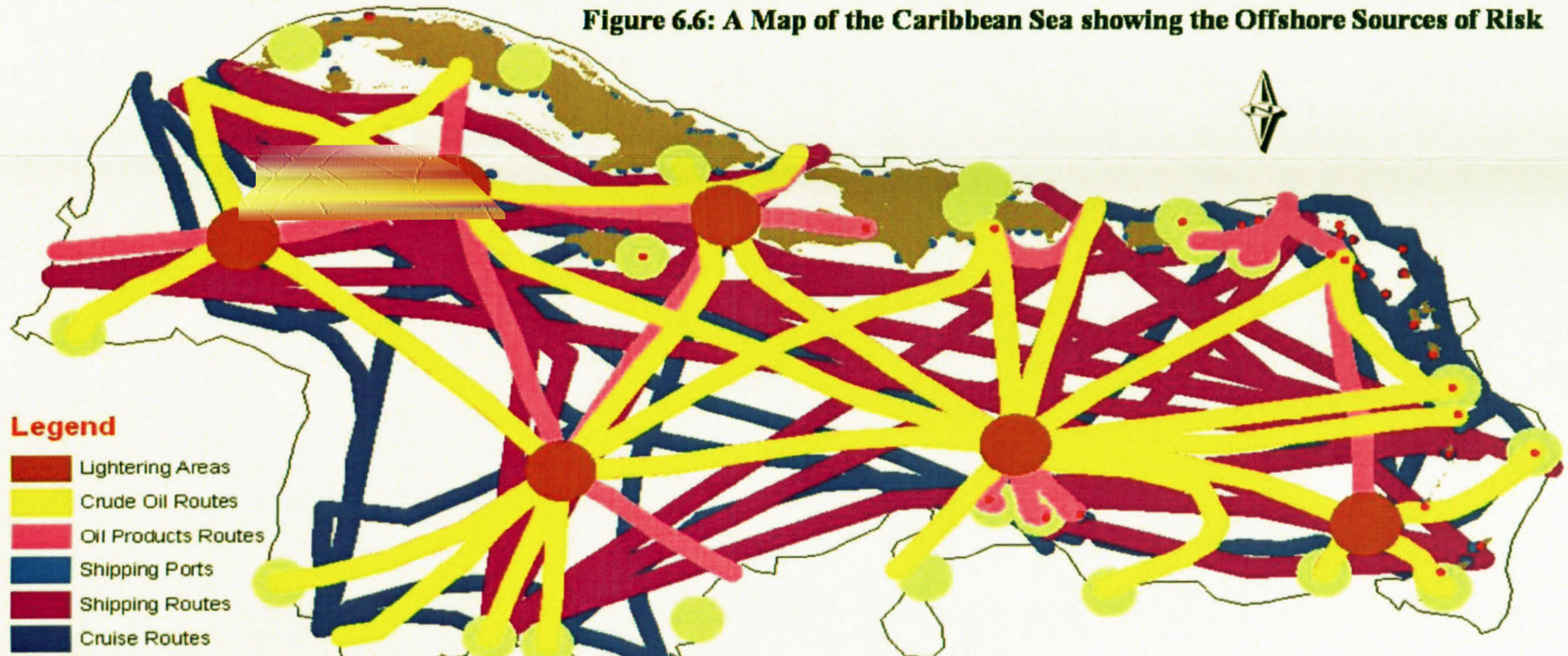


Figure 6.7: A Map of the Caribbean Sea showing all Sources of Risk

Sources of Risk: The coastal sources of risks are the cities, shipping ports and oil refineries/ oil handling terminals (Figure 6.5). Overall, there are more than 80 ports in the islands which are on the West Coast (Caribbean Sea). Most of the refineries are in South American countries that border the Sea while others are in islands such as Puerto Rico and the USVI.

The refineries throughout the Caribbean supply refined products to countries within the region, Gulf of Mexico and beyond. Refined products from outside the region are shipped into the Caribbean or through the Caribbean Sea (via Panama Canal) to other destinations.

There is a general pattern of crude oil movement within the Caribbean (Figure 6.6). Crude oil is shipped from Africa, the Middle East, Argentina and Alaska into the Caribbean (Dillion, 1995). It is also shipped from Venezuela, Trinidad and Columbia to the USA and other parts of the region. Large storage terminals in St Lucia, Curaçao, Aruba and St Eustatius are used as transhipment ports for crude oil. The processed oil follows a similar pattern of movement as the crude oil. The lightering areas[47] in the sea are used to load crude oil and refined products to larger or smaller ships which either travel into ports of the Caribbean countries or beyond the Sea.

The shipping network suggests a complex pattern of traffic throughout the Caribbean Sea (Figure 6.7). This traffic includes oil tankers, chemical tankers, yachts, cruise ships, ferries and large fishing vessels.

The habitats/ecosystems within these areas are susceptible to these maritime activities. Some habitats may be more susceptible to local coastal activities while others will be more susceptible on a regional level.

[47] This is a term used for areas in the sea where ships offload and unload cargo onto other ships.

6.4.3: Vulnerability

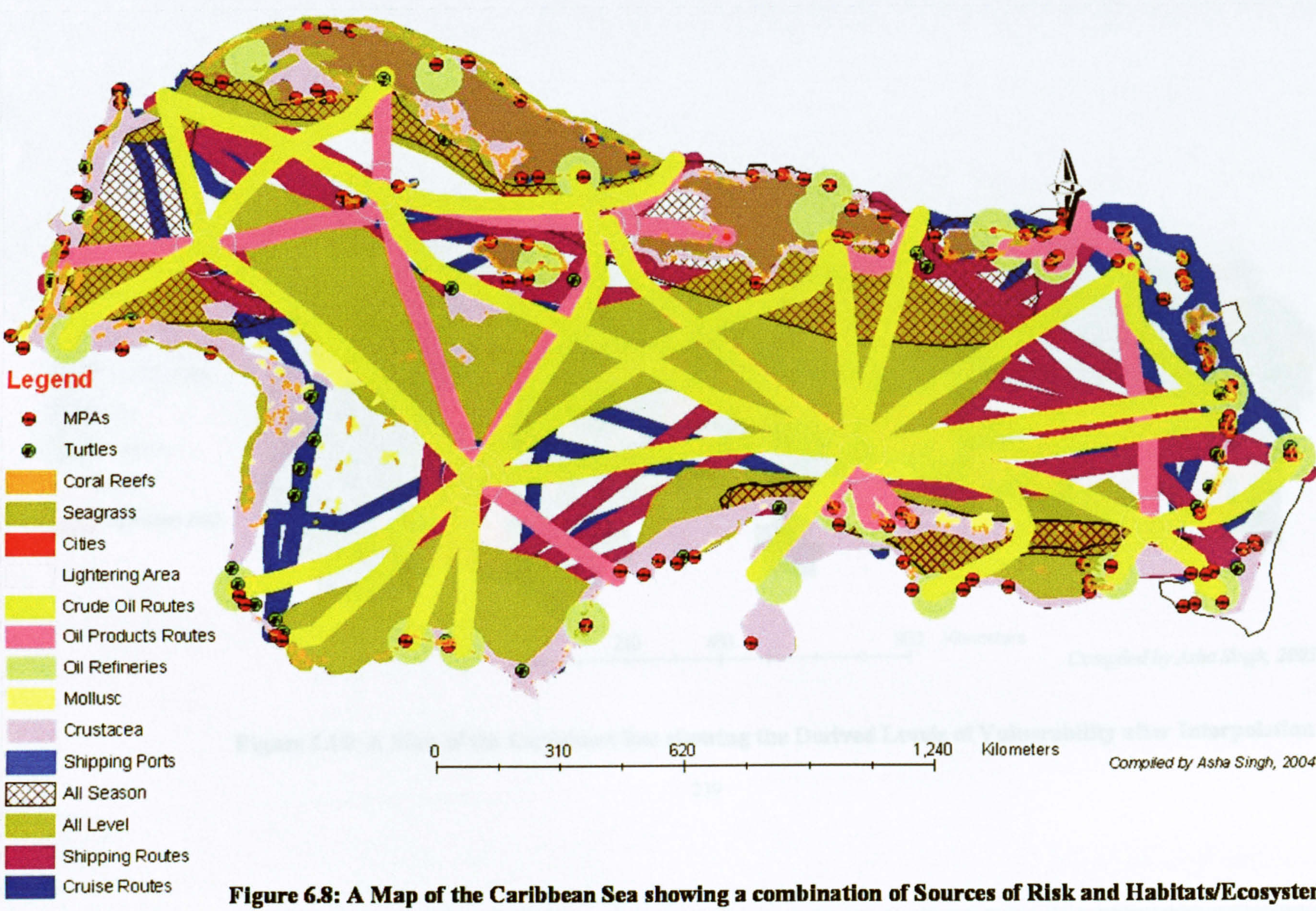


Figure 6.8: A Map of the Caribbean Sea showing a combination of Sources of Risk and Habitats/Ecosystems

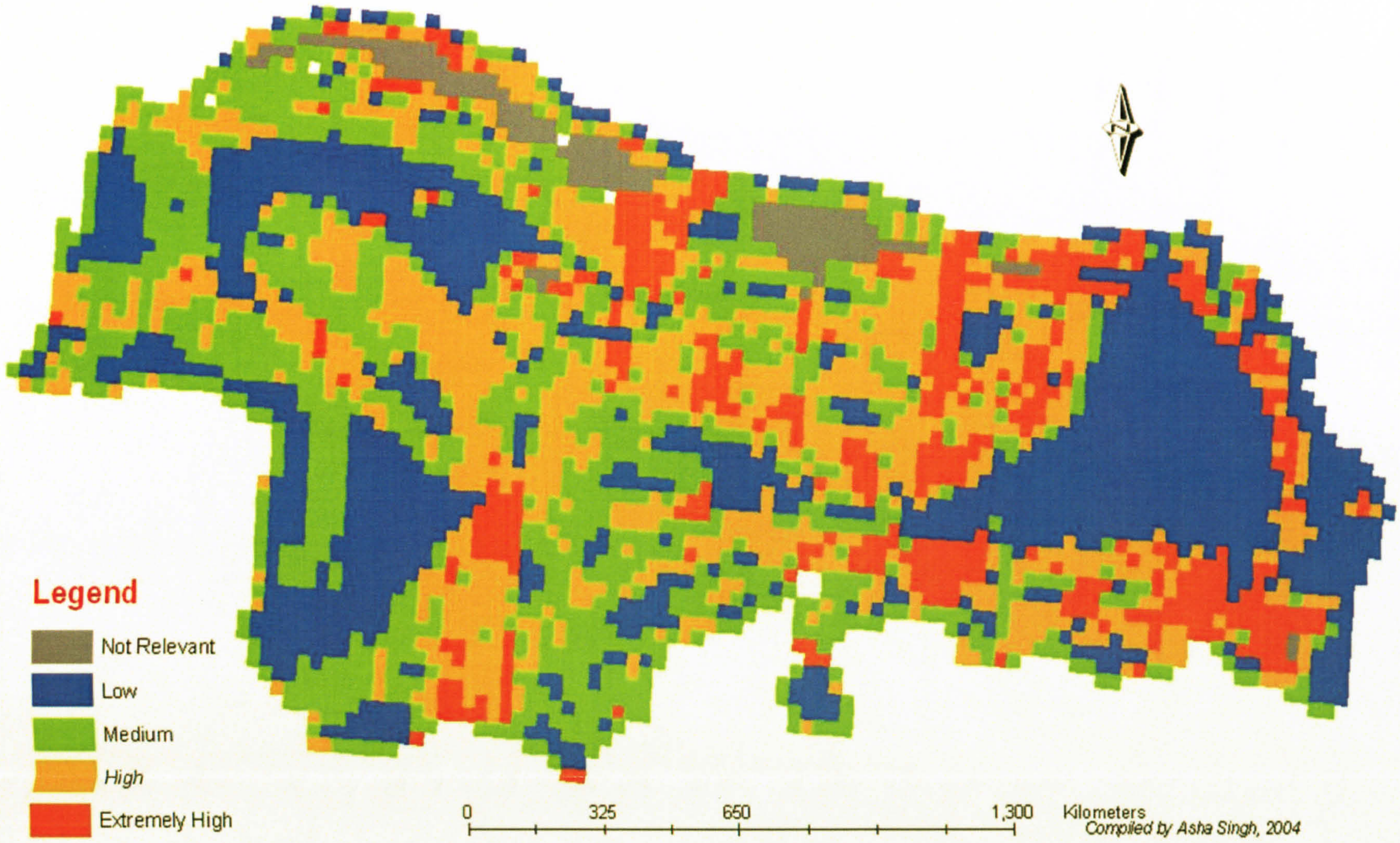
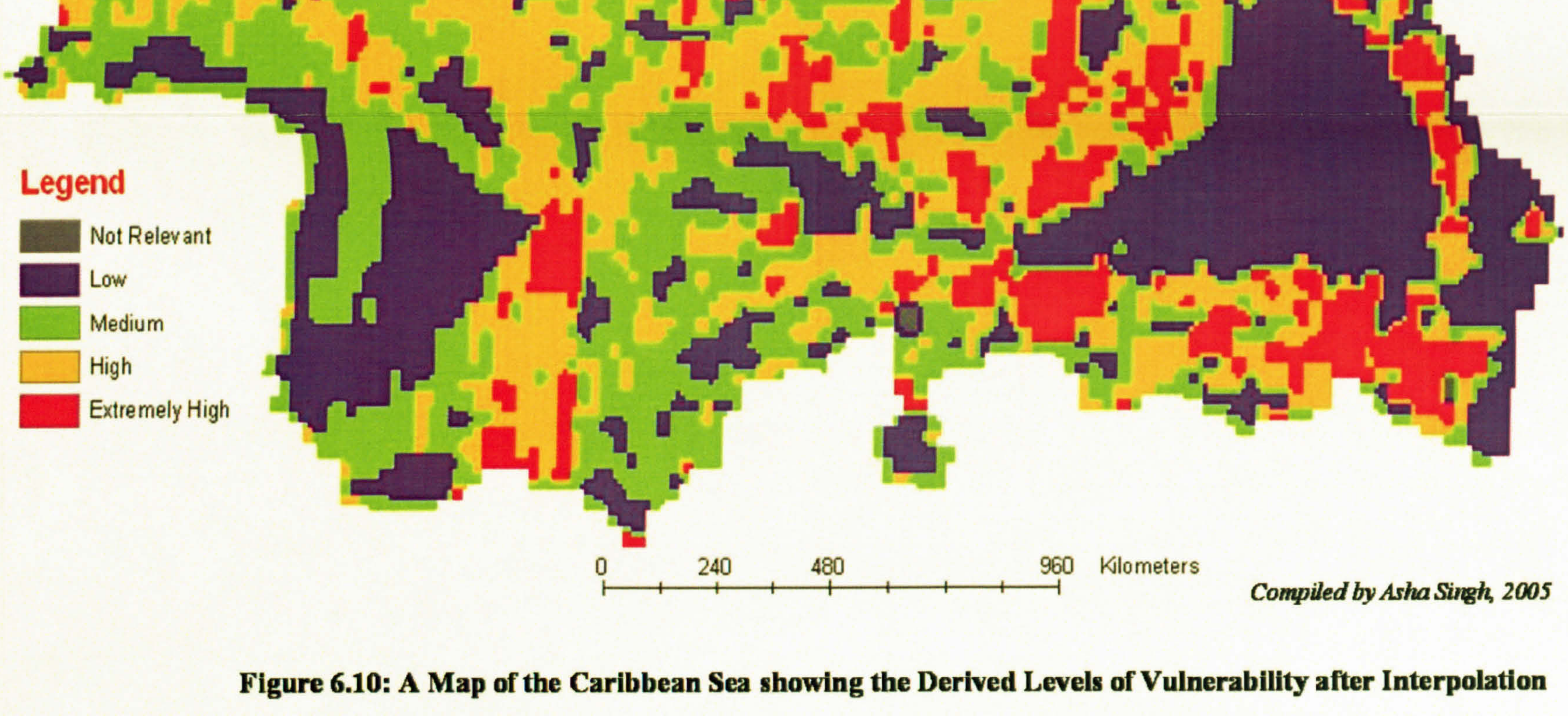


Figure 6.9: A Map of the Caribbean Sea showing the Derived Levels of Vulnerability



Compiled by Asha Singh, 2005

Figure 6.10: A Map of the Caribbean Sea showing the Derived Levels of Vulnerability after Interpolation

Vulnerability: The derived vulnerability assessment (Figure 6.9) shows many areas in the sea, which are ranked as high and extremely high levels of vulnerability. Many extremely high and high level areas are in close vicinity of landmasses, thus indicating the high risks of some of the habitats in these particular areas. There are also highly vulnerable areas in offshore locations, which further demonstrate the importance of managing the sea as an ecosystem. The low level areas shown in Figure 6.9 are locations with no habitats however, there are shipping and cruise routes in these areas hence the possibility of oil spills are probable. These pollution can move to habitat areas by the current movement.

6.4.4: Influences of Current and Wind

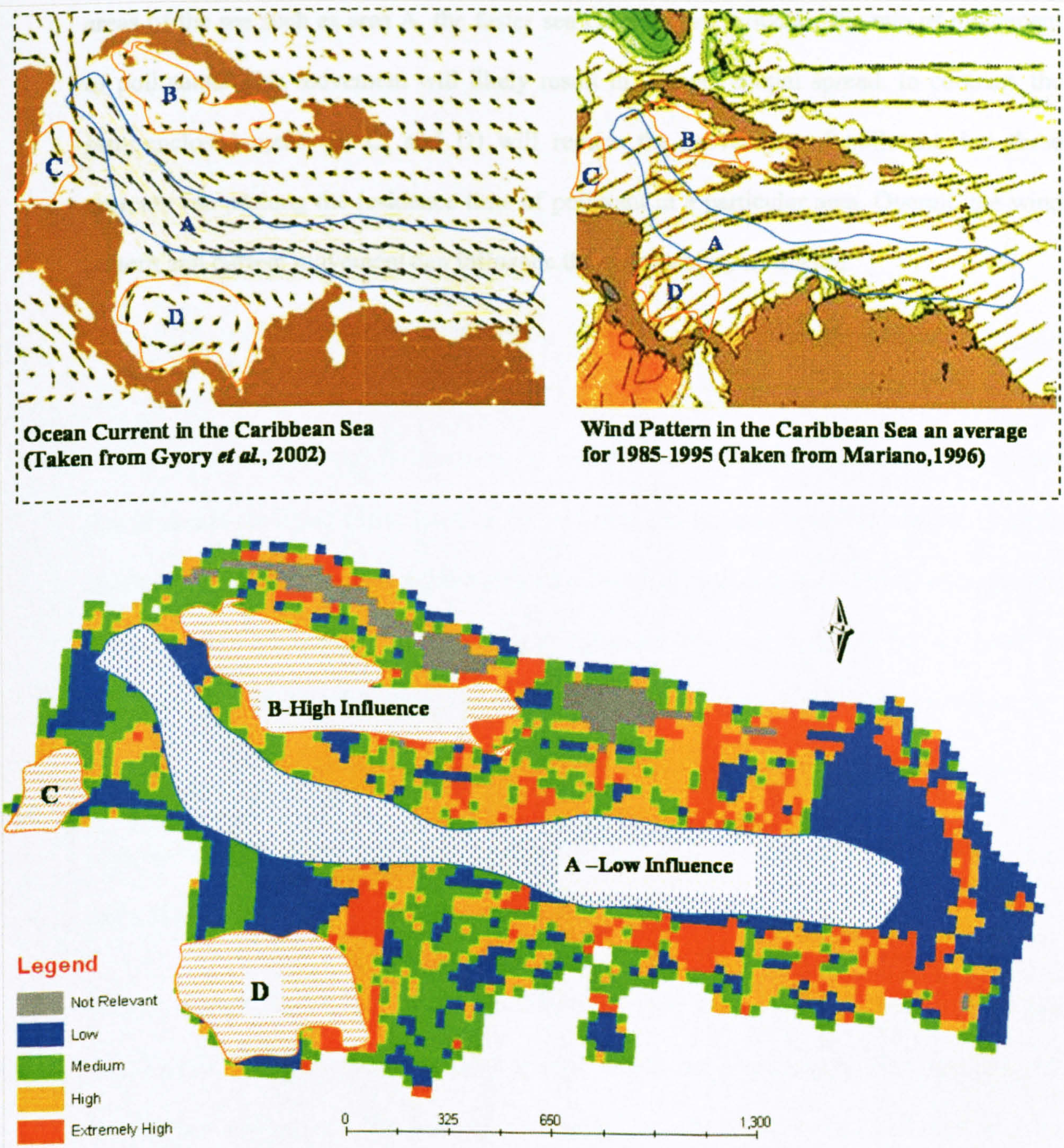


Figure 6.11: A Map of the Caribbean Sea showing Examples of Areas in the Sea where current movement and wind pattern can influence the derived vulnerability assessment

Influence of Currents and Wind: The current movement and wind pattern (Figure 6.11 inset) show some of the areas where these can influence the level of pollution. In some areas of the sea such as area A, the faster sea currents can influence the rate of movement of pollutants. This movement will likely result in a larger spatial spread. In contrast, the semi-enclosed areas (B, C, and D) will reduce the movement of pollutant, but these currents can prolong the residence time of pollutant in a particular area. Overall, the wind pattern and current movement can influence the vulnerability of the sea.

6.5 General Discussion

Overall, the spatial location of the various habitats and activities in the Caribbean reiterates and further demonstrates the importance of managing the Caribbean Sea as a large marine ecosystem. It is evident from this assessment that the marine ecosystem is under varying levels of stress from economic activities, such as shipping. Previous studies concluded that the Caribbean Sea is at risk and is vulnerable to long term or irreparable damages (UNEP, 1989; Richards and Bohnsack, 1990; UNEP, 1994; Siung-Chang, 1997; WCISC Unit, 1998; GESAMP, 2001; Burke and Maidens, 2004b; UNEP, 2004a). However, these studies did not demonstrate the spatial extent of the vulnerability. Hence, this assessment has attempted to provide such information by using a matrix of the Caribbean's ecosystems, and land and sea based activities. The derived map can be used by policy makers to direct management policy toward minimising the level of vulnerability. These management initiatives can be in the form of constructing more reception facilities for oil waste to reduce the possibility of dumping in the sea or more stringent and collective enforcement.

The spatial location of the vulnerable areas and contributing activities can be used as a basis to conduct further study into quantifying the levels of pollution through further data gathering and analysis.

Regard to current and wind influences, this assessment shows that current movement and winds in the Caribbean Sea can influence the movement of pollutants. However, the risk on habitats depends on the type of pollutants, rate of dispersion of pollutant and the proximity of a particular area to any discharge. For example, a study conducted in Cuba found that some offshore islands (Canarroeos and Sabana-Camaguey) are affected by oil pollution due to intense traffic in the Old Channel (Villasol *et. al.*, 1998). The main reason cited for this oil pollution is the movement of the currents, which enables the oil from nearby shipping channel to move to the islands.

6.6 Conclusion

The assessment conducted in this chapter illustrates how maritime activities are affecting the sea. These findings coupled with the findings of Chapter Four provide an overall assessment of the pressures on the Caribbean Sea.

This approach was particularly applicable to the Caribbean region because it has provided an overall assessment of the sea with the use of limited data. The findings of this assessment can be incorporated into policies, to define priorities for the management of the entire sea as an ecosystem. In terms of future studies, this assessment provides the baseline data for other forms of modelling such as pollution intensities and other empirical studies.

Thus far, the analysis and information presented in this study have shown the pressures on the marine environment, from anthropogenic activities (land and sea based activities) and from natural events. The Caribbean region is aware of these issues and has responded in the form of policies, institutions and other means. Therefore, the focus of Chapter Seven will be to critically examine the relevant response measures taken to mitigate or minimise marine degradation in the Caribbean Sea from these activities.

CHAPTER SEVEN

7.0 ANALYSIS OF CURRENT REGIONAL RESPONSES

7.1 Introduction

This study has gathered evidence that illustrates the declining state of the Caribbean Sea and indicates the major causes. These causes include inadequate management of waste (Chapter Two), economic activities (Chapter Three), land based activities (Chapter Four), natural events (Chapter Five) and sea based activities (Chapter Six). The degrading state of the marine environment in the region is recognised by the policy makers in the region and international agencies and were given prominence through many reports (UNEP, 1989, 1994; GESAMP, 2001; UNEP, 2004a). This recognition has manifested in numerous responses in the form of programme implementation, establishment of regional institutions and legal agreements.

The regional responses by the SIDS and other agencies to deal with issues in the region will be analysed in this chapter. The responses will be discussed based on the findings of this study also the other relevant responses (e.g. Barbados Plan of Action) that exist in the region.

7.2 Methodology

This analysis of regional responses to the degradation of the marine environment in the Caribbean is based on a synthesis of published and unpublished information regarding the existing mechanisms, which are currently in place in the region to respond to identified environmental issues.

Conventions and Protocols relevant to SIDS and the marine environment were compiled from various sources and categorised by island. Further, the percentage was calculated for the following:

a. The number of agreements by island
b. The number of islands that ratified each agreement.

This was done to demonstrate the success rate of these agreements within the region also to show the varying level of commitment by the islands to these agreements.

Spatial data, which were analysed in Chapter Three, were used to demonstrate the location of MPAs in the Caribbean. Buffer analysis was conducted in GIS to demonstrate the area of the Caribbean Sea protected under the MARPOL convention for oil, sewage and noxious substances.

The number of hotels in the SIDS was compiled and processed using database software (EXCEL) to produce a statistical database. The data were then analysed to determine the distribution of hotels by island.

7.3 Results of Response Analyses

The results of the various responses to marine degradation, fisheries loss, habitat destruction, natural events among others are discussed below.

7.3.1 Response to Marine Degradation

Chapters Two, Four and Five highlighted the declining state of the Caribbean Sea caused mainly by pollution from various sources. The responses are discussed below.

7.3.1.1 Pollution Survey

The threat of oil pollution in the Caribbean prompted a programme of pollution surveys, which took place from 1980 until 1987 for the Wider Caribbean[48]. These surveys were conducted under the auspices of The Caribbean Regional Pollution Program (CARIPOL) and initiated by IOC-UNESCO and UNEP. The analysed samples for the Caribbean Sea showed significant levels of petroleum pollution (Atwood *et. al.*, 1987a; Atwood *et. al.*, 1987b; Richardson *et. al.*, 1987; Wade, 1987; Persad and Rajkumar, 1995; Botello *et. al.*, 1997; Villasol *et. al.*, 1998). However, monitoring was discontinued due to the exhaustion of funds. To date, no other pollution survey was initiated.

7.3.1.2 Minimising Pollution from Ships

To respond to the pollution threat caused by vessels movement in the Caribbean Sea (Chapter Two and Five), a number of international Conventions and Protocols were adopted. To date there are seven major international agreements which deal with pollution in the marine environment caused by ships (IMO, 2005). As shown in Table 7.1, not all the SIDS are party to these conventions and protocols. The number of ratifications of these agreements is less than 40% for the SIDS. Oil producing islands like the Republic of Trinidad and Tobago is not party to any of these agreements as shown in Table 7.1.

The MARPOL Convention shown in Table 7.1 is one of the most important agreements for controlling pollution from ships. However, the Caribbean Sea is not a designated "special area" for oil waste. Therefore, all pollution prevention from ships under MARPOL must be enforced by either the flag states, port states or the discretion of the vessels crew. Overall pollution prevention (MARPOL 1-3) from ships is largely a self-regulating entity in the region because there is no active programme for the Caribbean Sea. In addition, the spatial limit of the sea protected under MARPOL does not cover the entire sea and as shown in Figure 7.1 dumping can occur for a large extent of the sea under international law.

[48] Wider Caribbean refers to the Caribbean Sea and Gulf of Mexico

Table 7.1: SIDS in the Caribbean that ratified the IMO Marine Pollution Related Conventions. The Year of Signatures and Ratifications is not available. The instruments of ratification deposited by USA, the Netherlands, France and the United Kingdom regarding the dependent islands are provided in Appendix Six. X = islands that ratified the agreement. Compiled using information from IMO, (2004)

Country / Agreement	MARPOL 73/78 Annex 1	Annex 11	Annex 111	Annex 1V	Annex V	Annex V1	London 1972	London 1990	London 2000	London 2001	London 2004	Montego Bay 1982
INDEPENDENT												
Antigua & Barbuda	X	X	X	X	X		X	X		X		X
Barbados	X	X	X	X	X	X						X
Cuba	X	X		X			X					X
Dominica	X	X	X		X							X
Dominican Republic	X	X	X	X	X		X					
Grenada												X
Haiti							X					X
Jamaica	X	X	X	X								X
St Kitts & Nevis	X	X	X	X	X			X	X			X
St Vincent & Grenadines	X	X	X	X	X							X
St. Lucia	X	X	X	X	X							X
Trinidad & Tobago												X
DEPENDENT												
USA												
USVI												
Puerto Rico												
The Netherlands												
Bonaire												
St Marteen												
Saba												
Aruba*	X	X	X	X	X		X					
St Eustatius												
Curaçao												
France												
Guadeloupe												
Martinique												
St Martin												
United Kingdom												
BVI												
Montserrat												
Anguilla												
Cayman Islands												
Ratification Rate (out of a total of 27 islands)	10	10	9	9	8	2	5	2	1	1	0	11
Calculated Success Rate in the SIDS (%)	37	37	33	33	29	7	18	7	4	4	0	40

NOTES

MARPOL 73/78 – International Convention for the Prevention of Pollution from Ships
MARPOL is the main international convention that deals with prevention of pollution of the marine environment by ships from operational or accidental causes

Annex 1 – Prevention of pollution from oil
Stipulates operational discharges from oil tankers. This includes no discharges within 43 NM of the nearest land

Annex 11 – Control of pollution by noxious liquid substances
Noxious substances include over 250 chemicals. The discharge of the residue of these substances is allowed only in reception facilities. No discharge is permitted within 10 NM of land area

Annex 111 – Prevention of pollution by harmful substances in package form
Stipulates requirements for labelling, packing, documentation, storage and preventing pollution of harmful substances

Annex 1V – Prevention of pollution by sewage from ships
The discharge of sewage is prohibited except when the ship is in operation. Comminuted and disinfected sewage can be discharged beyond 3NM from land. Not comminuted and disinfected sewage can be discharged beyond 12 NM from land

Annex V - Prevention of pollution by garbage from ships
Prohibits disposal of plastics and severely restricts discharges of other garbage into coastal water of "special area."

Annex V1- Prevention of pollution of Air by ships
Sets limits on sulphur oxide and nitrogen oxide emission from ship exhaust

LONDON 1972 – Convention on the Prevention of Marine Pollution by Dumping of Waste and other Matter

LONDON 1990 – International Convention on Oil Pollution, Preparedness, Response and Cooperation

LONDON 2000 – Protocol on Preparedness, Response and Cooperation on Pollution Incidence by Hazardous and Noxious

LONDON 2001 – International Convention on the Control of Harmful Anti-fouling systems on Ships (AFS)

LONDON 2004 – International Convention for the control and Management of SHIPS Ballast Water and Sediments

MONTEGO BAY 1982 – United Nations Convention on Law of the Sea

* Aruba is not a fully dependent islands of the Kingdom of Netherlands, it has partial independence since 1992

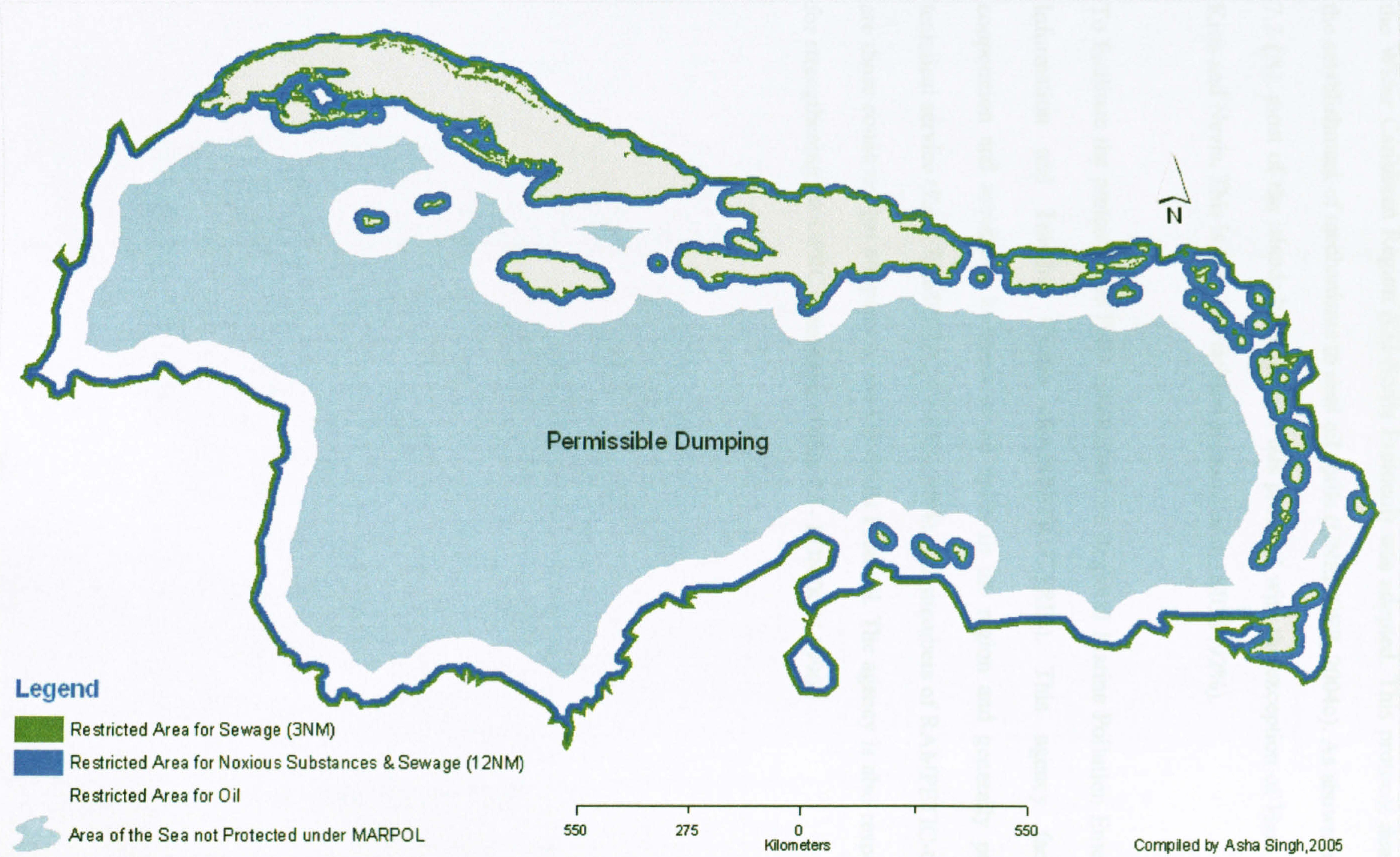


Figure 7.1 A derived Map of the Caribbean Sea showing the Restricted Area for Various Types of Waste covered under MARPOL Convention.

The recognition of the high maritime traffic combined with the high probability of oil spills in the Caribbean Sea (Chapter Two) has prompted the region to enhance its readiness. In 1983, the Protocol Concerning Cooperation and Development in Combating Oil Spills in the Wider Caribbean Region (Oil Spills Protocol) was adopted. This protocol deals with the establishment of mechanisms to deal oil spills (UNEP/CEP, 2004c). As shown in Table 7.2 (A), most of the islands have ratified this protocol with the exception of Haiti and St Kitts and Nevis. This is the most ratified protocol of the SIDS (92%).

To facilitate the protocol, the IMO established the Regional Marine Pollution Emergency Information and Training Centre (RAMPETIC/CARIB). This agency facilitates cooperation and assistance in cases of oil spills in the region and generally provides technical service (RAC/REMPEITC-CARIB, 2004). The members of RAMPETIC-CARIB are those countries that are party to the Oil Spills Protocol. The agency is also responsible for strengthening the OPRC agreement (Table 7.1- LONDON 1990).

Table 7.2: SIDS in the Caribbean that ratified the Marine Related Conventions. SD = Year of Signature, RD = Year of Ratification, LBS = Land Based Sources of Pollution, SPAW = Specially Protected Area and Wildlife, CITES = Convention on International Trade and Wildlife, CBS = Convention on Biological Diversity, UNFCCC = United Nation Framework Convention on Climate Change. Compiled using information from UNEP/CEP, (2004c,d,e),United Nations, (1995), CITES,(2005), CDB,(2005), UNFCCC, (2005) .

Country / Agreement	A		B		C		D		E		F		G		H		Number of Agreements Ratified by States* (total of 20)	Calculated % of ratified agreements
	Oil Spills#		LBS#		Migratory and Straddling Stock		SPAW#		CITIES		CBD		UNFCCC		KYOTO			
Category	SD	RD	SD	RD	SD	RD	SD	RD	SD	RD	SD	RD	SD	RD	SD	RD		
INDEPENDENT																		
Antigua & Barbuda		1986					1999		1997	1997	1993	1993	1993	1993	1998	1998	14	70
Barbados	1984	1985			2000			2002	1992	1993	1992	1992	1994	1994		2000	13	65
Cuba		1988					1990	1998	1990	1990	1992	1994	1994	1994	1999	2002	11	55
Dominica		1990							1995	1995		1994	1993	1993		2005	10	50
Dominican Republic		1998	2000					1998	1986	1987	1992	1992	1998	1998		2002	12	60
Grenada	1983	1987							1996	1999	1992	1994	1992	1994		2002	6	30
Haiti											1992	1996	1992	1996		2005	5	25
Jamaica	1983	1987					1990		1997	1997	1992	1995	1992	1995		1999	10	50
St Kitts & Nevis									1994	1994	1992	1993	1992	1993			11	55
St Vincent & Grenadines		1990						1991	1988	1989		1996		1996	1998	2004	12	60
St. Lucia	1983	1984			1996			2000	1983	1983		1993	1992	1993	1998	2003	12	60
Trinidad & Tobago		1986		2003				1999	1984	1984	1992	1996	1992	1994	1999	1999	7	35
DEPENDENT																		
USA																		
USVI	1983	1984					1990	2003									2	10
Puerto Rico	1983	1984					1990	2003									2	10
The Netherlands																		
Bonaire	1983	1984	1999				1990	1992			1994	2003					3	15
St Marteen	1983	1984	1999				1990	1992			1994	2003					3	15
Saba	1983	1984	1999				1990	1992			1994	2003					3	15
Aruba†	1983	1984	1999				1990	1992			1994	2003					3	15
St Eustatius	1983	1984	1999				1990	1992			1994	2003					3	15
Curaçao	1983	1984	1999				1990	1992			1994	2003					3	15
France																		
Guadeloupe	1983	1985	1999				1990	2002									2	10
Martinique	1983	1985	1999				1990	2002									2	10
St Martin	1983	1985	1999				1990	2002									2	10
United Kingdom																		
BVI	1983	1986	1999		2001		1990			1976		1994					3	15
Montserrat	1983	1986	1999				1990			1976							3	15
Anguilla	1983	1986	1999		2001		1990										3	15
Cayman Islands	1983	1986	1999				1990			1979		1994					3	15
Ratification Rate (out of a total of 27 islands)		25		1				17		14		20		11		11		
Calculated Success Rate in the SIDS (%)		92		4				62		52		74		41		41		

* This also include those agreements on Table 7.1, MARPOL is regarded as six agreements
# These are protocols of the Cartagena Convention which deals with the protection, management and development of the marine area of the Wider Caribbean
† Aruba is not a fully dependent islands of the Kingdom of Netherlands, it has partial independence since 1992

7.3.1.3 Minimising Pollution from Land Based Activities

The threat of land based pollution is evident in Chapter Two and from case studies presented in Chapter Four. Evidence presented in these two chapters demonstrates a large number of potential sources of pollution from land based activities.

One response mechanism to minimising marine degradation was the development of the Protocol concerning Pollution from Land based Sources and Activities (LBS Protocol). This protocol was sanctioned in 1983 and adopted in 1999 (UNEP/CEP, 2004d). It requires all contracting parties to respond appropriately to prevent, reduce and control pollution of the marine environment of the Caribbean. It has regional standards and practices for the prevention, reduction and control of pollution from land based activities. This protocol also advocates management approaches such as integrated coastal area management (UNEP/CEP, 2004d).

As a stipulation of the protocol, the ratifying states will be given 10 years from the date of ratification to adhere to standards and requirements within the protocol (UNEP/CEP, 2004d). This protocol was devised by the region to respond to the growing crisis in the Caribbean. However, the commitment from the region has been weak. In 2005, twenty-two years after its initiation, this protocol has not entered into force and to date Trinidad is the only country within the SIDS to ratify the protocol with the dependent territories signalling their intention to ratify as shown in Table 7.2 (B).

To date, coastal zone management plans are still lacking in many islands and no effluent discharge limits are being adhered to. This protocol is important if the region is to minimise the effects of land based activities. It is evident in the case studies in Chapter Four that habitats such as reefs are already being lost.

In 1995, the UNEP initiated a Global Plan of Action for the Protection of the Marine Environment from Land Based Activities (GPA) within the WSSD/Agenda 21 Framework (GPA, 2004). As part of this initiative, all countries are encouraged to formulate national plans of action for the protection of the marine environment. In countries where similar plans exist policy makers are encourage to adjust these plans to include marine management. The UNEP/CEP in the Caribbean is currently working with countries in the region to develop these national plans to enable these islands to protect the marine environment (Singh, 2005). It is the goal of UNEP/CEP that these NPAs will give credence to the LBS Protocol.

7.3.2 Response to Fisheries Loss

Chapters Two, Three, Four and Six have demonstrated the status, importance and issues regarding the fisheries sector in the region. The two types of fisheries in the region require different responses. Pelagic stocks are often straddling more than one EEZ while demersal stocks tend to be associated with particular habitats, occasionally shared between countries. There are many initiatives at programme, institutional and legal levels by the region to respond to fisheries losses, which are discussed below.

7.3.2.1 Island and Regional Initiatives

Exploitation within the geo-political borders of the islands has necessitated the establishment of fishing regulations to control overexploitation of stock. Efforts are being made by policy makers to encourage fishermen to shift from heavily fished inshore demersal fisheries, to those underutilised offshore pelagic fisheries (e.g. Dominica – Chapter Four). This response has not solved overexploitation of fisheries. Rather it has shifted the problem to another spatial area.

Another response to fisheries losses and dwindling stocks is that many governments in the SIDS have amended policies, which promote fisheries expansion to limiting or regulating unsustainable fishing operations. Some islands have taken the initiative to introduce aggressive management and regulatory systems e.g. Jamaica and Puerto Rico (Aiken and Haughton, 1992; Kimmel and Appledoorn, 1992; Sanders, 1996; Aiken and Kong, 2000) to deal with this growing problem. This response by some countries has resulted in an ad-hoc approach to fisheries management, which do not form any cohesive plan for fisheries management at an ecosystem level. For example, the management of the stock varies in the islands.

Institutional response to fisheries in the region was via regional entities. In 1991, CARICOM Fishery Resource Assessment and Management Programme (CFRAMP) was established to provide expertise in fishery management for its members. It is currently a functioning body with full membership of the CARICOM countries[49] (CFRAMP, 1998a). Another institution, which exists in the region, is the Caribbean Fishery Management Council (CFMC), which is a US initiative for its dependencies in the region. The CFMC is responsible for the management of fisheries resources and the creation of fisheries management plans (FMPs) for Puerto Rico and the USVI (CFMC, 2004). These institutional mechanisms that currently exist in the region to respond to fisheries management does not in any way deal with fisheries at a regional level and their mandates are within geo-political borders.

7.4.2 Initiative for Shared Stock

For shared pelagic stock, effective management requires commitment and cooperation among islands, especially for migratory species (Hunte and Mahon, 1982; CFRAMP, 1998b). In an effort to respond to the declining pelagic fisheries stock worldwide, the

[49] The SIDS members of CARICOM are Antigua & Barbuda, Haiti, Barbados, Dominica, Grenada, Jamaica, Montserrat, St Lucia, st Kitts, St Vincent and Trinidad & Tobago. Associate Members are Anguilla, BVI and Cayman Islands.

United Nations has addressed the movement of migratory species by implementing the Convention for the Conservation and Management of Straddling Stocks and Highly Migratory Fish Stock (United Nations, 1995). This agreement, which entered into force in 2001, is part of UNCLOS. This convention addresses the conservation of species and stocks that migrate between EEZs, the high seas and travel long distances. It articulates the precautionary approach, protection of biodiversity in the marine environment and sustainable use of fisheries resources. This agreement requires effective enforcement of flag states, port states and coastal states for the conservation and management of fish stock (United Nations, 1995). Some migratory species protected under this agreement are tuna and tuna-like species (FAO, 1994).

This convention is important for the region if the shared fisheries (Chapter Six) are to be sustainable managed on a Caribbean-wide level. However, there is no successful implementation of this convention in the region. A few of the islands have signed but none been ratified this convention as shown in Table 7.2 (C).

Another form of response to fisheries was by FAO. In 1995, FAO attempted to address declining stocks worldwide by providing guidelines for effective fisheries management. This was done through the Code of Conduct for Responsible Fisheries (FAO, 1995). This code of conduct advocates the management of fish stock through regional management arrangements. It also includes specifications for the management of stocks at regional levels, which may involve multi jurisdictions. It stipulates that there must be cooperation and negotiation among the states on scientific research, the establishment of total allowable catches (TACs) and enforcement measures (FAO, 1995). This code of conduct is global in scope and is a suitable application to the jurisdictional complexity that exists in the Caribbean (Chapter Three pg 100). However, the extent of incorporation of this voluntary code of conduct into specific management plans and regional responses is unknown.

7.3.3 Response to Habitat Destruction

Chapters Two and Four have provided evidence of human pressures on coral reef, seagrass and mangroves. The current responses to curb the anthropogenic pressures and destruction of habitats are discussed below.

7.3.3.1 Regional Initiative

The regional response mechanism to biodiversity loss in the Caribbean is through the Specially Protected Area and Wildlife (SPAW) Protocol. The objective of the protocol is to protect rare and fragile ecosystems and habitats by establishing proper management responses for protected areas (UNEP/CEP, 2004e). According to UNEP/CEP (2004e), the SPAW protocol is responsible for the regionalisation of global conventions and initiatives such as the Convention on Biological Diversity (CDB), the Convention on International Trade in Endangered Species (CITES) and the International Coral Reef Initiative (UNEP/CEP, 2004e). Many of the islands have ratified the SPAW protocol, in particular the dependent island as shown in Table 7.2 (D). The CITES and CDB conventions have been ratified by all the independent islands except Haiti which did not ratify CITES (CDB Secretariat, 2005; CITES, 2005). This is shown in Table 7.2 (E and F).

In general both member and non-member countries of these protocols and conventions have been responding to biodiversity protection by designating MPAs within their jurisdictions (refer to Appendix One island profiles). In addition, many have made effort on a national level to legislate the establishment of MPAs (e.g. Dominica - Chapter Four). Data gathered for this study revealed that currently there are 104 legally designated Marine Protected Areas (MPAs) in the region, of which 94 are found in the Caribbean Sea. The MPAs vary in size and are found throughout the sea as shown in Figure 7.2.

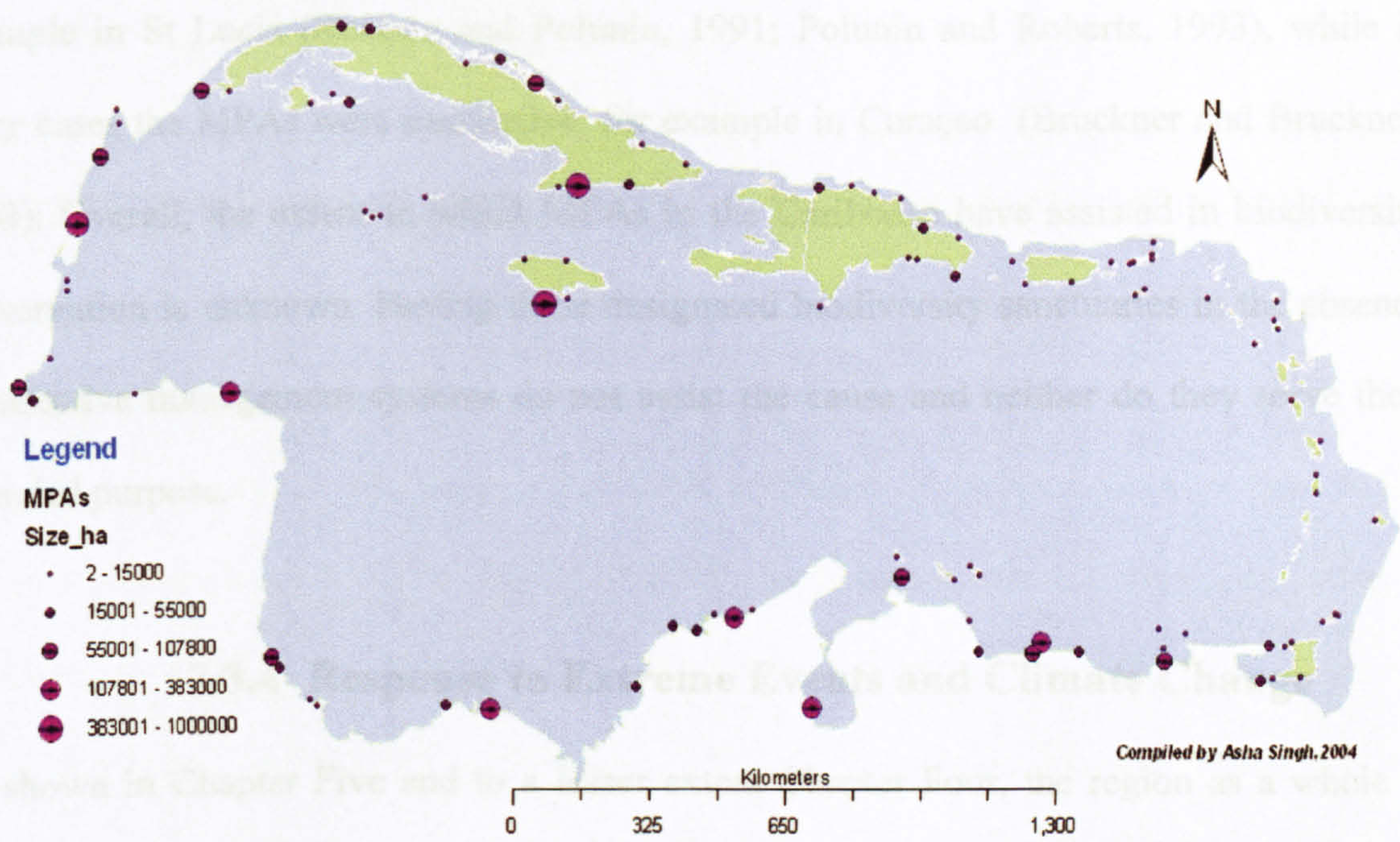


Figure 7.2: Spatial distribution of legally designated Marine Protected Areas in the Caribbean Sea. This map was derived using information compiled from OAS, (1988) and Geoghagan *et.al,* (2001)

The large number of MPAs in the region has evidently shown that the policy makers in the region have recognised the importance of MPAs. They are viewed as an approach, which will conserve marine biodiversity and maintain productivity of marine environment. However, although these protected areas have been demarcated, only a small percentage has any satisfactory management plans. According to the Organisation of American States, over 70% have not achieved meaningful management (OAS, 1988). Geoghegan *et. al.*, (2001), found that there are a total of forty-five MPAs in the SIDS with active management. Among them, four are ranked as having high level management[50] in place and a high proportion (nineteen) are ranked as having low level of management.

[50] High level management is where objective, management plan or operations plan is in place. Adequate human and other resources are available to address all stated objectives with actions and programmes. There is a high level of awareness of and adhererance to management rule. Low level management is where activities are in place, but objective are unstated or not addressed, resources are insufficient, management rules are not widely adhered to, and management may not be evident to visitors (Geoghegan *et. al.*, 2000)

In some islands MPAs have been effective in arresting the decline of certain species, for example in St Lucia (Roberts and Polunin, 1991; Polunin and Roberts, 1993), while in other cases the MPAs were ineffective, for example in Curaçao (Bruckner and Bruckner, 2003). Overall, the extent to which MPAs in the Caribbean have assisted in biodiversity conservation is unknown. Having these designated biodiversity sanctuaries in the absence of effective management systems do not assist the cause and neither do they serve their intended purpose.

7.3.4 Response to Extreme Events and Climate Change

As shown in Chapter Five and to a lesser extent Chapter Four, the region as a whole is vulnerable to external influences in the form of natural disasters (hurricane, tsunamis and climate change). The responses to these extreme events are discussed in the following section.

7.3.4.1 Hurricanes

In 1991, The Caribbean Disaster Emergency Response Agency (CDERA) was established to provide coordinated responses to its members in the event of disasters such as hurricanes. CDERA is a CARICOM initiative and its members are the CARICOM countries. Outside of CARICOM, Turks and Caicos and the BVI participate as associate members (CDERA, 2004). This agency provides assistance to its member states in the form of emergency services. It also provides prior warnings of hurricane events.

7.3.4.2 Tsunamis

The imminent risk from tsunamis in the region (Chapter Five) has prompted the region to respond to this unforeseen phenomenon. In 2004, efforts were made to implement an early warning system in the Caribbean. This is currently under construction for Puerto Rico and the US Virgin Islands (Andrade-Hillebrandt and Moreno, 2004). This system is funded by the US Government and it is likely that the entire Caribbean region will benefit from the provision of prior warnings. There is no regional response to deal with the economic and human threats of tsunamis.

7.4.4.3 Effects of Climate Change

The response to sea level rise from climate change in the Caribbean is coordinated through the International Framework Convention on Global Climate Change (UNFCCC). This convention was entered into force in 1992 and was followed by the Kyoto Protocol which was entered into force in 2005 (UNFCCC, 2005). Both agreements deal with a reduction in the use of destructive green house gases. The Caribbean islands are part of Non Annex 1 category within the UNFCCC (UNFCCC, 2005). This category includes states that are vulnerable to climate change. Many of the SIDS as shown in Table 7.2 (G and H) have ratified the UNFCC and the Kyoto Protocol.

In terms of institutional response, the Caribbean region has established a response programme known as the Caribbean Planning for Adaptation to Climate Change in 1995. This was a GEF funded initiative, which supports the CARICOM countries (CPACC, 2000).The objective of this agency was to assist the countries with preparation to cope with the adverse effects of sea level rise in coastal and marine areas. These preparations include vulnerability assessments, adaptation planning and related capacity-building initiatives. In 2001, the CPACC project was replaced by the Adaptation to Caribbean Climate Change (ACCC), working with the same countries and mandate. This project expired in 2003 and was replaced by Mainstreaming Adaptation to Climate Change (MACC). MACC project focuses on the integration of climate change threats into island programmes. The vulnerable sectors are targeted which include tourism, fisheries and agriculture (Caribbean Community Climate Change Centre, 2005). The MACC programme membership includes some members of CARICOM. The dependent islands along with Dominican Republic, Haiti and Cuba are not part of this programme.

7.3.5 Economic Sectoral Response

The region's large tourism sector, which was discussed in Chapter Three, also highlights the pressures on the marine environment caused by the large-scale coastal development, which characterised this sector. In addition, the steady increase in fossil fuel usage in the Caribbean makes the region economically vulnerable from global price fluctuations. The responses to minimise the pressures from these two sectors are discussed below.

7.3.5.1 Tourism

In an effort to minimise the pressure on the marine environment, the hospitality sector has responded by streamlining their operations according to sustainable practices. This is accomplished through the Green Globe 21[51] certification programme for hotels. Green Globe certification requires that certain key performance targets be met. These include effective waste disposal and energy conservation (Green Globe 21, 2005). In 2005, there was a recorded fifty-eight GG21 certified properties in the SIDS with an additional twelve working towards certification. This distribution by islands is shown in Figure 7.3. Jamaica has the highest number (26) of green globe certified properties followed by Barbados (8). According to the Caribbean Alliance for Sustainable Tourism (2005), the Caribbean region[52] leads the world in the number of certified properties. Data compiled for this study showed that there are in excess of nine hundred (900) hotels in the SIDS. Therefore, statistically, 6.4% of all the hotels in the SIDS are operating to prescribe sustainable practices. The number of hotels distributed by island is shown in Figure 7.3.

[51] Green Globe Certification is a global benchmarking,certification and improvement system for sustainable travel and tourism. It is based on Agenda 21 and endorsed at the Rio Summit

[52] includes some mainland countries of Central America

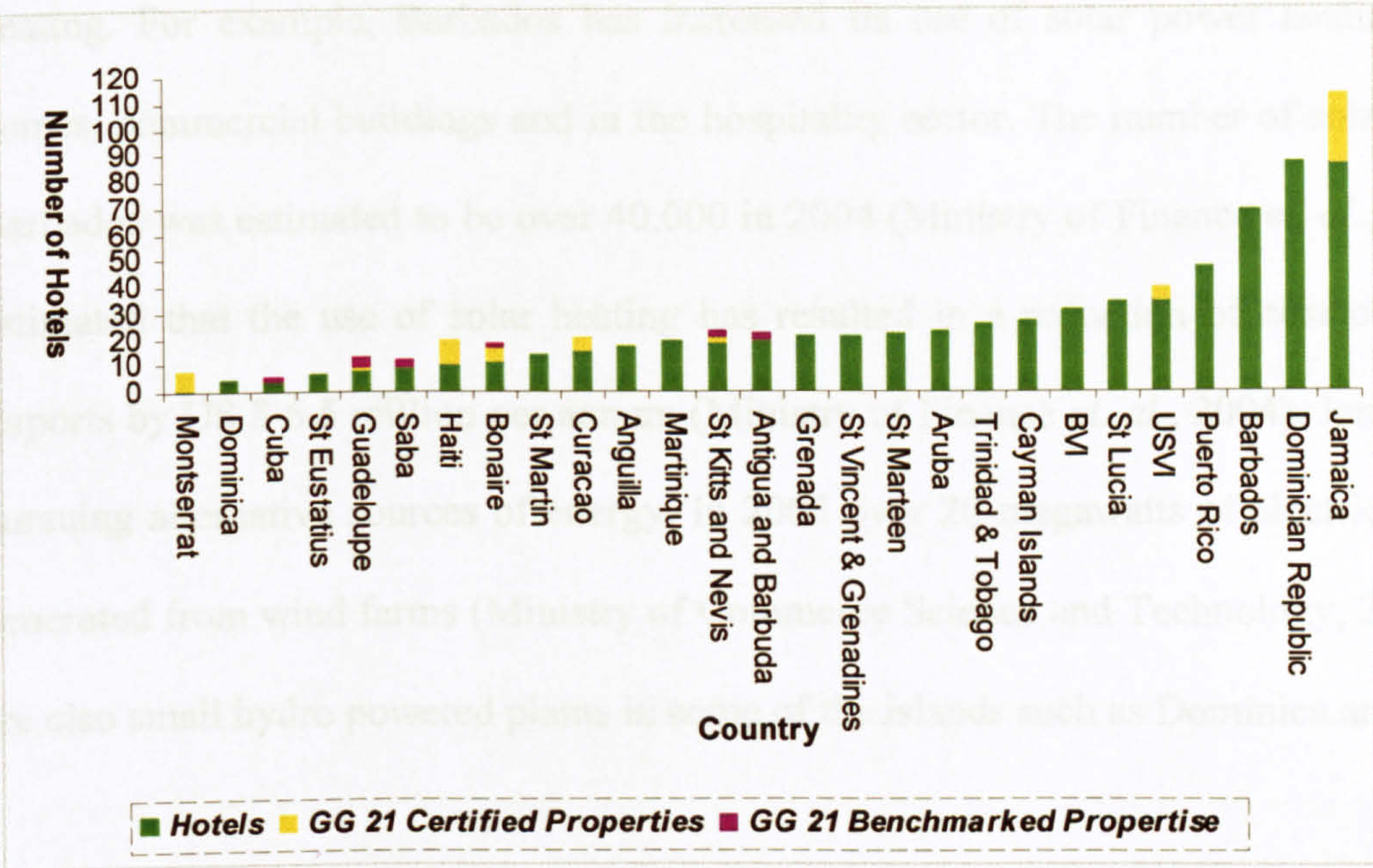


Figure 7.3: Total Number of Hotels in the Caribbean SIDS also the GG21 Properties. Compiled using data from Caribbean Alliance for Sustainable Tourism, (2005) and other island agencies in the SIDS

The total number of hotels given in this study does not account for apartments, villas and guesthouses. Although the number of apartments and guesthouses accommodation is unknown for all the islands, many islands have more of these alternative accommodations when compared to hotels. For example, data provided by Grenada Hotel Association, (2004), showed that Grenada has twenty-one hotels and thirty-nine alternative accommodations. Similar situation is likely in the other islands.

7.3.5.2 Energy

The need to find other forms of sustainable sources to fulfil demands, led to the formation of The Caribbean Renewable Energy Development Programme (CREDP) in 1998. This is a CARICOM initiative and has only CARICOM countries as members. As part of this programme, the CREDP aims to reduce greenhouse gas emissions by fostering renewable energy development, establishing the foundation for a sustainable renewable energy industry and creating a framework under which regional and national renewable energy projects are mutually supportive (CREPD, 2002). Some countries have responded to the high use of fossil fuels by increasing their use of alternative energy sources such as solar heating. For example, Barbados has increased its use of solar power heating in many homes, commercial buildings and in the hospitality sector. The number of solar heating in Barbados was estimated to be over 40,000 in 2004 (Ministry of Finance *et. al.*, 2004). It is estimated that the use of solar heating has resulted in a reduction of cost of fossil fuel imports by US $ 6.5 million per annum (Ministry of Finance *et. al.*, 2004). Jamaica is also pursuing alternative sources of energy. In 2005 over 20 megawatts of electricity is being generated from wind farms (Ministry of Commerce Science and Technology, 2004). There are also small hydro powered plants in some of the islands such as Dominica and Jamaica.

However, the data for fossil fuel usage in Chapter Three suggest that the region still relies heavily on this source to fulfil energy demands. Data for the 1990s show a general increase in total fossil fuel consumption in the Caribbean SIDS as shown in Figure 7.4. There is also significant differences in the annual consumption rate during this period.

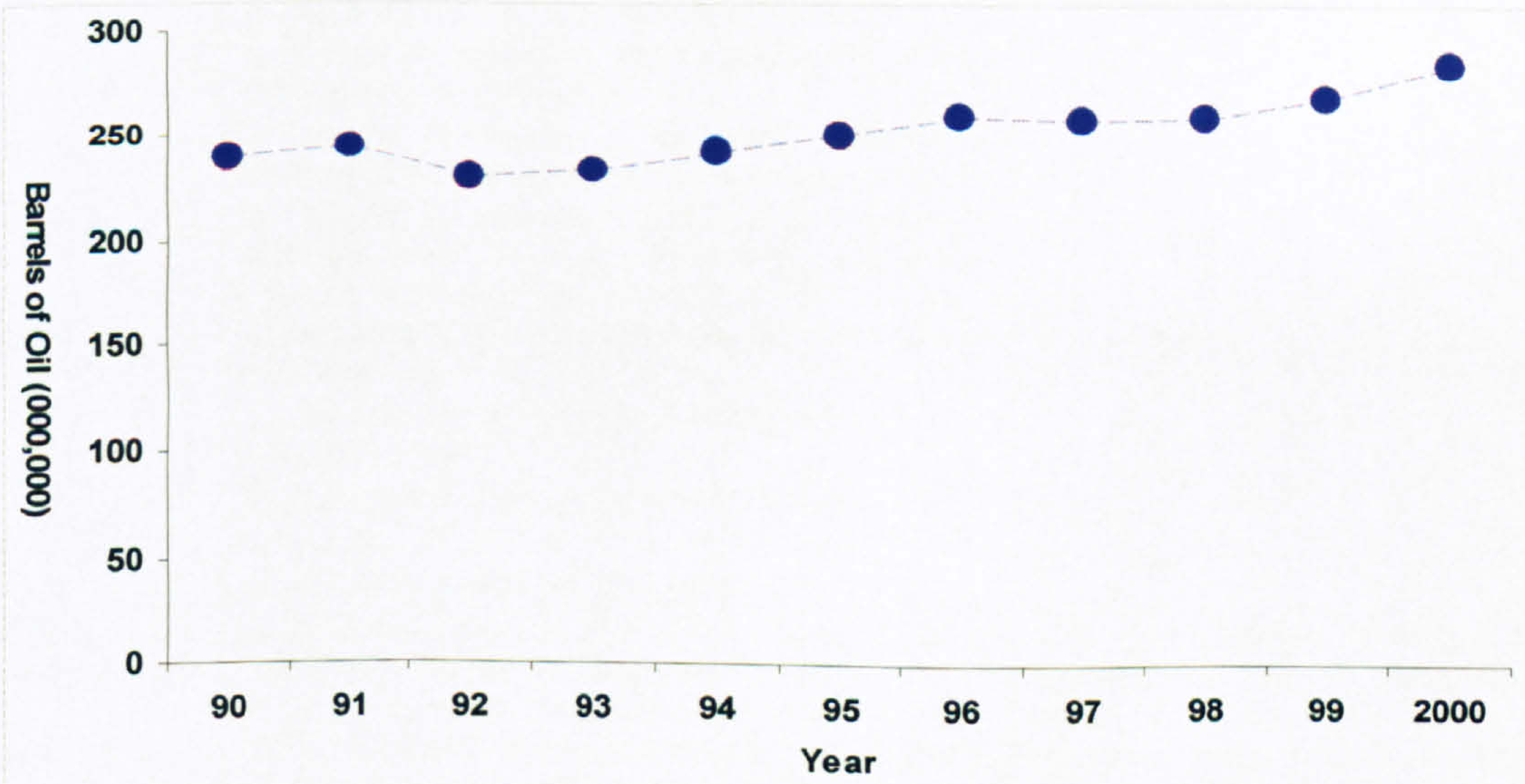


Figure 7.4: Total fossil fuels usage in the Caribbean SIDS for 1990 to 2000. There is a significant difference (P = .000) in the annual values for the data period. Compiled using data from Energy Information Administration, (2003)

Further, there are attempts by the region to improve the supply system of natural gas within the islands. In 2003, Guardian Holdings Ltd of Trinidad and Tobago proposed to lay a natural gas pipeline from Trinidad to Guadeloupe, with a spur to Barbados, in order to supply natural gas to the islands. A total of 570 miles of pipe will be laid at a maximum depth of 6,000ft in the Caribbean Sea (Gooding, 2005). This project is still in the negotiation phase.

The analysis provided so far in this chapter is directly related to the findings of this study. However, there other programmes and institutions that were initiated to address the overall management of the marine environment. These are reviewed below in the context of the Caribbean Sea and the SIDS.

7.3.6 Proactive Responses to SIDS Vulnerability

It is recognised that Small Island Developing States worldwide are environmentally and economically vulnerable which severely limits their capacities to respond to incessant disasters and sustainable development. In 1994 as a response to these needs, the Barbados Plan of Action (BPOA) was adopted to place SIDS throughout the world in a special category with special needs (United Nations General Assembly, 1994; UNEP, 2004b). By 2005, the BPOA had two major reviews to determine the progress made regarding SIDS and their sustainability. The BPOA and its subsequent reviews are summarised in Table 7.3.

Table 7.3: A Summary of the BPOA and follow up Reviews

Framework	Agreement	Comments
1994 Barbados Plan of Action	Major priorities were defined. These include: 1. International cooperation to assist SIDS in capacity building and transfer of technology among others 2.Managing natural and environmental disasters 3.Implement sustainable fisheries management 4. Establish effective and sustainable waste management schemes 5.Toursim resources – promote sustainable tourism and diversity the tourism product in SIDS 6. Energy Resources - develop and promote efficient use energy, including indigenous sources and renewable energy. 7. Respond to the threats of climate change and sea level rise 8. Sustainable Management of coastal and marine resource 9. Sustainable Management of freshwater resource 10. Protect biodiversity resource	According to the Commonwealth Secretariat (2004) the BPOA has remained largely unimplemented since its inception in 1994
2002 World Summit on Sustainable Development (WSSD) Johannesburg Meeting	At the WSSD a recommendation was made that "a full and comprehensive review of the implementation of the Barbados Programme of Action for the Sustainable Development of Small Island Developing States should take place in 2004" (Commonwealth Secretariat, 2004)	The review sought a renewed political commitment by all countries to the Programme of Action. It also focused on practical and pragmatic actions for further implementation, including mobilisation of resources and assistance for SIDS (Commonwealth Secretariat, 2004)
2005 Mauritius Declaration	The BPOA was reaffirmed as the blue print providing framework for sustainable development in the SIDS. It was agreed that these vulnerabilities will continue to escalate unless immediate steps are taken (UNEP, 2005b). Also the challenges of small islands, their problems of integration into the global economy, and the need to support the programmes were reiterated	The Mauritius Strategy (UNEP, 2005a), which represents proactive measures to further implement the Barbados Plan of Action (BPOA), and the Mauritius Declaration (UNEP, 2005a), aimed at reinforcing commitment at the political level were adopted.

In the Caribbean, many initiatives are being taken (such as those highlighted in this Chapter). However, the BPOA remains largely unimplemented at a regional level. In 2005, at a meeting for the BPOA +10 in Mauritius, Jamaica's Minister of Land and Environment, Dean Peart conceded *"We are nowhere near where we are supposed to be in terms of the implementation of the BPOA"* (Davidson, 2005).

7.3.7 Institutional Response to Marine Management of the Caribbean Sea

The Caribbean Environmental Programme (CEP) was initiated in 1976 by the United Nations Environment Programme at the request of the Governments of the Wider Caribbean Region (UNEP/CEP, 2004a). UNEP/CEP provides support for the countries within the Wider Caribbean region. Its main functions include:

- Providing assistance to all countries in the region and recognising the special situation of the smaller islands.
- Coordination of international assistance activities in the region.
- Strengthen existing national and subregional institutions.
- Technical co-operation in the use of the region's human, financial and natural resources.

UNEP/CEP operates from the Caribbean Trust Fund (CTF), which is funded through voluntarily contribution by its members (Governments in the Wider Caribbean). How much of the pledged contribution are paid into the fund each year is not known. In 2004, available information for pledges showed that France was the largest donor followed by USA and Venezuela respectively (UNEP/CEP, 2004b). France and USA donate on behalf of their respective dependencies. Pledge amounts are shown in Figure 7.5.

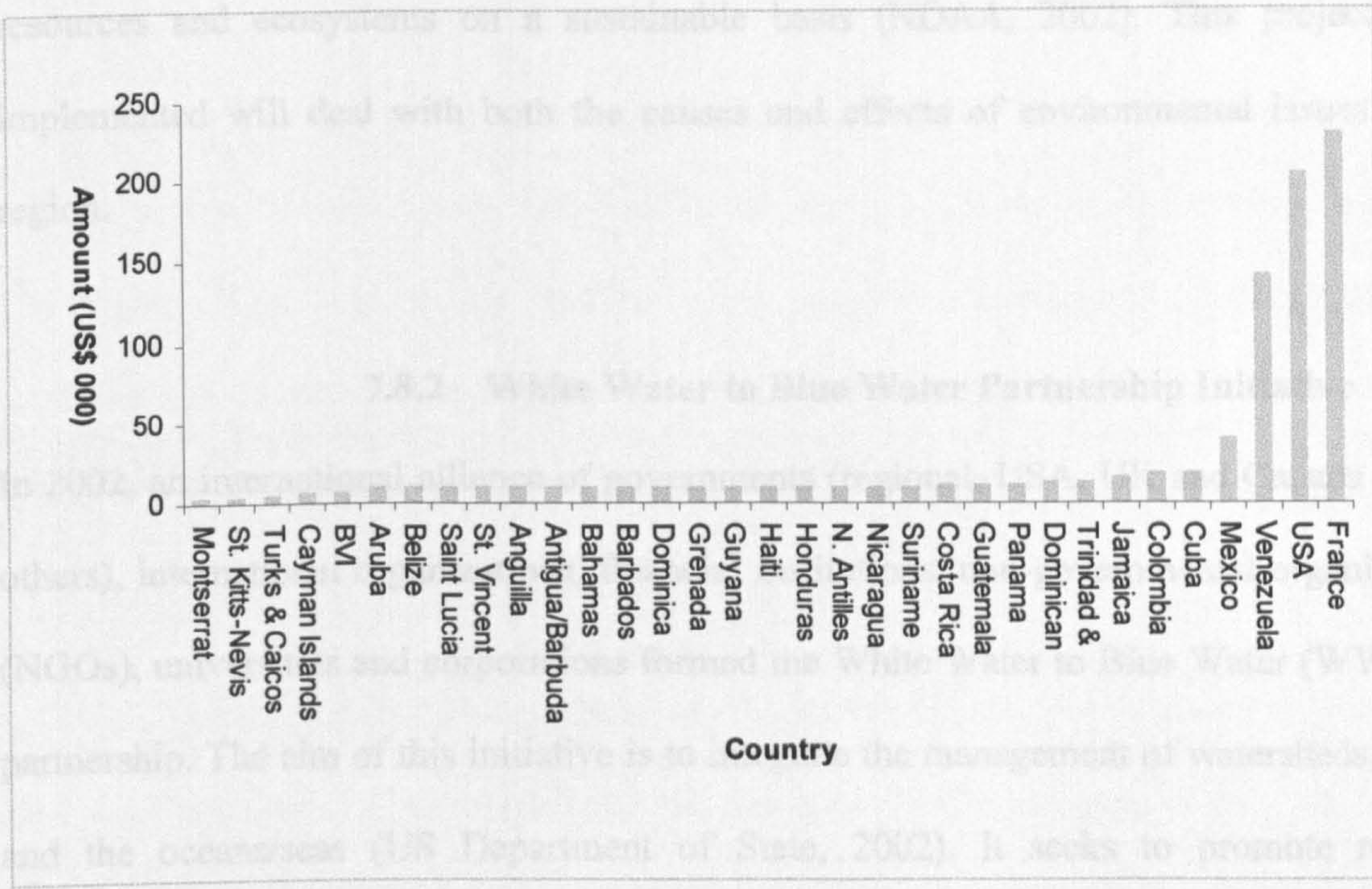


Figure 7.5: The Contribution made to the Caribbean Environmental Fund in 2004. Compiled using information from UNEP, (2005). France and the USA donate to this fund on behalf of their territories in the Caribbean

7.3.8 Existing Programmes for the Caribbean Sea

Currently there are a number of existing programmes for the Caribbean. Some are for the Wider Caribbean, which are the Caribbean Sea and Gulf of Mexico and others are for the Caribbean Sea. The programmes that include the Caribbean Sea are discussed below.

7.8.1 Integrated Watershed and Coastal Area Management

At a regional level, NOAA, UNEP and selected islands in the Caribbean have jointly undertaken the Integrated Watershed and Coastal Area Management (IWCAM) project to respond to issues of terrestrial and marine degradation in the region. The objective of the project is to strengthen the capacity of the participating SIDS countries (Antigua and Barbuda, Barbados, Cuba, Dominican Republic, Dominica, Grenada, Haiti, Jamaica, St Kitts, St Lucia, St Vincent and the Grenadines and Trinidad and Tobago) to implement an integrated approach to the management of watersheds and coastal areas. It is expected that this project will enhance the capacity of the countries to plan and manage their aquatic resources and ecosystems on a sustainable basis (NOAA, 2002). This project when implemented will deal with both the causes and effects of environmental issues in the region.

7.8.2 White Water to Blue Water Partnership Initiative

In 2002, an international alliance of governments (regional, USA, UK and Canada among others), international organizations, financial institutions, non-governmental organizations (NGOs), universities and corporations formed the White Water to Blue Water (WW2BW) partnership. The aim of this initiative is to integrate the management of watersheds, coasts and the oceans/seas (US Department of State, 2002). It seeks to promote regional cooperation and strengthen the developing countries capacity to address land based sources of marine pollution (e.g. sewage and industrial discharges, agricultural runoff, etc.). It also aims at promoting sustainable fisheries, agriculture and forestry practices and address the challenges associated with tourism and degradation of coastal areas (US Department of State, 2002). This project was officially launched in 2004.

This initiative began with the Wider Caribbean (Caribbean Sea and Gulf of Mexico) but it is expected that the outcomes in the Caribbean will serve as a blueprint for future efforts in Africa and the South Pacific (US Department of State, 2002). There are four thematic areas of this initiative, which are Integrated Watershed Management, Marine Ecosystem Based Management, Sustainable Tourism and Environmentally Sound Marine Transportation. The WW2BW initiative is seeking to bring together the existing programmes in the region under a single programme in order to avoid duplications. All the SIDS in the Caribbean Sea are involved in this initiative except Cuba. Therefore, impacts on the Caribbean Sea that emanates from Cuba are not addressed within this initiative.

7.8.3 The Caribbean Sea as a Special Area

In 2002, Governments in the region devised the Caribbean Sea Initiative, which was an attempt to declare the sea a Special Area in the context of Sustainable Development in the UN system. The aim of this initiative was to seek a constituted international legal instrument to address all the major uses and impacts on the Caribbean Sea. This was done within the overarching objective of sustainable development within the BPOA (Girvan, 2002).

In 2002, the Caribbean Sea initiative was presented to the UN General Assembly for approval however, the UN Assembly did not approve this because of lack of facilities especially in the leading maritime states (Girvan, 2002). A compromise resolution deal was negotiated, calling for Integrated Management of the Caribbean Sea. The initiative to receive special status for the Sea is still being pursued by the Association of Caribbean States on behalf of its members.

7.4 Discussion

The analyses provided in this chapter regarding the responses in the region to threats of marine degradation seem to suggest that marine management is still heavily influenced by political alignment and colonial alliances (Chapter One). Most of the programmes are sustained by funding from past colonial authorities. This political bias impedes the full integration of Caribbean states, a component that is vital to pursue integrated marine management. The analysis also shows that majority of the response programmes and management efforts are CARICOM based initiatives, which involve only some of the islands in the region. Cuba is not part of many of these programmes despite contributing to many of the issues in the Caribbean Sea such as pollution (Chapter Two and Appendix One). This exclusion of Cuba is mainly because of pressure from its political adversaries.

In addition, the dependent islands of France, the United States of America, United Kingdom and the Netherlands, operate in a league of their own even though these states use the geographical region and resources – the Caribbean Sea. These dependent states do not participate or are not integrated into many of the programmes. This lack of participation, which is vital to managing the marine environment, results in compromised and ineffective management.

The region wide initiatives such as the IWCAM is aiming to conduct holistic management of the watershed and coastal area but has so far aligned itself to mainly CARICOM member islands. If efforts are not made to incorporate the other islands, this project may become just "another" project and the Caribbean Sea will be its casualty. Marine management of the Caribbean Sea cannot be addressed without integrated cooperation from all the islands and this cooperation must overcome political, linguistic and cultural differences.

The UNEP/CEP has been less effective in integrating these countries into effective marine management. To date, the UNEP/CEP has aligned many of its programmes along existing traditional political entities such as CARICOM. In many cases, UNEP/CEP executes programmes that relied mainly on external funding. These funds are often granted with given clauses such as which countries should benefit. For example, Cuba is mostly excluded from benefiting from programmes, which are funded by donor countries. The political agenda of these donor countries and the alliances of the islands have resulted in a web of disconnected programmes and environmental management disparities. If common agenda is sought, these efforts will be able to deal with the environmental problems more effectively and invariably address the region's vulnerability.

The analysis shows that legal obligation is a major concern in the region. If commitment to marine management is measured by treaty obligations, this region is in a serious predicament. The analysis showed that many islands have not ratified many of the necessary protocols and conventions, which can aid marine management. There are cases where islands are signatory to the protocols but the time lag between signature, ratification and implementation are long, for example the LBS Protocol (Table 7.1). This problem exists for the dependent islands as well. Many of the "parent" countries have not required their dependent islands to become obligated to many of these treaties. Therefore, it seems to suggest that the commitment is absent. In many cases, for example oil related protocols (Table 7.1), many of the parent countries, despite being party to the treaties, have not signed their respective dependent territories to these treaties. Overall, there is a wide disparity of ratification rate in the region's SIDS (Table 7.2).

Inadequate funding for marine management is a major hurdle in the region as shown by the paltry amounts being donated to the CTF. Besides GEF funding, the majority of the monetary resources that enter the Caribbean for environmental management and conservation are donated in the form of grants, mostly from the U.S.A (USAID), U.K (DFID), EU (LOME 1V) and Canada (CIDA). These funds have facilitated a number of projects to assist in many management initiatives. However, most of these funds are for short termed projects with limited commitment. In most cases, these projects require consistent funding and commitment in order to alleviate the degradation of the marine environment. Generally, many of these programmes begin with an initial core group of countries with the intention of incorporating others but many of the programmes end without achieving the latter. The voluntary contribution method of the CTF has demonstrated the low level of commitment from Governments within the region to deal with the environmental problems. Inadequate financial resources have hindered the capability and potential of the UNEP/CEP in adequately addressing environmental management at a regional level.

In terms of fisheries management, it is evident that the concerted actions needed to arrest the decline of fisheries have fallen to the wayside in the Caribbean's quest for sustainability. It is evident that some islands have improved their practices however they cannot solve the fisheries issues (Chapter Two, Three and Four) in isolation rather more integrated management is needed.

The analysis shows that the region is responding to the high reliance of fossil fuels by promoting sustainable energy uses. However, if sustainable energy translates to reduced consumption of fossil fuels, then the SIDS have not made significant progress with this goal. Collectively, total fossil fuel usage has increased in the SIDS. The same trend is evident in the individual islands (Chapter Three). Therefore, a more concerted and collective effort is needed by the SIDS in the region.

In terms of proactive responses, the initiative such as the BPOA was a well-intentioned effort to deal with SIDS vulnerability. However, it lacks the necessary jurisdictional power needed for its successful implementation. Its non-binding principles allow for manoeuvres and the reviews highlight its meagre achievements after 10 years from its conception.

Overall, it is evident that there are active programmes in the Caribbean, which are attempting to address the problems highlighted in this study. However, most of these programmes have stopped short of a holistic marine management of the Caribbean Sea.

7.5 Conclusion

Collectively, there are many responses regarding management of the marine environment. However, these responses are still dictated by political bureaucracy and alliances, which stemmed from lack of cooperation and high dependence on extra regional funding. Thus, ecosystem management of the marine environment is not being seriously considered and is often compromised. The quest for sustainability continues to elude the Caribbean region and the SIDS continue to be regarded as special cases.

Based on the analysis, the effective management of the Caribbean Sea requires firm political commitment and a clearly defined ecosystem strategy. The focus of the following chapter will be to discuss sustainability of the region and provide recommendations for management.

CHAPTER EIGHT

8.0 SIDS, SUSTAINABILTY AND THE CARIBBEAN SEA

8.1 Introduction

In general, islands are systems that are faced with limited resource availability, tenuous resource security and limited economic options. While these issues are not unique to the Caribbean SIDS it is evident from this study that sustainable management of the environment is immediate for the islands and the Caribbean Sea. In this chapter, sustainable management in the context of SIDS and the Caribbean Sea will be discussed and recommendations will be made in an effort to support such management of the Caribbean Sea.

8.2 Sustainability in the Caribbean Sea: current progress and future implications

Internationally, 1972 was an important year in the environmental calendar, because it culminated in the vivid awareness of the declining natural wealth of the earth marked by the Stockholm Convention. Twenty years later in 1992, the world population gathered yet again to comment on the still declining resources and efforts were made to arrest the problem. Sustainable Development was defined and Agenda 21 was developed as a "blue print" to achieving sustainable development by sustainable management of the resources. In 1994, SIDS were given special status (Chapter Seven). It was agreed that economic progression in the SIDS are inter-related with sustainable management of the environment (UNEP, 2004b). Eleven years later, this study shows that sustainable management of the region's environmental assets continues to elude the Caribbean SIDS. Sustainable management remains a simple concept, "of maintenance of the resources to meet the needs of present generation without compromising the ability of future generations to meet their own needs" (WCED, 1987). However, this study has illustrated the difficulties in applying this concept in the Caribbean SIDS, let alone achieving any plausible outcomes. Overall, the SIDS has made little progress in managing its marine environment.

This study shows that the region is still "development-oriented" and many practices in the SIDS are not in tandem with the ethos of sustainability. It is also evident that the SIDS are very disjointed in their approach to environmental management. The region has failed to work collectively and their lack of cooperation in tackling environmental issues is further complicated by political rhetoric. It is obvious that each island standing alone cannot be sustainable and even more so, they cannot sustain the favourably economic progression necessary for the growing populations. Individually, they are unable to make suitable choices for sustainable management of the marine environment. These islands have not fully recognised the importance of the marine environment, which they rely on for economic development (Chapter Three). Although there are many programmes, it is evident that many do not extend to marine management and in cases where such initiatives are extended, all the countries are not integrated (Chapter Seven).

This inability to cooperate will be catastrophic especially with the onset of globalisation, trade liberalisation and loss of preferential market access. Therefore, in order for the region to fully embrace sustainable management of the Caribbean Sea, they must give equal recognition to all the facets for sustainability. This must include sustainable usage of resources, favourable water quality and maintaining habitat integrity of the sea, as shown in Figure 8.1.

These components must be regarded as synergies and dealt with equitably. If one is absent or compromised then like a three-legged stool (Barrow, 1995), it will fall over and prevent the region from achieving sustainable management of the Caribbean Sea.

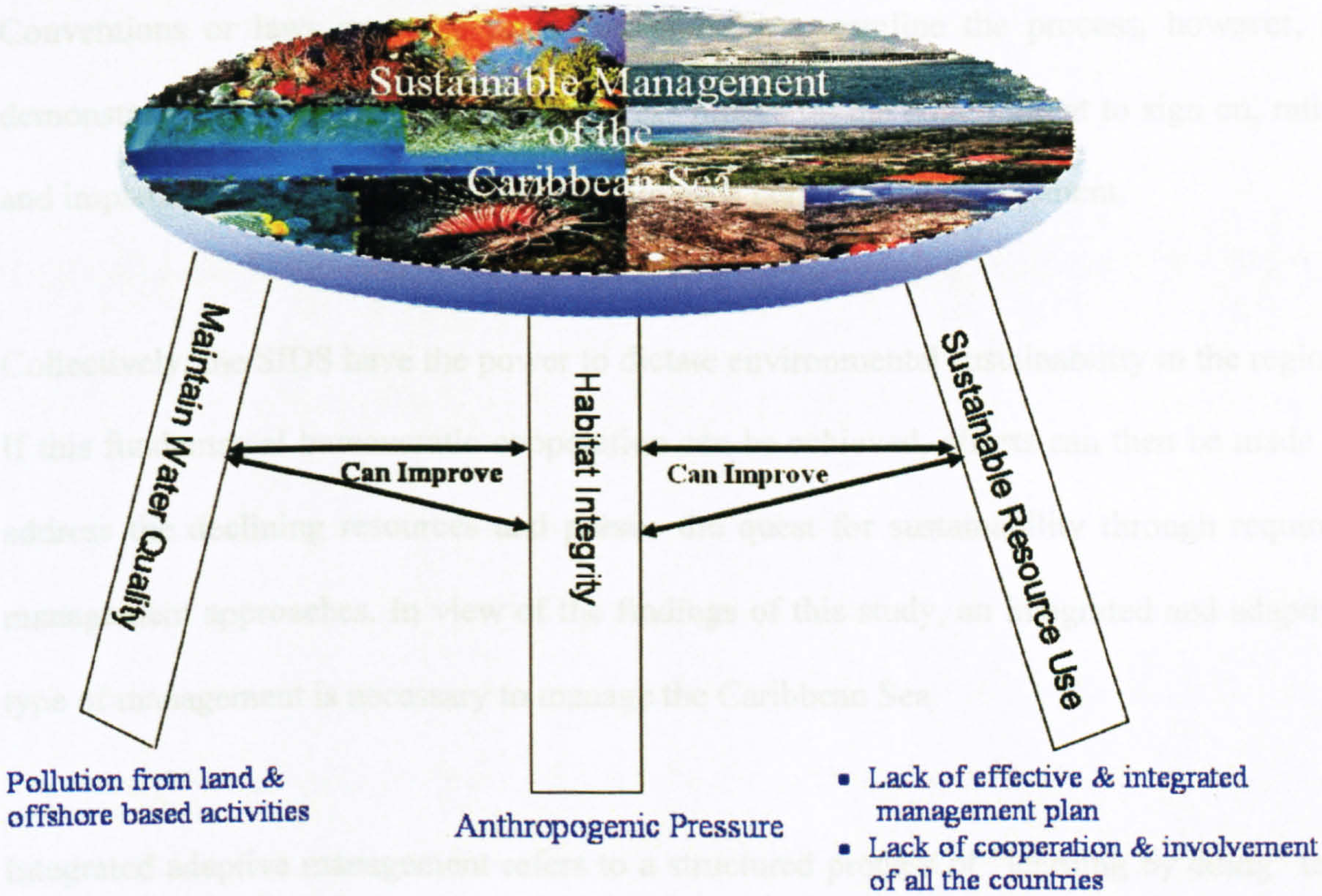


Figure 8.1: A Three- Legged Stool demonstration of the components required for Sustainable Management of the Caribbean Sea. The general issues that are affecting these components are shown in the diagram. The arrows show the inter-relationships of the components.

This study has shown that at present, water quality, habitat integrity and sustainable resource usage are all compromised in the Caribbean Sea. Therefore, it is important that the region rethink its current management regime of this marine area.

8.3 Recommendations: Advocating Effective Marine Management of the Caribbean Sea

The environmental issues related to the Caribbean Sea is complex to address because it is a wide expanse of marine area with many stakeholders. This complexity makes it convenient for the governments in the region to ignore these important environmental issues. Even sound practices within their jurisdictions depend largely on the willingness to achieve environmental progress. Therefore, negotiations, awareness and cooperation are requisite features when striving to advance sustainable management of the sea.

Conventions or laws are very important and can streamline the process, however, as demonstrated in Chapter Seven, their success hinges on the commitment to sign on, ratify and implement the principles set forth within each convention or agreement.

Collectively, the SIDS have the power to dictate environmental sustainability in the region. If this fundamental bureaucratic cooperation can be achieved, efforts can then be made to address the declining resources and pursue the quest for sustainability through required management approaches. In view of the findings of this study, an integrated and adaptive type of management is necessary to manage the Caribbean Sea.

Integrated adaptive management refers to a structured process of "learning by doing" that involves much more than better ecological monitoring and responses to unexpected management impacts. Adaptive management has been promulgated as an integrated, multi-disciplinary approach for confronting uncertainty in natural resources issues (Holling, 1978; Walters, 1997; Gunderson, 1999). It is adaptive because it recognizes that resource management will always change as a result of human interventions. These human interventions include but are not limited to new discoveries, shift in policies or new emerging uncertainties.

8.3.1 The Proposed Adaptive Management Strategy

An Adaptive Integrated Management Strategy is formulated for the Caribbean Sea to provide a framework for further development of specific policies, programmes and projects. The aim of this management approach is to minimise degradation and move towards attaining the management level that will procure sustainability. This proposed strategy for the sea must be continually modified and it must be resilient and flexible to adaptation because no environmental system is static. This is important because if there is no resilience in the ecosystem or flexibility among stakeholders, then resources cannot be managed adaptively (Walters, 1986).

The recommended components of the management strategy are as follows:

8.3.1.1 Policies

Even if an integrated effort is made to manage the Caribbean Sea, judicial powers must be consistent with the required level of enforcement. Some observers believe that judicial limits on public enforcement powers may result in traditional enforcement agencies unable to provide a completely adequate response to the environmental degradation which may result from non-compliance (Russell *et. al.*, 1986; Harrington, 1988; Russell, 1990). This problem exist in the region therefore, policy makers in the Caribbean must overcome this barrier through cooperation, restructuring and the use of common policies. Based on the results of this study, it is evident that there are major economic and environmental activities that require an integrated regional approach type of management. These include fisheries, tourism and pollution among others. In view of this need, the following policies should be devised for the SIDS and the Caribbean Sea:

1. A common fisheries policy, which should be informed by the current knowledge about the habitats, species targeted, catch rates and landings. This should also allow for quota systems, along with gear and trap restrictions and other management techniques. The FAO Code of Practice for Responsible Fishing (FAO, 1995) should be used as a guideline.
2. A common cruise tourism policy with an implementation of guidelines and rules for waste and sewage disposal by vessels.
3. A common waste policy should be initiated to ensure that waste generated by the countries is dealt with in a manner that prevents it from reaching the

marine environment. This is necessary in order to reduce ecosystem damage. Capacities to accommodate and disposed of waste for maritime traffic are important in the region. This is vital in avoiding the indiscriminate disposal of wastes in the marine environment.

4. A common agricultural policy should be incorporated into each island policy plans. This policy will be implemented at a local level with a regional objective.
5. A common sewage policy aimed at minimising the effects of sewage on the marine environment. All the islands must address the issue of untreated and/or inadequate treatment of sewage.
6. A common policy to address pollution from ships, involving stringent measures for ballast water and bilges. This is vital because of the threat posed on the marine environment from invasive species and pollution. A few countries have been alerted by the introduction of exotic species found in marine areas (Kairo and Ali, 2003). This is a serious issue and should be tackled with increased research and awareness. Efforts should be made to secure a ballast water programme for the Caribbean Sea, similar to those that exist for other regions such as Asia/Pacific and Eastern Europe (Global Ballast Water Management Programme, 2005)

These policies made at the sea/regional level can then be implemented through formulated programmes and projects in the region. An example of this tier approach is illustrated in Figure 8.2.

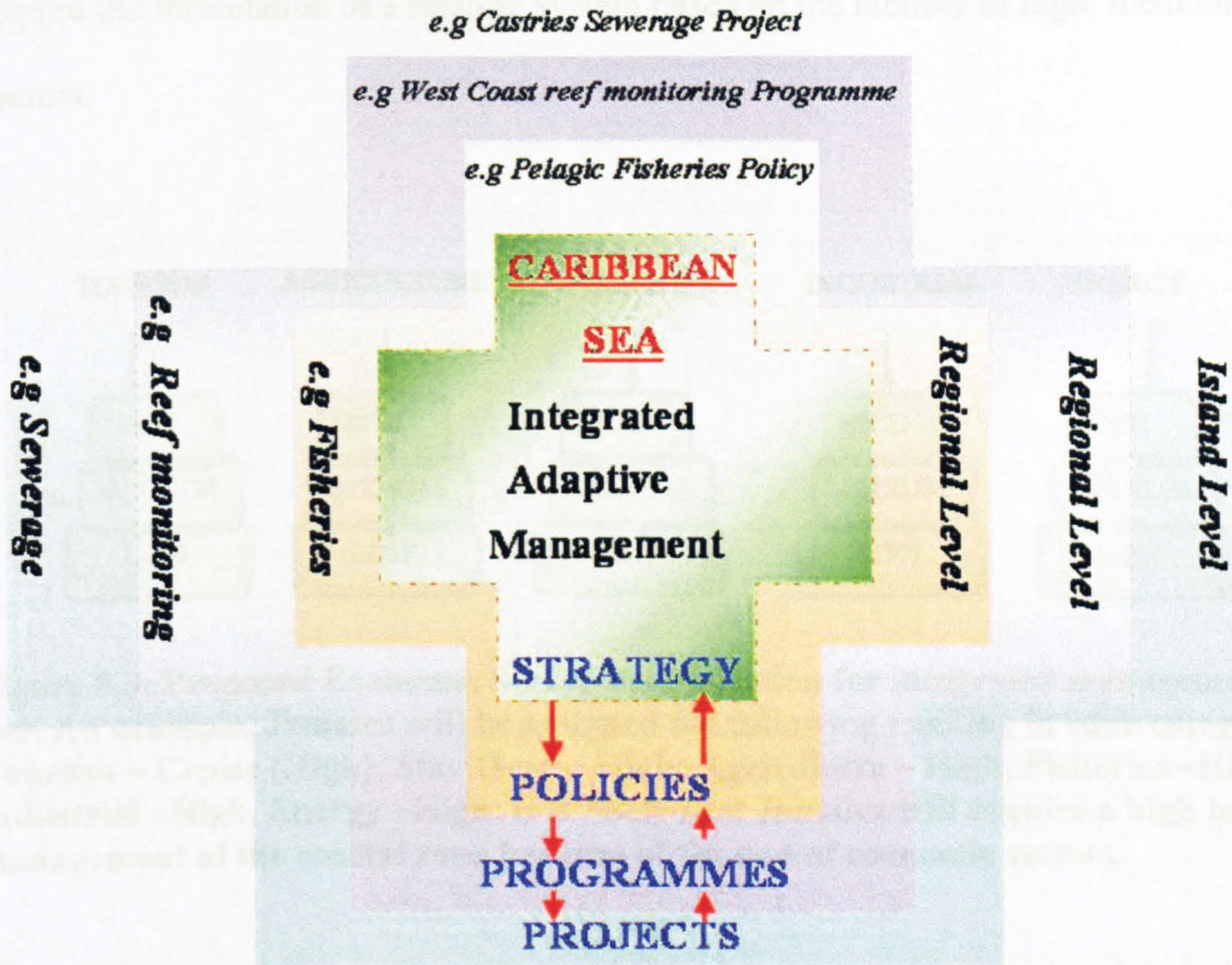


Figure 8.2: Example of the Proposed Tier Approach to achieving integrated management. It shows examples of the type of policies (pelagic fisheries policy) devised at a regional level. These policies are further divided into programmes (reef monitoring) which are done at a regional level. These programmes are further divided into projects which are implemented at an island level

8.3.1.2 Economic Sectors

As demonstrated in Chapter Three, the size of the economic sectors varies within the islands. Therefore, islands should be grouped for each economic sector depended on their level of development as shown in Figure 8.3. The assigning of the islands sectors into groups will be informed by the devised ranking provided in Chapter Three (Table 3.11 pg. 86). This method will assist in devising water quality monitoring programmes for the sea.

Templates for coastal integrated management should be devised targeting the scale of management (high, medium and low) required. Each island should be assigned one of these categories of coastal templates. The assigning of the categories to the islands will require the formulation of a ranking system based on the number of high, medium and low sectors.

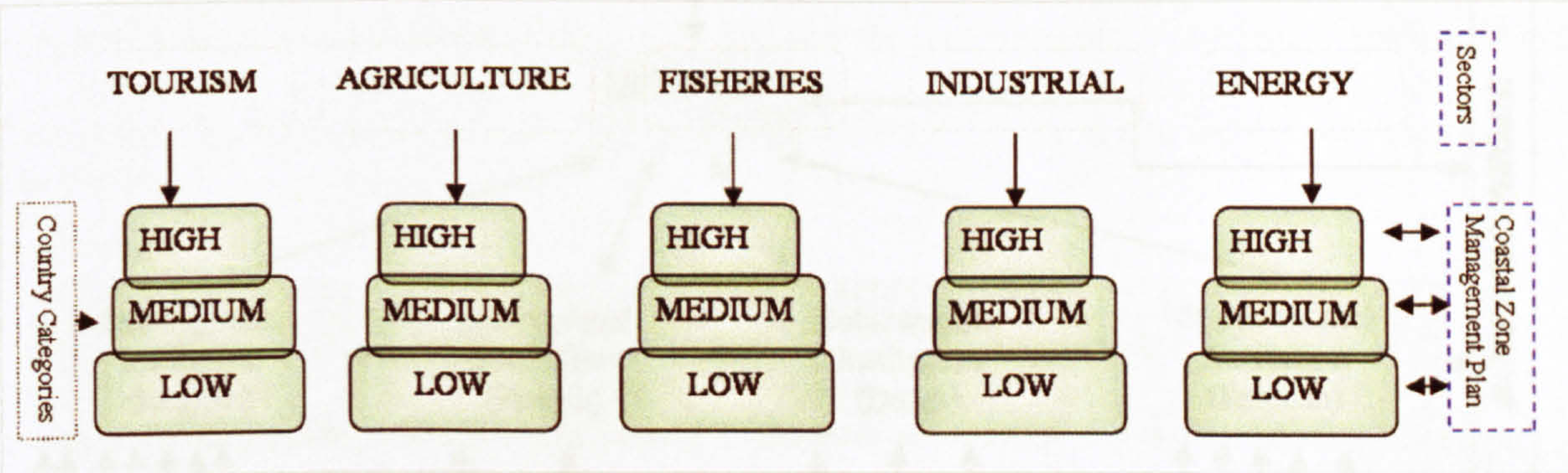


Figure 8.3: Proposed Economic Sector Prioritization for integrated management of the Sea. An example, Jamaica will be assigned the following ranking in each category. Tourism – Cruise (High), Stay Over – High; Agriculture – High, Fisheries –High, Industrial –High, Energy –High. It is likely that Jamaica will require a high level of management of the coastal zone because of the size of economic sectors.

8.2.1.3 Institutional

Agreed cooperation and common policies require efficient and integrated institutional mechanisms. This must involve all islands and efforts must be made to overcome language and cultural barriers. The Caribbean is a mutli-lingual basin therefore, a four-tiered approach with top-down, bottom-up and horizontal information flow will be useful and should be considered. This is illustrated in Figure 8.4. The UNEP/CEP has provided valuable assistance to the region and should be empowered to play a more central role in managing the sea. This will better facilitate the programmes in the region. It will also reduce the duplication of projects and promote ecosystem based programmes. These institutions are already in existence, for example, CARICOM can be used for the English speaking Caribbean countries. In terms of collaboration, there must also be horizontal flow of information and cooperation, as language and islands alignment must be seamless in order to deal with the management of the Caribbean Sea.

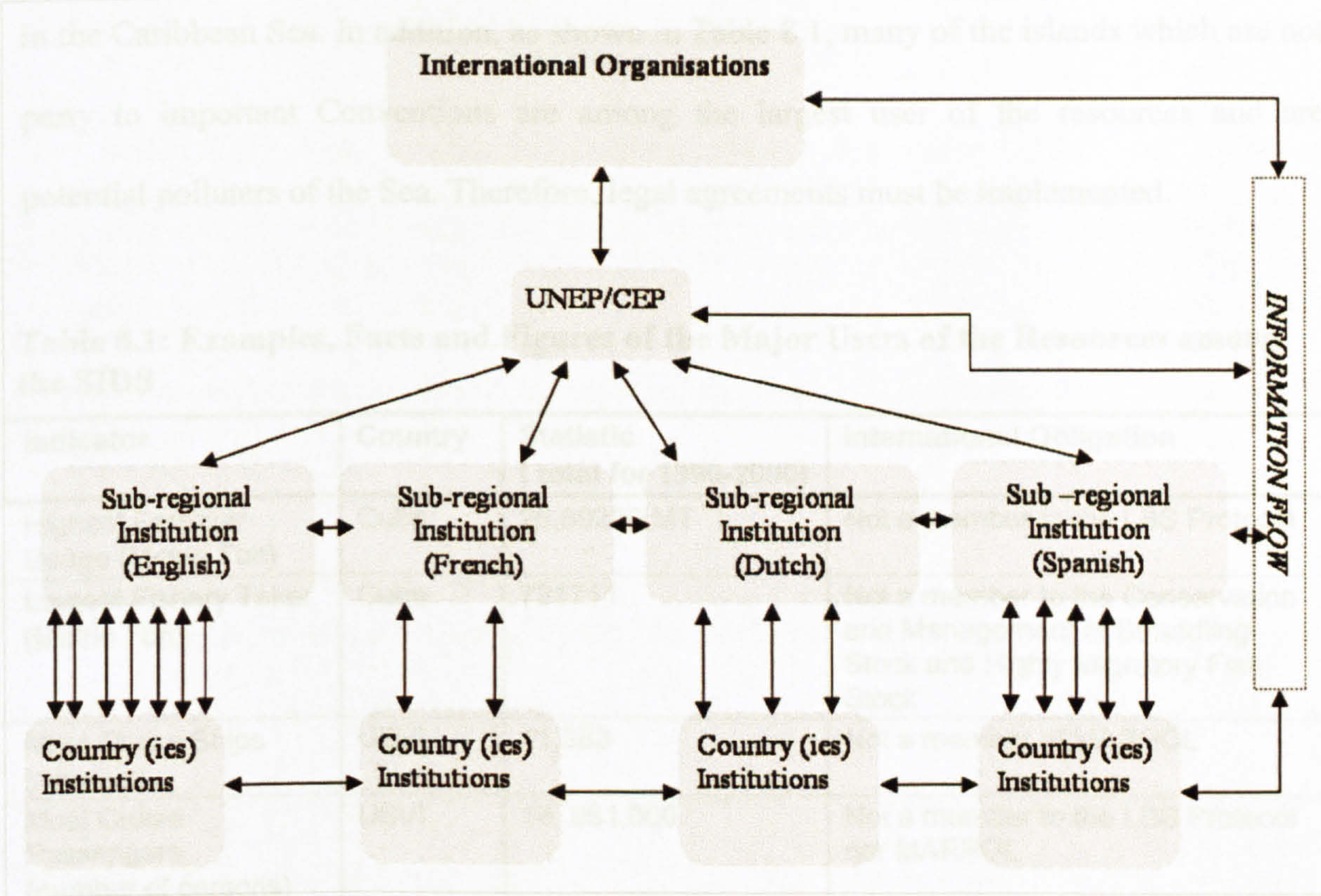


Figure 8.4: Proposed Institutional Structure for Integrated Management of the Sea. For example, information regarding all the devised policies programmes and projects implementation are reported to a sub- regional institution (e.g CARICOM) which is then fed to the UNEP/CEP. This will allow UNEP/CEP to better negotiate with international organisations. Islands must also develop cooperation and allow for flow of information

8.3.1.4 Obligations

Conventions discussed in Chapter Seven, which are related to marine and land based pollution and activities, should be ratified and implemented by all the countries within the Caribbean Sea Basin. This will provide a common base upon which the region can build sound management regimes. Particularly, the dependent islands must be part of the treaties. This would be particularly useful as many of the parent countries are moving their unsustainable practices offshore. For example, the U.S.A has implemented hefty fines for pollution along its coastline. This will likely result in increased oil related activities in its dependent islands (USVI and Puerto Rico) because the laws are more relaxed in the region. Also, the USA is currently reviewing harsher legislation for sewage and wastewater from cruise ships which are being dumped in coastal waters (Pain, 2005). If this is passed and if the region does not take a stand like USA, then there is likely to be an increase in dumping in the Caribbean Sea. In addition, as shown in Table 8.1, many of the islands which are not party to important Conventions are among the largest user of the resources and are potential polluters of the Sea. Therefore, legal agreements must be implemented.

Table 8.1: Examples, Facts and Figures of the Major Users of the Resources among the SIDS

Indicator	Country	Statistic (total for 1990-2000)	International Obligation
Highest Fertilizer Usage (Metric Ton)	Cuba	26,69200 MT	Not a member to the LBS Protocol
Largest Fishery Taker (Metric Ton)	Cuba	731711	Not a member to the Conservation and Management of Straddling Stock and Highly Migratory Fish Stock
Most Cruise Ships (Amount)	USVI	11,383	Not a member of MARPOL
Most Cruise Passengers (number of persons)	USVI	14, 961,000	Not a member to the LBS Protocol nor MARPOL
Highest Fossil Fuel User (barrels)	Cuba	727,240,320	Not Relevant These do not fall under any international obligations which are related to the marine environment. However, these would require the use of the Sea to transport supplies
Highest per capita User (barrels)	USVI	120	
Largest Oil Producer (barrels)	Trinidad & Tobago	572038380	

8.3.1.5 Finance

Chapter Seven highlights the problem of funding in the region. More financial commitment is required from the Governments and international organizations to manage the sea. The existing Caribbean Trust Fund should be revised, to ensure contributions from each island. It should set specific amounts of contributions and make these contributions mandatory. More available finances will empower the region to undertake long-term projects which are required to effectively manage the marine environment. This can also be used to meet the stipulation of funding agencies like the GEF in accessing grants for projects.

8.3.1.6 Standards, Monitoring Programmes and Data Collection

The increasingly high coastal development means that water quality and emission standards need to be taken seriously. Based on the current knowledge, common monitoring schemes should be devised and used by all the countries. Each country should have a regime for water sampling which must be based on the specific category of the economic sectors (Figure 8.3).

For example, high level countries in the tourism sector will have a higher frequency of samples taken. The monitoring sites and the parameters sampled will be based on spatial information, using land use information as conducted in Chapter Four for the case studies – Dominica, St Lucia and Curaçao.

Data collection should be an important priority, as this is the only way to further the understanding of the marine environment, while simultaneously providing information about environmental changes. Indicators should be developed to gauge the state of the environment, specifically pollution indicators. There should be a repository for data storage which should be made readily available to any country of the SIDS and other relevant stakeholders.

Too often, research and scientific communities are unable to access data to conduct studies. Therefore, measures must be instituted to allow for information flow while maintaining property rights.

8.3.1.7 Research

Integrated management is an ongoing process and resources should be prioritised to fulfil the research needs for ongoing management. New information regarding the Caribbean Sea's functioning and biodiversity should be continuously incorporated into this proposed management strategy. Importantly, decision makers must acknowledge that managing the sea should be an adaptive process, with policy making being an iterative process. They must acknowledges that there are uncertainties rather than static answers which should be reflected in the policies.

8.3.1.8 Public Awareness

This proposed strategy must have an element of ongoing public awareness campaigns and dialogues in order to succeed and to increase environmental awareness regarding the management of the Sea. These awareness programmes should be designed for both island and regional levels. Media agencies and educational institutions should be used to promote environmental awareness in the region. In addition, it is vital to recognise that stakeholders' dialogue and participation are essential.

8.4 CONCLUSION

This study brings a unique dimension to marine science of the Caribbean Sea. It provides a comprehensive demonstration of the problems and barriers that are affecting and hindering sustainable management from both the SIDS and regional sea perspectives. In addition, this study explored different approaches to indicate pressures on the Sea and demonstrates the challenges, that are facing the region in balancing the fragile ecosystem with economic development. It is illustrated in this study that the sea is under severe stress from anthropogenic activities and the current policies in the region do little to arrest the problem. There are no collective efforts and no evidence at integrated management.

Overall, the study shows the interdependencies between the people and the sea and proves that the Caribbean Sea is integral to the islands socio- economic development. This established link therefore, requires a shift from contingency and reactive management to necessity management. The region must make a concerted effort to realign and rethink our current actions regarding the management of the Caribbean Sea.

8.5 Recommendations for Future Work

This study has recommended a management strategy for the Caribbean Sea and provided spatial and empirical databases on the Sea and the SIDS, which was previously non-existent. However, there is a scarcity of data on various parameters of the marine environment. Such data are important to further our understanding and to provide information which can assist in managing the sea as a large ecosystem. Citing this fact, the following recommendations are made for future study:

a. The strategy recommended for the Caribbean Sea is a blue print and requires the formulation of various policies, programmes and projects.
b. The vulnerability assessment of the sea should be enhanced by incorporating empirical data such as oil measurements. Pollution intensity maps for oil and other chemicals should be derived from empirical data.
c. This study should be extended to include the South and Central American countries that border the Caribbean Sea. The large population and economies will likely increase the pressures on the Sea.
d. Empirical data need to be compiled on shipping and determine the effects of shipping intensities on the sea.
e. The application of the DPSIR/GIS used in this study should be extended to the other islands in this study.
f. Suitable locations for MPAs need to be established, based on the sea's ecosystem rather than the present confinement of MPAs within geo-political borders.

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APPENDICES

APPENDIX ONE

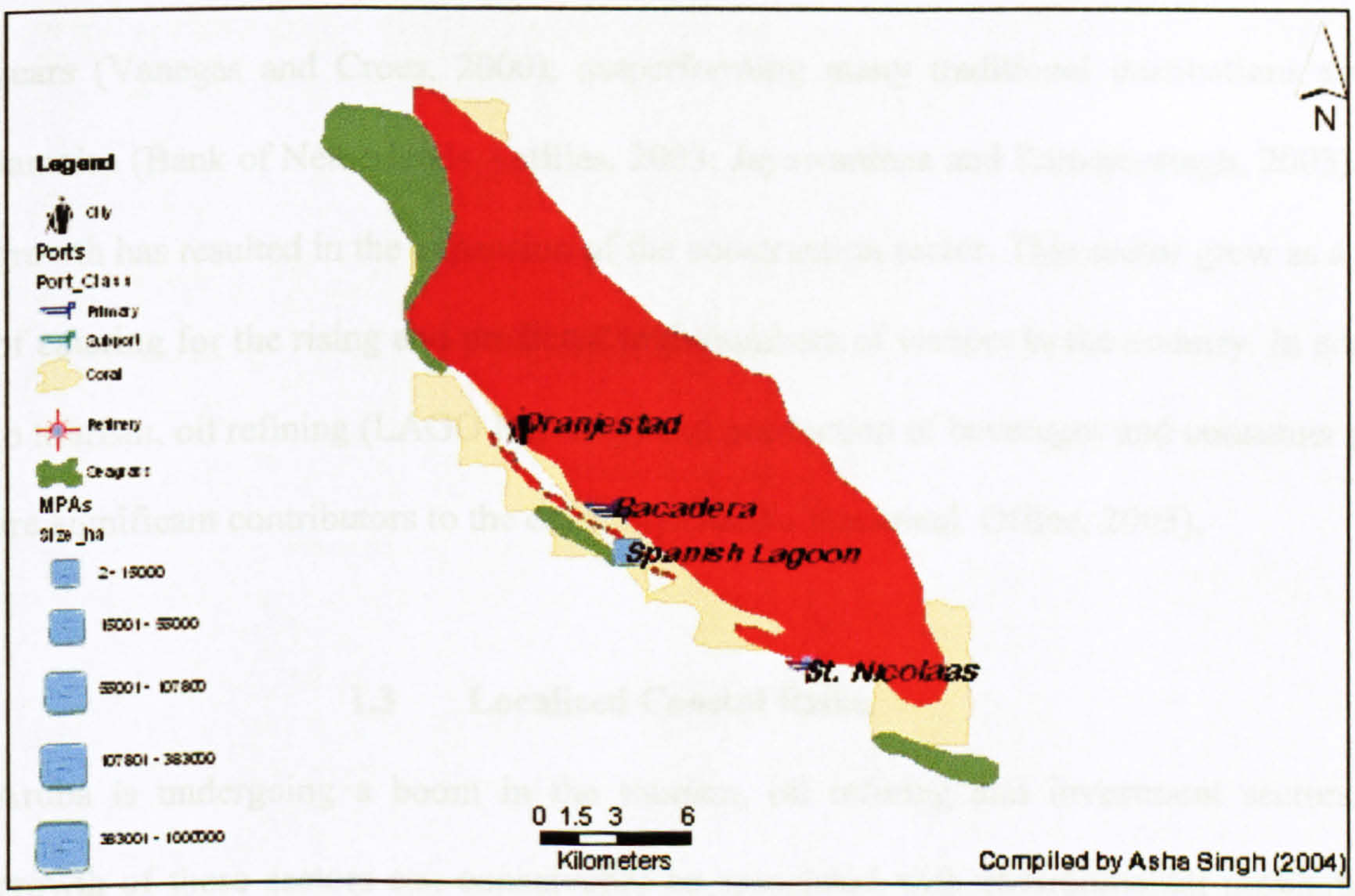
Island Profile[+], Statistical* and Spatial Results

+ Profile for Dominica, St Lucia and Curaçao is not presented in this Appendix, these are incorporated into the case studies presented in Chapter Four.

** The statistical data gathered for each profile are presented on the CD*

In this section, each island in the study area will be described individually within the context of general physiographic and pertinent environmental issues.

1. ARUBA



Area	**193 sq km**
Capital	**Oranjestad**
Population & Density	**Total 79333, 411/sqkm**
Location	**12^0, 30' N, 69^0, 58' W**
Language	**Dutch (Papiamento)**

Figure 1: Showing Features of Aruba

1.1 General Description

Aruba has been an autonomous member of the Kingdom of Netherlands Antilles since 1986 with a pending bid for independence (Thorndike, 1988). The island is divided into eight administrative regions and Oranjestad is the most populated region (PAHO, 1998). The island is flat, except for the northern area which is hilly, with the highest point being Mount Jamanota at 188 m (De Buisonje, 1974). Aruba has a coastline of 68.5 km, 200 NM maritime claims (CIA, 2004b), and a marine shelf of 1,140km^2 (Burke and Maidens, 2004a).

The island has a tropical climate with an average temperature of 28^{0}C all year round. Annual average rainfall is 395 mm (Travel Guide, 2002), which is regarded as very dry.

1.2 Economy in Perspective

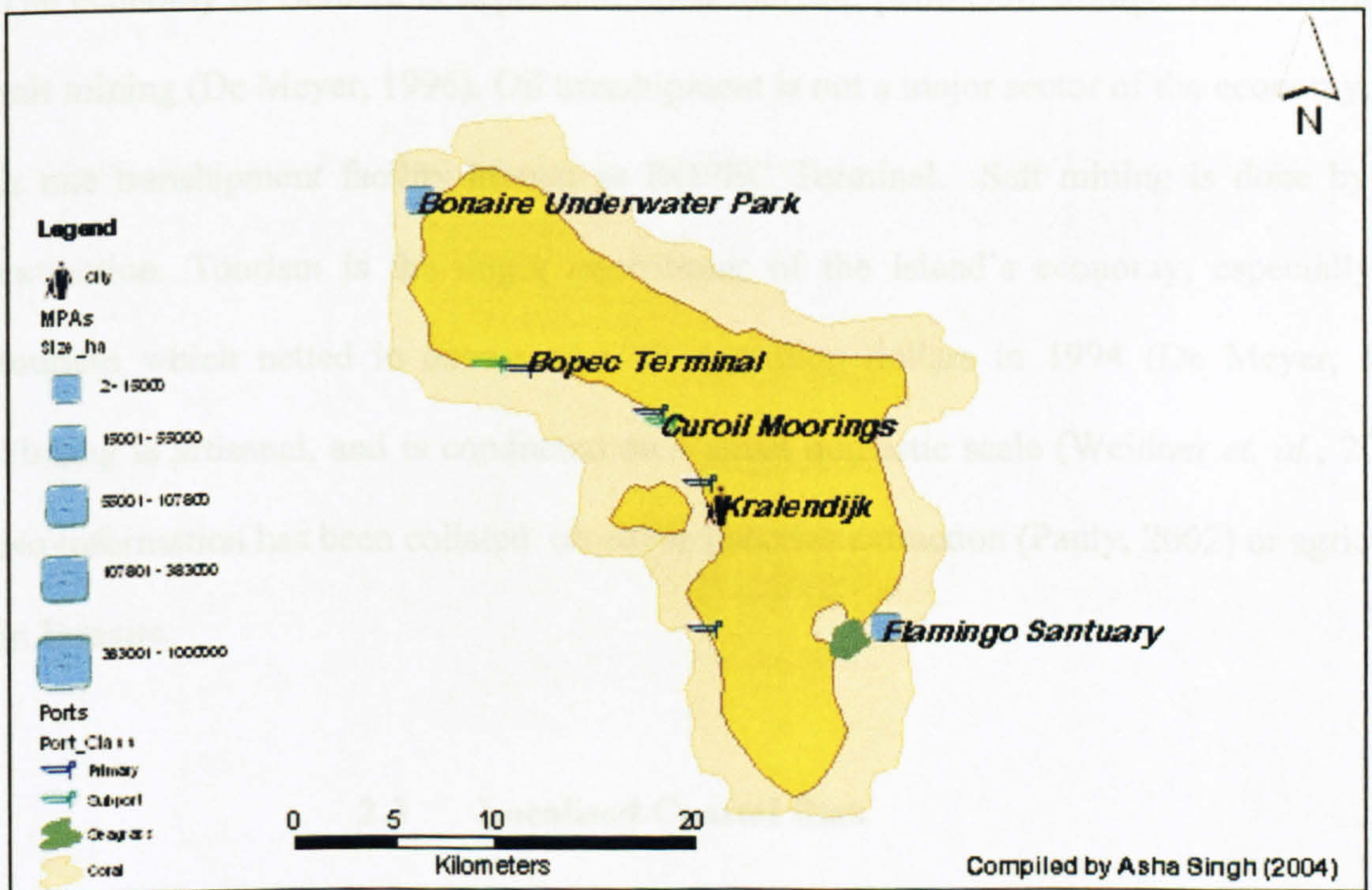
Aruba's main economic sector is tourism, which has increased rapidly over the last few years (Vanegas and Croes, 2000), outperforming many traditional destinations such as Jamaica (Bank of Netherlands Antilles, 2003; Jayawardena and Ramajeesingh, 2003). This growth has resulted in the expansion of the construction sector. This sector grew as a result of catering for the rising and predicted high numbers of visitors to the country. In addition to tourism, oil refining (LAGO Refinery) and production of beverages and consumer goods are significant contributors to the economy (Aruba Statistical Office, 2003).

1.3 Localised Coastal Risks

Aruba is undergoing a boom in the tourism, oil refining and investment sectors. The growth of these sectors can conceivably be associated with environmental problems and risk. There is however, no available information which this study can use to determine the present and/or foreseeable environmental problems which may emanate from these activities.

N.B: Statistical data presented on CD: Profile_1_Aruba

2. BONAIRE



Area	**288 sq km**
Capital	**Kralendijk**
Population & Density	**Total 11218, 39/sqkm**
Location	**12^0, 10' N, 68^0,15' W**
Language	**Dutch**

Figure 2: Showing Features of Bonaire

2.1 General Description

Bonaire, is a dependent territory of The Netherlands and forms part of a group of islands that make up the Netherlands Antilles. It is approximately 40 km long and 11 km wide at its widest point (Beets, 1972). Klein Bonaire, an uninhabited island, forms part of Bonaire. Bonaire is flat with its highest point being Bandaris Hill at a height of 241 m (Miller *et. al.*, 2003).

The climate of this island is semi-arid (Semmens-Pattengill, 1998) with little seasonal variation. It registers an annual rainfall average of 490.5 mm (De Meyer, 1996). There are two rainy seasons in Bonaire which occur during October to January and in the month of July. The average temperature is 29^0C (Bonaire Travel Guide, 2004).

2.2 Economy in Perspective

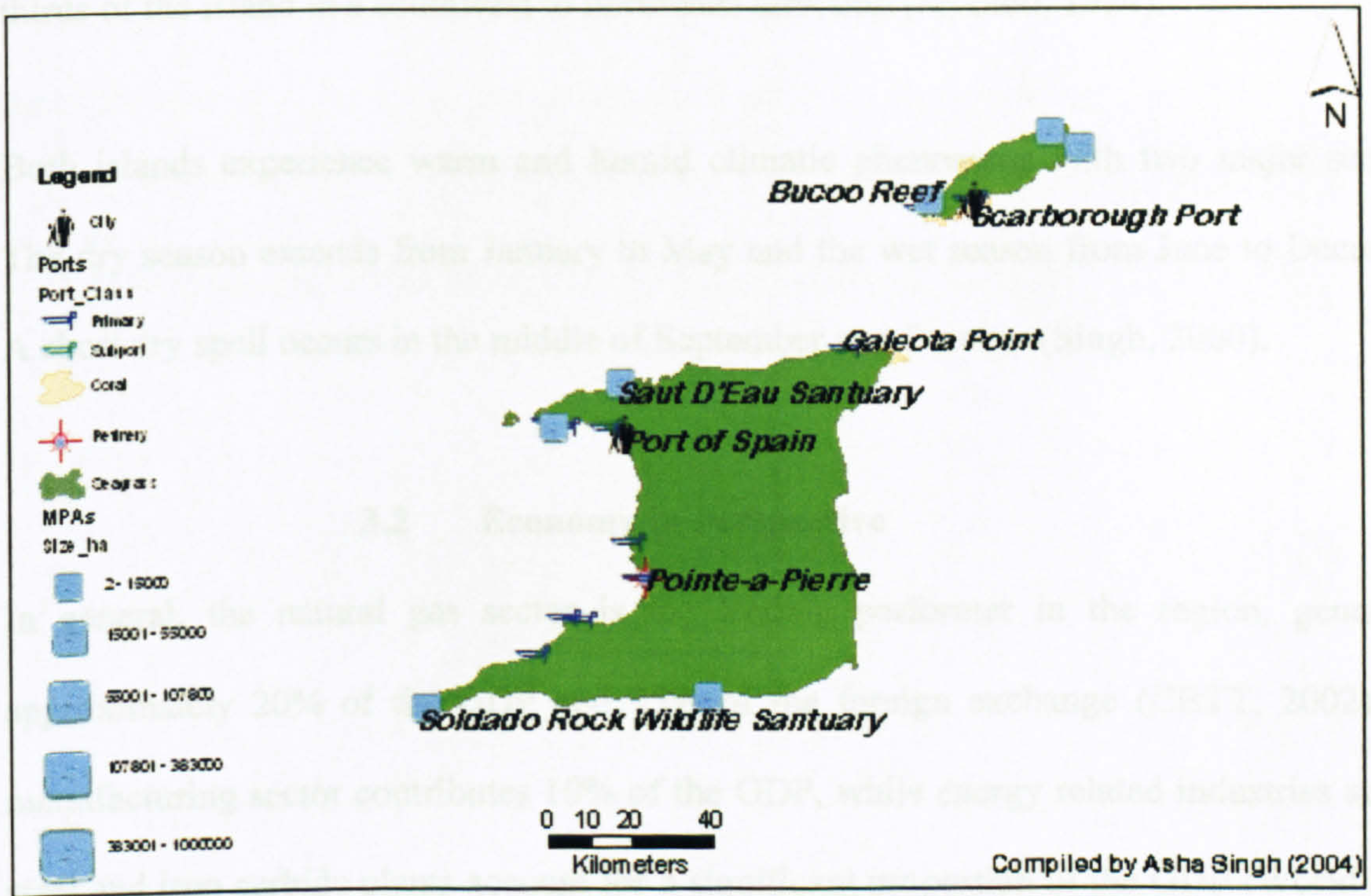
The economy of Bonaire is dependent upon tourism, petroleum storage, rice refining and salt mining (De Meyer, 1996). Oil transhipment is not a major sector of the economy, there is one transhipment facility known as BOPEC Terminal. Salt mining is done by solar extraction. Tourism is the major contributor of the island's economy, especially dive tourism which netted in excess of US$34 million dollars in 1994 (De Meyer, 1996). Fishing is artisanal, and is conducted on a small domestic scale (Weidner *et. al.*, 2001d). No information has been collated on either fisheries extraction (Pauly, 2002) or agriculture in Bonaire.

2.3 Localised Coastal Risk

Since 1979, waters within a 200 ft depth of the coastline were designated as a marine park (Dixon *et. al.*, 1993). The activities of the marine park are restricted in order to minimise damages to the existing coral reefs, seagrass and mangrove ecosystems. The high number of visitors to Bonaire has placed immense strain on the island's coastal resources. Scura and van't Hof (1993) noted that many of the dive sites which has an estimated carrying capacity of 250 000 visitors per year is often exceeded. In addition, coral damage from diving, anchoring, sedimentation and nutrient enrichment are issues of concern. There has been an increase in algal cover on the reef (Roberts and Hawkins, 1994) and it is attributed to the leaching of sewerage from the septic tanks of households, hotels and the coastal population. Poor construction practices and land clearance are identified as the causes of increased turbidity in the marine area.

N.B: Statistical data presented on CD: Profile_2_Bonaire

3. TRINIDAD AND TOBAGO



Area	**Trinidad 4 862 sq km, Tobago 300 sq km**
Capital	**Port of Spain and Scarborough**
Population& Density	**Total 1 255 000, 243/sqkm**
Location	**11^0, 00', N, 61 00 W**
Language	**English**

Figure 3: Showing Features of Trinidad and Tobago

3.1 General Description

Trinidad and Tobago is a twin island state located at the southern end of the Caribbean archipelago chain. Combined, the coastline is 362km in length (CIA, 2004t), with full maritime claims. According to Burke and Maidens (2004a), the total shelf area within the maritime claim is 24045 Km^2.

Trinidad features three mountainous ranges, the main range in the north extends to the east –west boundary and accommodates the highest point of the twin island state - El Cerro del Aripo at 940 m (Harcount and Sayer, 1996). The smallest mountain range is in the central part of the island and the other range is in the southern part of the island. The range in the south is characterised by low hills, undulating plains and swamps (Singh, 2000). Comparatively, the dominant topography of Tobago is mountainous, metamorphic and volcanic in structure (Thelen and Faizool, 1980). The main ridge covers approximately two thirds of the island in a southwest to northwest direction (Mootoo, 1984).

Both islands experience warm and humid climatic phenomena with two major seasons. The dry season extends from January to May and the wet season from June to December. A short dry spell occurs in the middle of September and October (Singh, 2000).

3.2 Economy in Perspective

In general, the natural gas sector is the leading performer in the region, generating approximately 20% of the GDP and 75% of the foreign exchange (CBTT, 2002). The manufacturing sector contributes 10% of the GDP, while energy related industries such as steel and iron carbide plants account for a significant proportion of the GDP (World Bank, 2002). Tourism, is a growing and important sector and is predominantly vibrant in Tobago (Holder, 2001). This sector is not proportionately as important in Trinidad and Tobago as in other Caribbean islands, because the other islands have a larger and more vibrant tourism sector. Other sectors such as agriculture, employ about 10% of the labour force (CIA, 2004t), with sugar and its by-products accounting for most of the agricultural exports of Trinidad (CBTT, 2002).

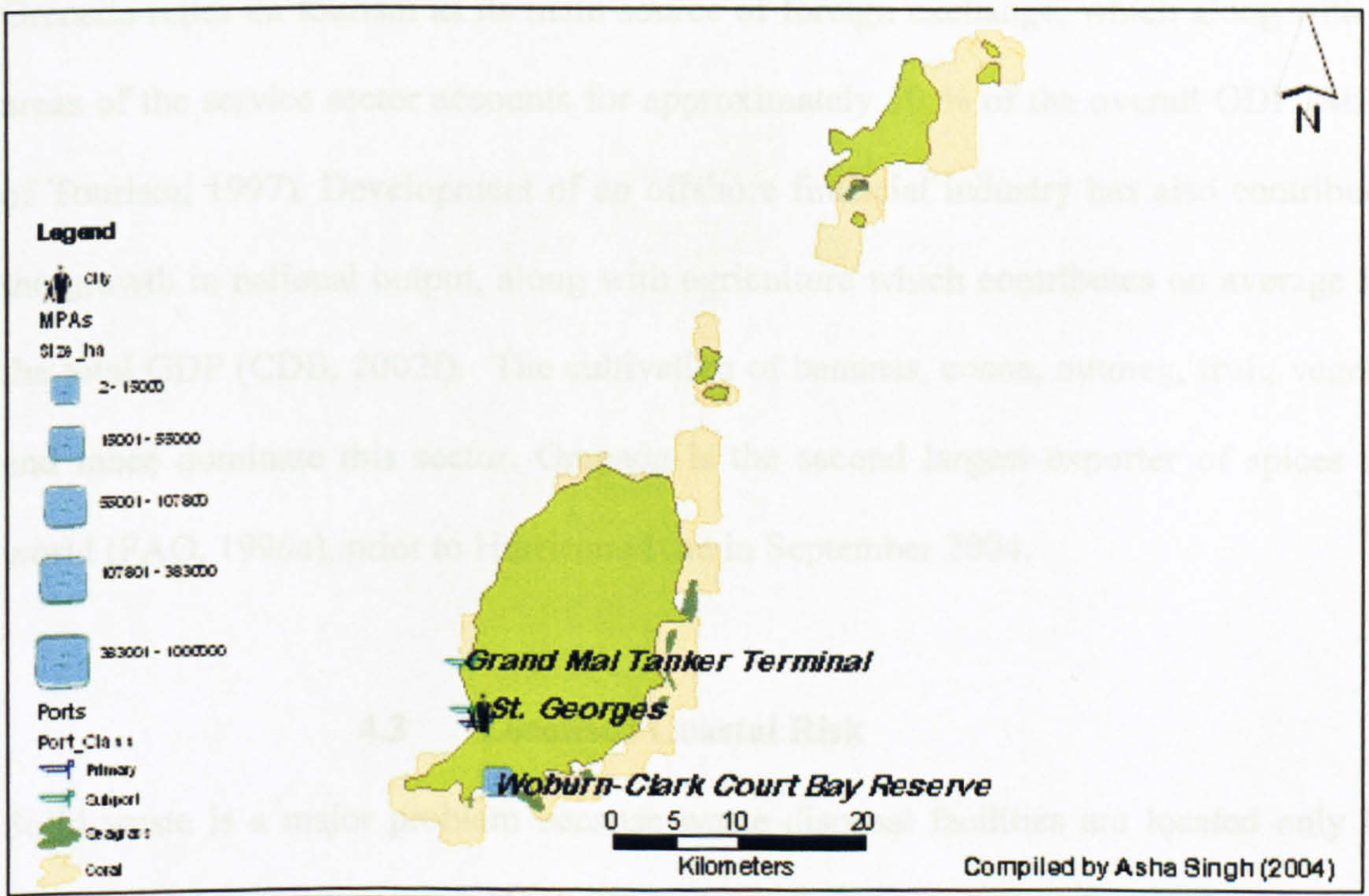
3.3 Localised Coastal Risks

Pollution due to erosion from deforestation, agrochemicals, industrial waste, and disposal of untreated sewerage are major issues of Trinidad (EMA, 1997a, 1999). In addition, the ever present risk of hydrocarbon pollution is high, mainly due to the large extent of petroleum extraction, processing and transportation. Oil in the form of tar balls often contaminate beaches in Trinidad (Georges and Oostdam, 1983; Siung-Chang, 1997) rendering some beaches restricted for recreational purposes. In Tobago tourism has been negatively impacted through problems generated by untreated sewage (Water Resource

Agency, 2001), degradation of coral reefs by boat anchors, and divers, and the gross overfishing of shellfish (EMA, 1997b). Marine production is relatively high compared to the other islands under focus in this study (see statistical information) .

N.B: Statistical data presented on CD: Profile_3_Trinidad_Tobago

4. GRENADA



Area	**340 sq km**
Capital	**Saint George's**
Population & Density	**Total 83 000, 244/sqkm**
Location	**12 07 N and 61 40 W**
Language	**English**

Figure 4: Showing Features of Grenada

4.1 General Description

The state of Grenada includes the islands of Grenada, Carriacou and Petit Martinique. It encompasses a total coastline length of 121 km and 211 nm maritime claims (CIA, 2004q). This island is volcanic in origin, and also mountainous with the highest point being Mount St. Catherine which reaches an elevation of 838 m (CCA, 1991). The climate is humid tropical, with an average annual temperature of 28° C, and annual rainfall of 1524 mm on the coast. Grenada has a pronounced rainy season between June and December (Ministry of Finance, 2000). In 2004, Hurricane Ivan made landfall and destroyed major infrastructure on the island of Grenada. The hurricane causes damage which was estimated to be in the billions of dollars.

4.2 Economy in Perspective

Grenada relies on tourism as its main source of foreign exchange, which along with other areas of the service sector accounts for approximately 70 % of the overall GDP (Ministry of Tourism, 1997). Development of an offshore financial industry has also contributed to the growth in national output, along with agriculture which contributes on average 8% of the total GDP (CDB, 2002f). The cultivation of bananas, cocoa, nutmeg, fruit, vegetables and mace dominate this sector. Grenada is the second largest exporter of spices in the world (FAO, 1996a), prior to Hurricane Ivan in September 2004.

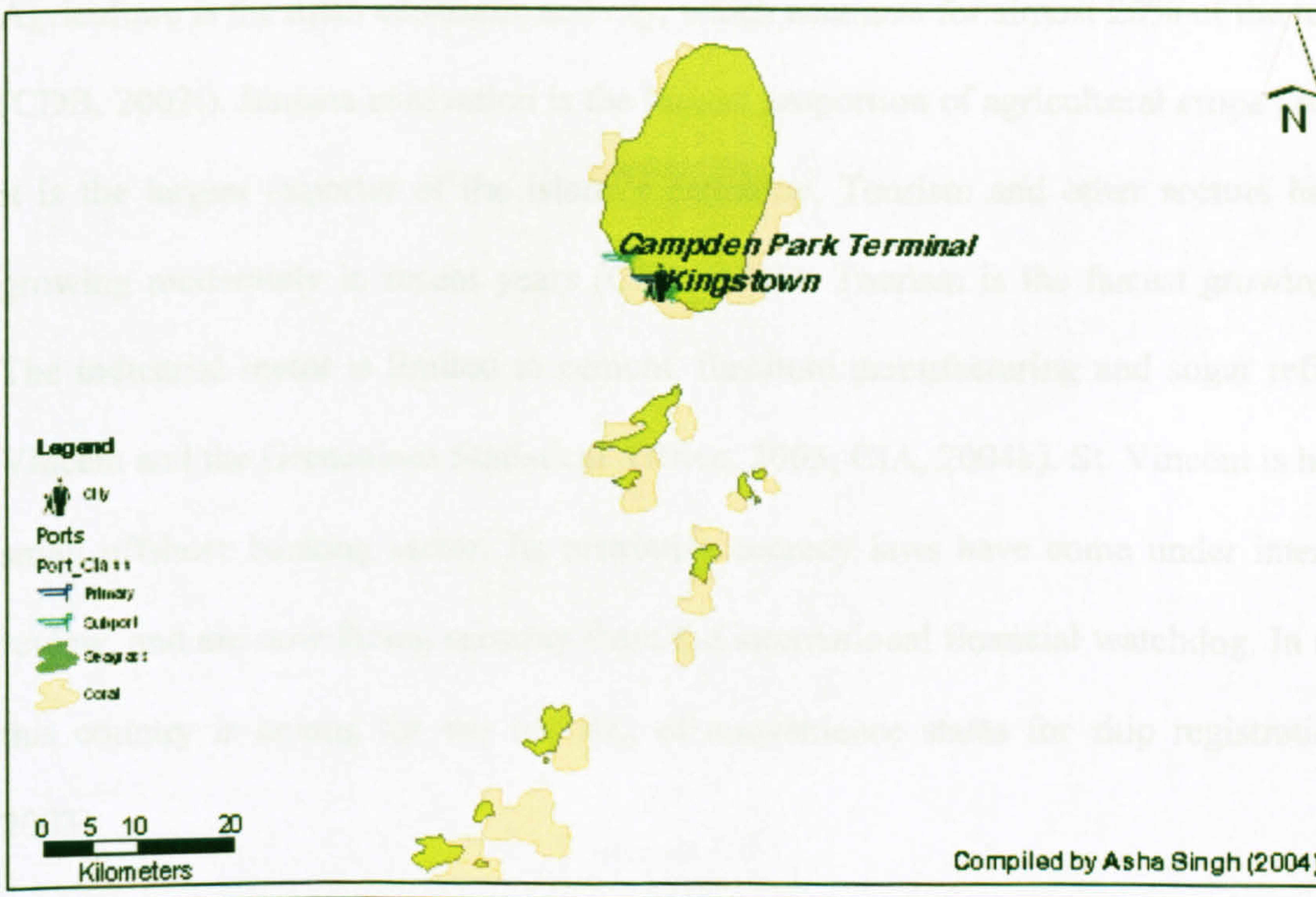
4.3 Localised Coastal Risk

Solid waste is a major problem because waste disposal facilities are located only in the capital and adjacent areas. Ineffective liquid waste management and agricultural chemicals are major issues affecting the coastal areas and marine waters (Department of Economic Affairs, 2001). In addition, increased infrastructure development in the expanding tourism sector (Ministry of Tourism, 1997) has witnessed an increase in quarrying activities, thus causing siltation of nearby coastal areas (Department of Economic Affairs, 2001) and beach erosion (Cambers, 1996; COSALC, 1996c). It is estimated that 60 % of Grenada's beaches will be lost due to a projected 50 cm increase in the sea level (Peters, 2000).

The Grand Anse area is the most polluted area of Grenada due to the discharge from abattoirs, industrial waste, eroded silt, grey waste, raw sewerage, hillside run off from housing developments, and agrochemicals (Department of Economic Affairs, 2001). Oil pollution is a major issue especially in the St. George's Harbour. Frequent pollution in the coastal area occur from the release of oily waters by passing ships (Ministry of Finance, 2000).

N.B: Statistical data presented on CD: Profile_4_Grenada

5. ST VINCENT AND THE GRENADINES



Area	**389 sq km (made up of 23 islands)**
Capital	**Kingstown**
Population & Density	**Total 114 000, 293/sqkm**
Location	**13^0, 15' N, 61^0,12' W**
Language	**English**

Figure 5: Showing Features of St Vincent and Grenadines

5.1 General Description

St Vincent and the Grenadines is a 30 island state (CCA, 1990), which is volcanic in origin. These states are made up of a forested mountain range, with the highest elevation reaching 1234 m above sea level (Birdsey *et. al.*, 1986) in the form of an active volcano known as La Soufriere. St Vincent and the Grenadines has fully extended maritime claims and has a coastline length of 85 km (CIA, 2004k).

The climate is tropical with an average annual temperature of 24ºC (Government of St Vincent and the Grenadines, 2002) and varied annual rainfall of 1,524 mm and 3,810 mm on the coastal areas and in the mountains respectively (NEAB/ Ministry of Environment, 2000).

5.2 Economy in Perspective

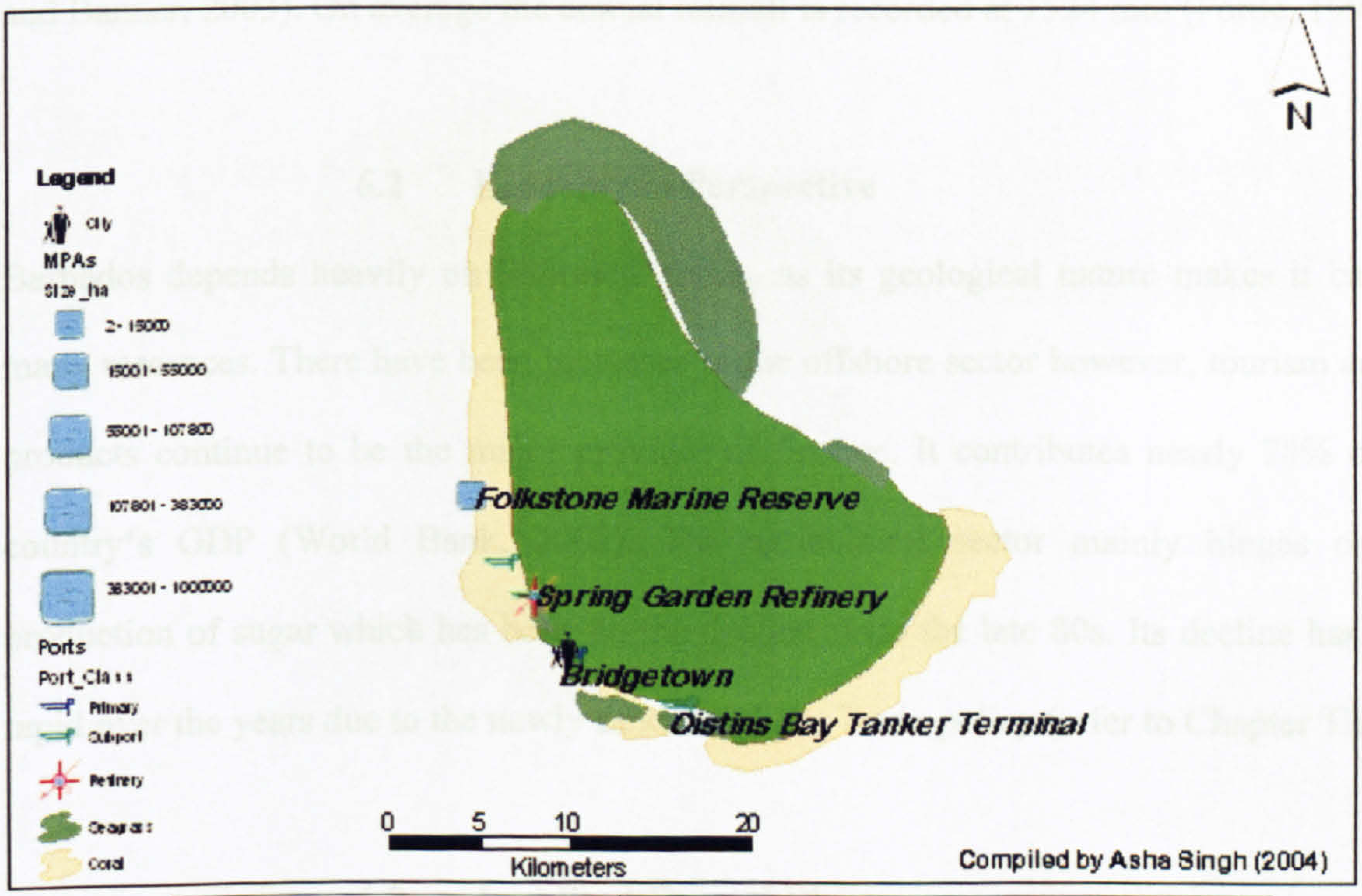
Agriculture is the main economic activity, which accounts for almost 20% of the total GDP (CDB, 2002i). Banana cultivation is the largest proportion of agricultural crops grown, and it is the largest exporter of the island's economy. Tourism and other sectors have been growing moderately in recent years (CDB, 1996). Tourism is the fastest growing sector. The industrial sector is limited to cement, furniture manufacturing and sugar refining (St Vincent and the Grenadines Statistical Office, 2003; CIA, 2004k). St. Vincent is home to a small offshore banking sector. Its restrictive secrecy laws have come under international review, and are now facing scrutiny from the international financial watchdog. In addition, this country is among the top ten flag of convenience states for ship registration (ITF, 2003).

5.3 Localised Coastal Risks

Solid waste disposal is a major issue in St Vincent and the Grenadines, mainly because of improper, inadequate, and the lack of a collection systems (Anonymous, 2001b). Discharges from yachts and other effluents are causing the pollution of coastal waters. In some areas pollution is severe enough to render swimming prohibitive (iExplorer and National Geographic, 2004). Over fishing has become a major concern in the last decade. This is evident in the decline in total marine fisheries production (see statistical information). Emerging issues include environmentally unsound agricultural practices which is causing siltation (Murray, 2003), and agrochemical pollution (Anonymous, 2001b) from a discernible increase in fertilizer usage which occurred in the late 1990s.

N.B: Statistical data presented on CD: Profile_5_St_Vincent_and_the_Grenadines

6. BARBADOS



Area	**431 sq km**
Capital	**Bridgetown**
Population & Density	**Total 262333, 608/sqkm**
Location	**13^0, 10' N, 59^0, 32' W**
Language	**English**

Figure 6: Showing Features of Barbados

6.1 General Description

Barbados is predominantly a coral limestone island (Brewster and Mwansa, 2001) which forms a landscape of terraces, slopes and scarps. Its highest point is Mount Hillaby, which stands at 336 m (Anonymous, 2004a). There are many near vertical cliffs and gullies, the latter which act as the island's drainage network. Barbados has a coastline length of 97 km with a 200 NM of maritime claims (CIA, 2004c), and 167 000 km^2 of Exclusive Economic Zone (Government of Barbados, 2002).

The climate is mainly a sub-humid tropical climate (James *et. al.*, 1977) with an average annual temperature of between 24-28^{0}C (All Info About, 2005). There is seasonal rainfall with a dry season from January to May and its wet season from June to December (Jones and Banner, 2003). On average the annual rainfall is recorded at 1524 mm (Forde, 1999).

6.2 Economy in Perspective

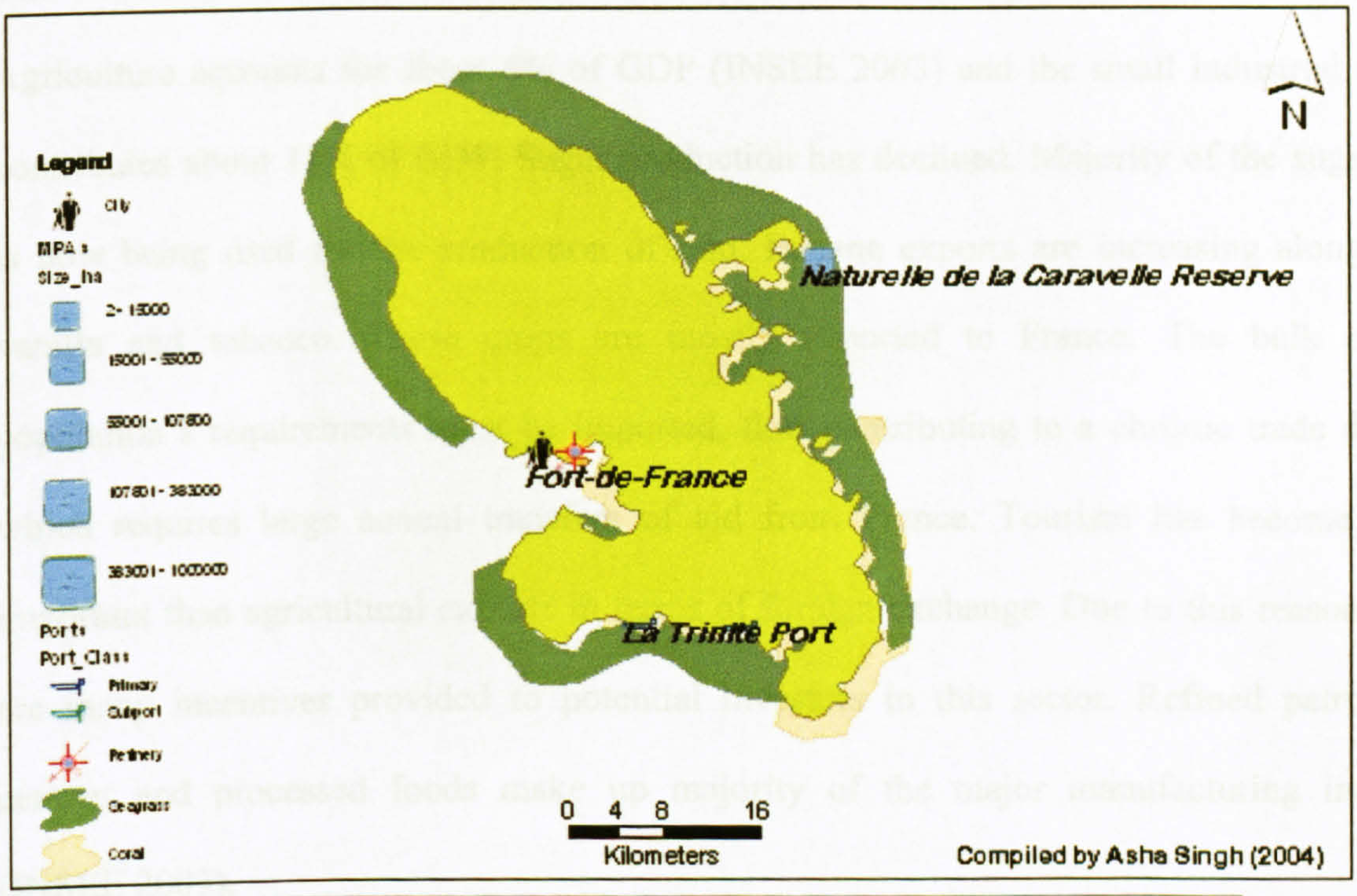
Barbados depends heavily on imported goods, as its geological nature makes it bare of many resources. There have been increases in the offshore sector however, tourism and its products continue to be the major provider of finance. It contributes nearly 78% of the country's GDP (World Bank, 2002). The agricultural sector mainly hinges on the production of sugar which has been on the decline since the late 80s. Its decline has been rapid over the years due to the newly sanctioned EU Trade policy (refer to Chapter Three).

6.3 Localised Coastal Risks

Barbados has an active coastal zone management system in place along with effective land use planning, which minimizes many of the possible environmental threats to the coastal and marine areas that are experienced on a wider scale in many other small islands. Pollution from agricultural activities, leacheate from defunct landfill sites and household wastewaters are major concerns for the island (Carmichael, 1995). The coral reef ecosystem is the most threatened marine habitat and has declined over the last few decades, mainly from disease (Aronson and Precht, 2001) and anthropogenic activities. These anthropogenic activities include fertilizer and pesticide runoff, and ineffective sewage management in some areas of the island (Government of Barbados, 2002). Overfishing in the reefs is a major concern (Government of Barbados, 2002). The fisheries contributes approximately 1% to national income (Laya and Weidner, 2001d) and efforts are being made to implement management of the fish stock. However, overall efforts are being made to arrest the impacts on the marine environment such as construction of sewerage treatment plants.

N.B: Statistical data presented on CD: Profile_6_Barbados

7. MARTINIQUE



Area	**1 100 sq km**
Capital	**Fort –de-France**
Population& Density	**Total 373 000, 339/sqkm**
Location	**14^0, 40' N and 61^0, 00' W**
Language	**French**

Figure 7: Showing Features of Martinique

7.1 General Description

Martinique is one of the most densely populated island of the Caribbean (Crondon and Ogden, 1996). It is volcanic in nature, and is characterised by an indented coastline of some 350 km and a 200 NM maritime claim (CIA, 2004f). This island is very mountainous with its highest point being Mt. Pelee, a volcano which reaches 1,397 m (Mattioli *et. al.*, 1996).

The climate is tropical, influenced by the trade winds with average temperatures of 17.3°C. Its pronounced rainy season is from June to October (Khamsouk, 2001). Martinique is vulnerable to devastating cyclones (hurricanes) which hit every eight years on average.

7.2 Economy in Perspective

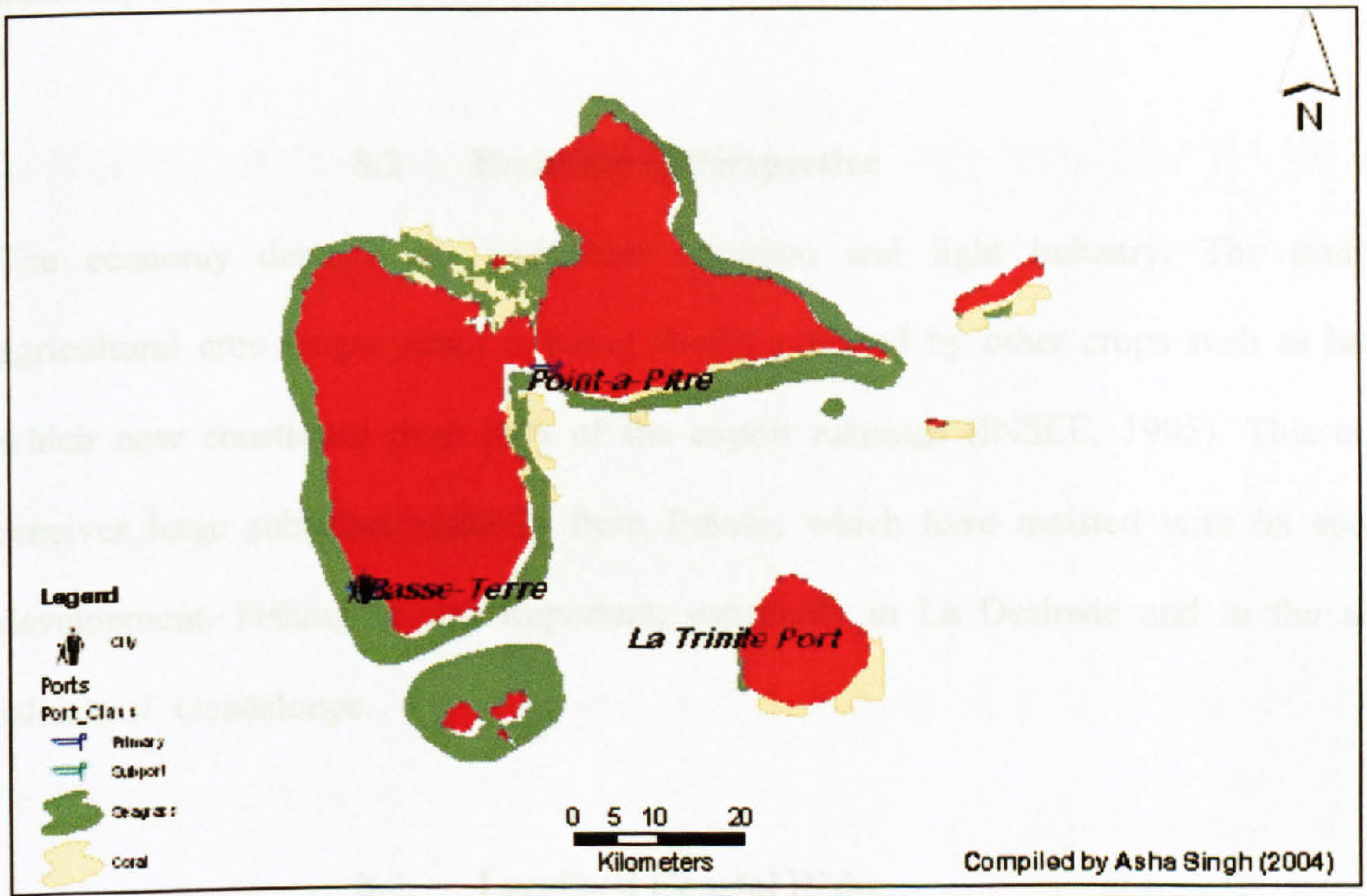
The economy is based on sugarcane, bananas, fishing, light industry and tourism. Agriculture accounts for about 6% of GDP (INSEE 2003) and the small industrial sector contributes about 11% of GDP. Sugar production has declined. Majority of the sugarcane is now being used for the production of rum. Banana exports are increasing along with vanilla and tobacco. These crops are mostly exported to France. The bulk of the population's requirements must be imported, thus contributing to a chronic trade deficit, which requires large annual transfers of aid from France. Tourism has become more important than agricultural exports in terms of foreign exchange. Due to this reason there are many incentives provided to potential investors in this sector. Refined petroleum, cement and processed foods make up majority of the major manufacturing industry (INSEE 2003).

7.3 Localised Coastal Risks

Tax incentives are provided for tourism and industrial investments in Martinique. Information on the implications of this is not known at this point. In addition, the oil refinery is also being expanded but no literature is available on the possible implications.

N.B: Statistical data presented on CD: Profile_7_Martinique

8. GUADELOUPE



Area	**1 780 sq km**
Capital	**Basse -terre**
Population & Density	**Total 409 333, 229/sqkm**
Location	**16^0,15' N, 61^0 35' W**
Language	**French**

Figure 8: Showing Features of Guadeloupe

8.1 General Description

Guadeloupe is a volcanic island characterised by an indented coastline of 306 km with mountainous terrain (CIA, 2004f). It has a maritime claim of 200 NM (CIA, 2004f). The climate is subtropical, which is hot and humid, and is tempered by the Trade Winds (Greenwich Mean Time, 2004). The mean annual temperature is 25° C and the average annual rainfall is 982 cm (Mahe and Mancel, 1999).

Guadeloupe is a dependent territory of France and is made up of a group of islands (Basse-terre, Grande-terre, La Desirade and Les Saintes). Basse-terre is the most mountainous of the islands with the highest point being Soufriere, an active volcano at 1484 m (Fink and Fairbridge, 1975). Grand Terre has flat terrain which makes it ideal for agricultural activities of Guadeloupe are concentrated. A narrow channel called River Salee separates Basse-terre and Grand Terre.

8.2 Economy in Perspective

The economy depends on agriculture, tourism and light industry. The traditional agricultural crop (sugar cane) is being slowly replaced by other crops such as bananas which now constitutes over 50% of the export earnings (INSEE, 1995). This country receives large subsidies annually from France, which have assisted with its economy development. Fishing is also important, especially in La Desirade and in the smaller islands of Guadeloupe.

8.3 Localised Coastal Risks

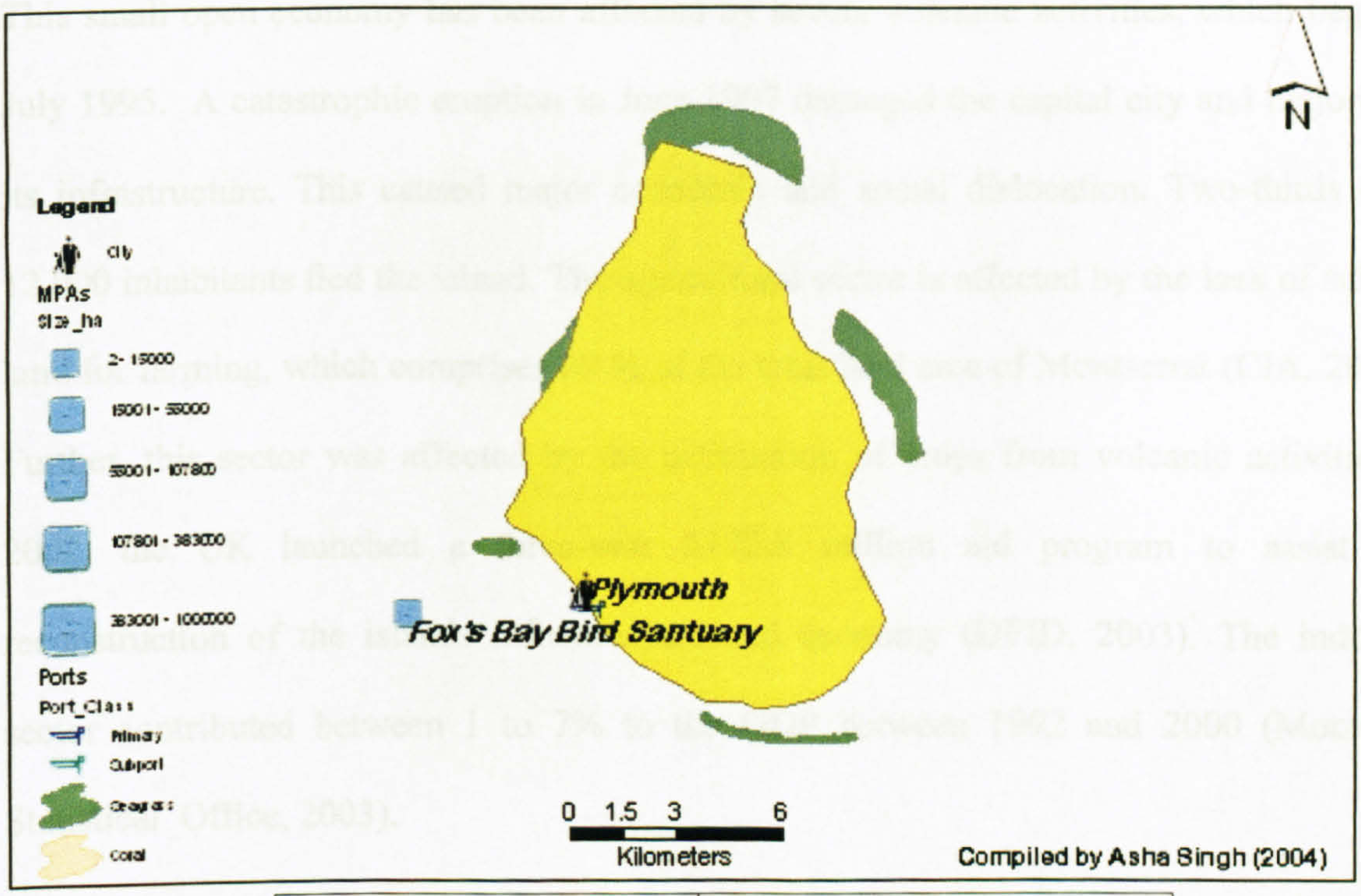
Guadeloupe's coastal and marine environment are subjected to a variety of human pressures. Some of the most significant pressures are caused by agricultural pollution, heavy metal pollution, sugar mill and distillery liquid wastes, urban pollution sediment runoff, construction, and dredging (DRIRE (ed.), 1994). About 900 tonnes of pesticides are used each year in Guadeloupe's banana and sugar cane production (DAF, 1991). Given the drainage and topography, it is likely that a significant amount of these pollutants (substances) reach the marine system. The contamination from fertilizer runoffs into the marine environment caused by high nitrates levels having resulted in increased algal growth (IFRECOR, 2000).

Most of the mangrove swamps are used as a disposal areas for sump oil. Industrial waste production is estimated at 4,050 tonnes/year (10 kg/yr/cap), of which 90% is oil waste (DRIRE (ed.), 1994). This is alarming, especially since there are no local treatment facilities. It is estimated that the quantities of organic pollution from distillers and sugar cane factories which enter the environment during the manufacturing period (80-15- days per year) is equivalent to the domestic sewerage generated by the total population of Guadeloupe for a given day (DRIRE (ed.), 1994).

Most of the original vegetation has been cleared for agricultural purposes. This has lead to an ever-increasing rate of soil erosion and resultant inflows of sediments into the sea (IFRECOR, 2000). In addition, construction projects in the coastal areas are conducted without proper environmental directives. The building of St. Françoise Harbour, Jarry Industrial Zone, marinas, coastal roads and airports are such examples of projects done without adequate environmental consideration. Guadeloupe currently extracts sand offshore in the Caribbean Sea, however to date, no study has been conducted to evaluate the impacts of this activity.

N.B: Statistical data presented on CD: Profile_8_Guadeloupe

9. MONTSERRAT



Area	**102 sq km**
Capital	**Plymouth**
Population & Density	**Total 8333, 82/sqkm**
Location	**16^0, 45' N,62^0,15' W**
Language	**English**

Figure 9: Showing Features of Montserrat

9.1 General Description

Montserrat is a dependent territory of the United Kingdom with its own system of government. It is mountainous and volcanic in nature, consisting of two volcanoes (IRF, 1993) in the Soufrière Hill range. Montserrat has a high saddle of fertile land in the centre, with a rugged indented coastline of 40 km (CIA, 2004h). There is little seasonal variation with an average annual temperature of 28° C, and an annual average rainfall of 1778 mm (Montserrat Tourist Board, 2002). There are a number of black volcanic beaches and one white sand beach in the north of Rendezvous Bay. The highest elevation is Chances Peak which is 3, 000 ft (Anonymous, 2003c). Montserrat is severely disadvantaged in terms of fisheries. It has the smallest maritime claims (EFZ 200 NM) of all the Caribbean islands because of its geographic location in relation to its neighbours (Weidner *et. al.*, 2001c).

9.2 Economy in Perspective

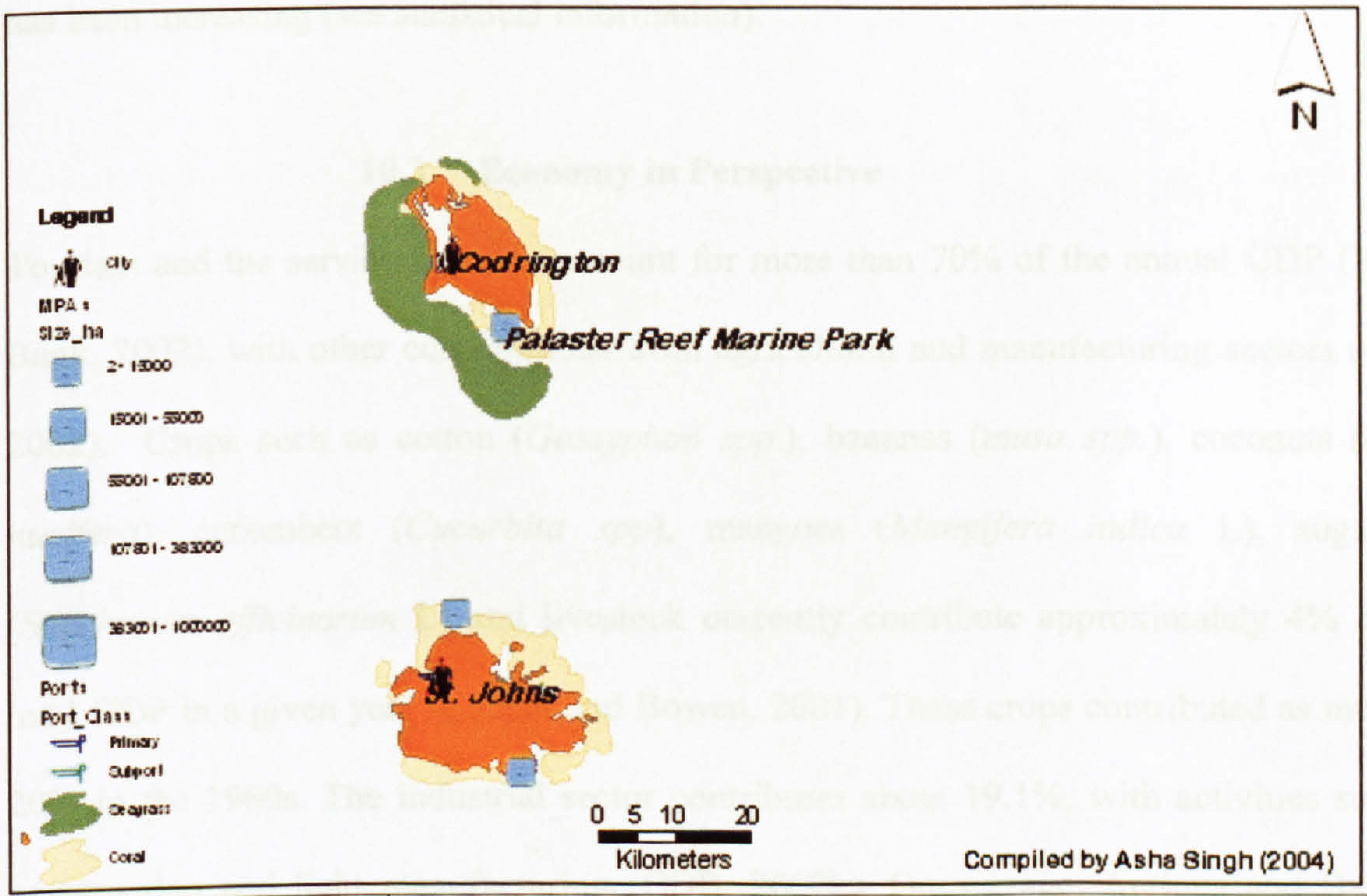
This small open economy has been affected by severe volcanic activities, which began in July 1995. A catastrophic eruption in June 1997 damaged the capital city and majority of its infrastructure. This caused major economic and social dislocation. Two-thirds of its 12,000 inhabitants fled the island. The agricultural sector is affected by the lack of suitable land for farming, which comprises 20 % of the total land area of Montserrat (CIA, 2004h). Further, this sector was affected by the destruction of crops from volcanic activities. In 2002, the UK launched a three-year $122.8 million aid program to assist with reconstruction of the islands infrastructure and economy (DFID, 2003). The industrial sector contributed between 1 to 7% to the GDP between 1992 and 2000 (Montserrat Statistical Office, 2003).

9.3 Localised Coastal Risks

Sand mining on the beaches is very prevalent and is a cause for concern (Gunne-Jones, 1998) as nearby marine areas are likely to be affected.

N.B: Statistical data presented on CD: Profile_9_Montserrat

10.ANTIGUA AND BARBUDA



Area	**Antigua 279 ,Barbuda 160 ,Redonda 1 sq km**
Capital	**Saint Johns**
Population & Density	**Total 67 333, 153/sqkm**
Location	**17^0, 03 N and 61^0, 48 W**
Language	**English**

Figure 10: Showing Features of Antigua and Barbuda

10.1 General Description

This country has a coastline length of 153 km (CIA, 2004a) and 200NM of maritime claim. The climate of Antigua is described as tropical humid with average temperatures of 29° C during summer and 24° C during winter months (IRF/CCA, 1991a). The average rainfall is 1,065 mm per annum, though it varies considerably from year to year. On the other hand, Barbuda, is one of the driest islands in the Caribbean with an average annual rainfall between 760 mm and 990 mm (Historical Conservation and Environment Commission, 1991). There is another small island called Redonda which is privately owned and virtually uninhabited. The main topographical features in Antigua are its hills in the north, fertile plains in the central area and volcanoes in the southwest. The highest point is Boggy Peak, which reaches an elevation of 402 m (Beard, 1949). In 1984, it was estimated that nearly

60% of the population lived in the city (Cooper and Bowen, 2001). The urban population has been increasing (see statistical information).

10.2 Economy in Perspective

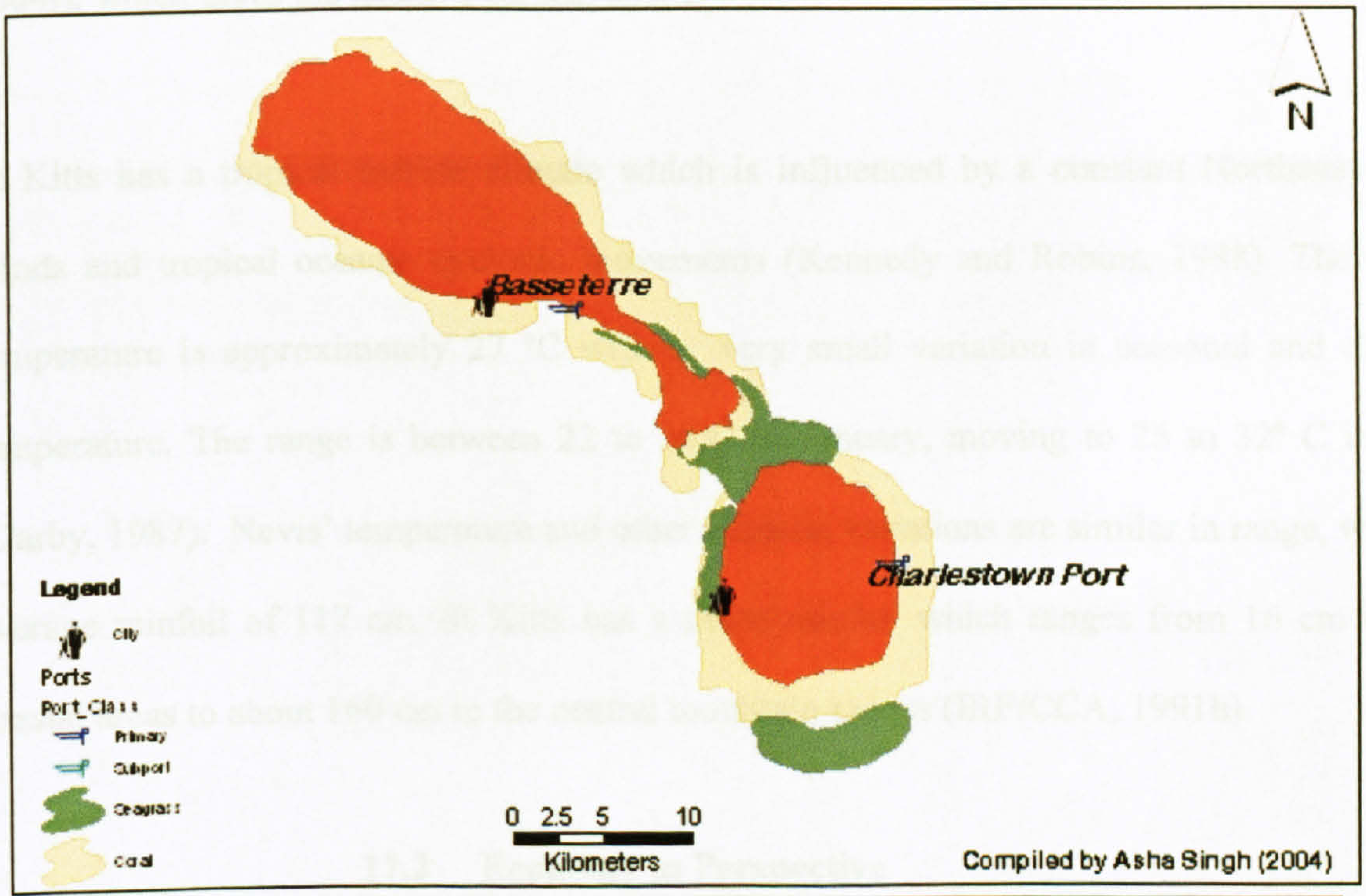
Tourism and the service industry account for more than 70% of the annual GDP (World Bank, 2002), with other contributions from agricultural and manufacturing sectors (CDB, 2002). Crops such as cotton (*Gossypium spp.*), bananas (*musa spp.*), coconuts (*cocos nucifera*), cucumbers (*Cucurbita spp*), mangoes (*Mangifera indica* L), sugarcane (*Saccharum officinarum* L) and livestock currently contribute approximately 4% of the total GDP in a given year (Cooper and Bowen, 2001). These crops contributed as much as 20% in the 1960s. The industrial sector contributes about 19.1%, with activities such as construction and light manufacturing (CDB, 2002b). On average, Antigua and Barbuda consume 93 million Kw/h of electricity which is generated mainly from fossil fuels (CIA, 2004a).

10.3 Localised Coastal Risks

Antigua's main problems are related to intensive tourism development (Hill, 1988) which has resulted in major biophysical alterations to the coastline (Freestone, 1991; Cambers, 1997), and destruction of coastal and marine habitats (Fernandez *et. al.*, 1999). Sewage is disposed of through sceptic tanks due to the lack of a central sewerage system (Cooper and Bowen, 2001). Erosion and other threats from sand mining (COSALC, 1996b) are also major problems (Jeffery and McRonnie, 2000).

N.B: Statistical data presented on CD: Profile_10_Antigua_Barbuda

11. KITTS AND NEVIS



Area	**Saint Kitts 168 sq km, Nevis 93 sq km**
Capital	**Basseterre**
Population & Density	**Total 42 333, 162/sqkm**
Location	**17^0, 20' N, 62^0, 45' W**
Language	**English**

Figure 11: Showing Features of St Kitts and Nevis

11.1 General Description

St Kitts and Nevis are a twin island state, the former being 80 km long and 16 km wide (Tourism Authority, 2004), rising from the coastline towards its mountain cluster in the centre. Its highest point is Mt Liamuiga at a height of 1,156 m (IRF/CCA, 1991b). The length of the coastline is 135 km long (CIA, 2004i) with St Kitts and Nevis having fully extended maritime claims.

St Kitts is very mountainous, thus shaping the climate, land use and the general physical development of the island. On the other hand, Nevis lies on the inner volcanic arc of the Lesser Antilles. It comprises of nine distinct volcanic centres strung southwest along a parallel of inner volcanic arc (CCA, 1987). Nevis' central peak, has a height of 985m (CIA, 2004i), which gives the island a conical shape.

St Kitts has a tropical marine climate which is influenced by a constant Northeast trade winds and tropical oceanic cyclonic movements (Kennedy and Robins, 1988). The mean temperature is approximately 27 °C with a very small variation in seasonal and diurnal temperature. The range is between 22 to 29°C in January, moving to 25 to 32° C in July (Darby, 1987). Nevis' temperature and other climatic variations are similar in range, with an average rainfall of 117 cm. St Kitts has a mean rainfall which ranges from 16 cm in the coastal areas to about 160 cm in the central mountain ranges (IRF/CCA, 1991b).

11.2 Economy in Perspective

Sugar cane cultivation dominates the agricultural sector which is a significant contributor to the economy (US Department of State, 2004). However, tourism, export-oriented manufacturing, and offshore banking have assumed larger roles in the economy. Tourism revenues are now regarded as the chief source of the islands' foreign exchange and GDP contribution. In 1999, tourism contributed over 33 % to the GDP (Goodwin *et. al.*, 2004).

11.3 Localised Coastal Risks

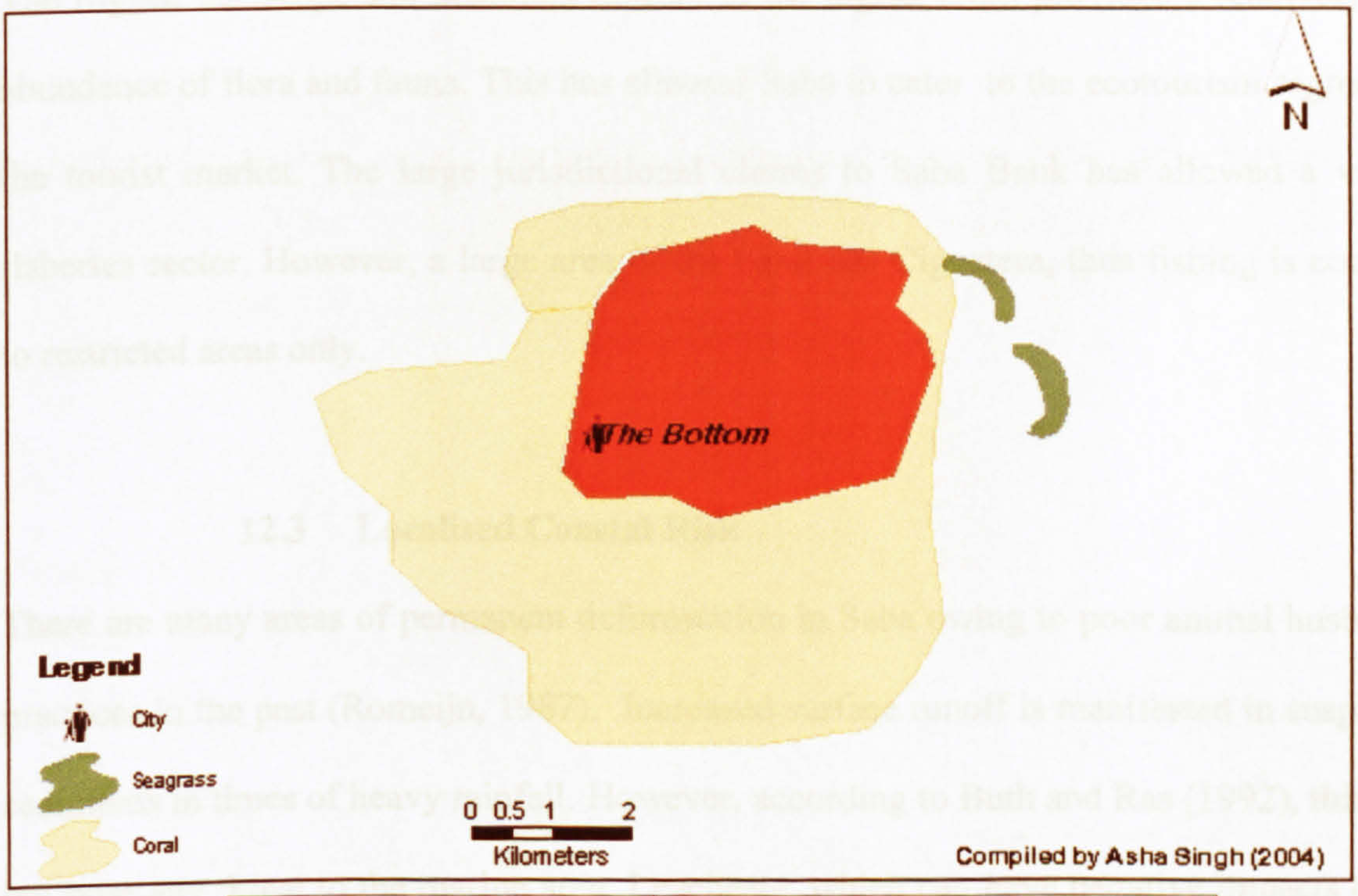
The marine environment St Kitts and Nevis comprised of coral reefs and sea grass habitats, while the coastal areas are made up of mangroves and salt marshes (CCA, 1987). There is no legally designated Marine Protected Area (OAS, 1988; Geoghegan *et. al.*, 2001), though some marine areas are being earmarked for protection.

Pollution from improper sewerage disposal, oils, agrochemicals and solid waste from recreational activities are some of the major problems in St Kitts and Nevis (Department of Environment, 2001).

Over fishing is a major issue which is affecting the reef fisheries. According to Wilkins (1983) the exploited species include turtles (*Cheloniidae spp* etc.), conch (S*trombus giga*), sea moss (*Scleractinia spp.*) and lobsters (*Panulirus spp.*). In addition, the "accidental" potting and netting of juvenile reef fish remains a serious concern and has resulted in a marked decrease in the availability of reef fish (Department of Environment, 2001). The physical damage of reef is from anchors which is mainly from mooring vessels and dive tours.

N.B: Statistical data presented on CD: Profile_11_St_Kitts_and_Nevis

12. SABA



Area	12 sq km
Capital	The Bottom
Population & Density	Total 1244, 104/sqkm
Location	17^0, 20' N, 62^0, 45' W
Language	Dutch

Figure 12: Showing Features of Saba

12.1 General Description

Saba, a dormant volcano (Westerman and Kiel, 1961) is the smallest island of the Netherlands Antilles. This island is very rugged and is characterised by steep cliffs, deep ravines and scant sheltered bays. There are no beaches and wetlands in Saba. Mount Scenery is the highest point reaching a height of 870 m (Rojer, 1997a). The small population live in four villages on the south eastern end of the island.

The climate is tropical (Stoffers, 1956) with an average annual rainfall of 1,101mm (Rojer, 1997). The higher altitudes receives more than rainfall than the lowlands. There is no defined seasonal rainfall and the average temperature is 26^0C (Augustinus *et. al.*, 1985).

12.2 Economy in Perspective

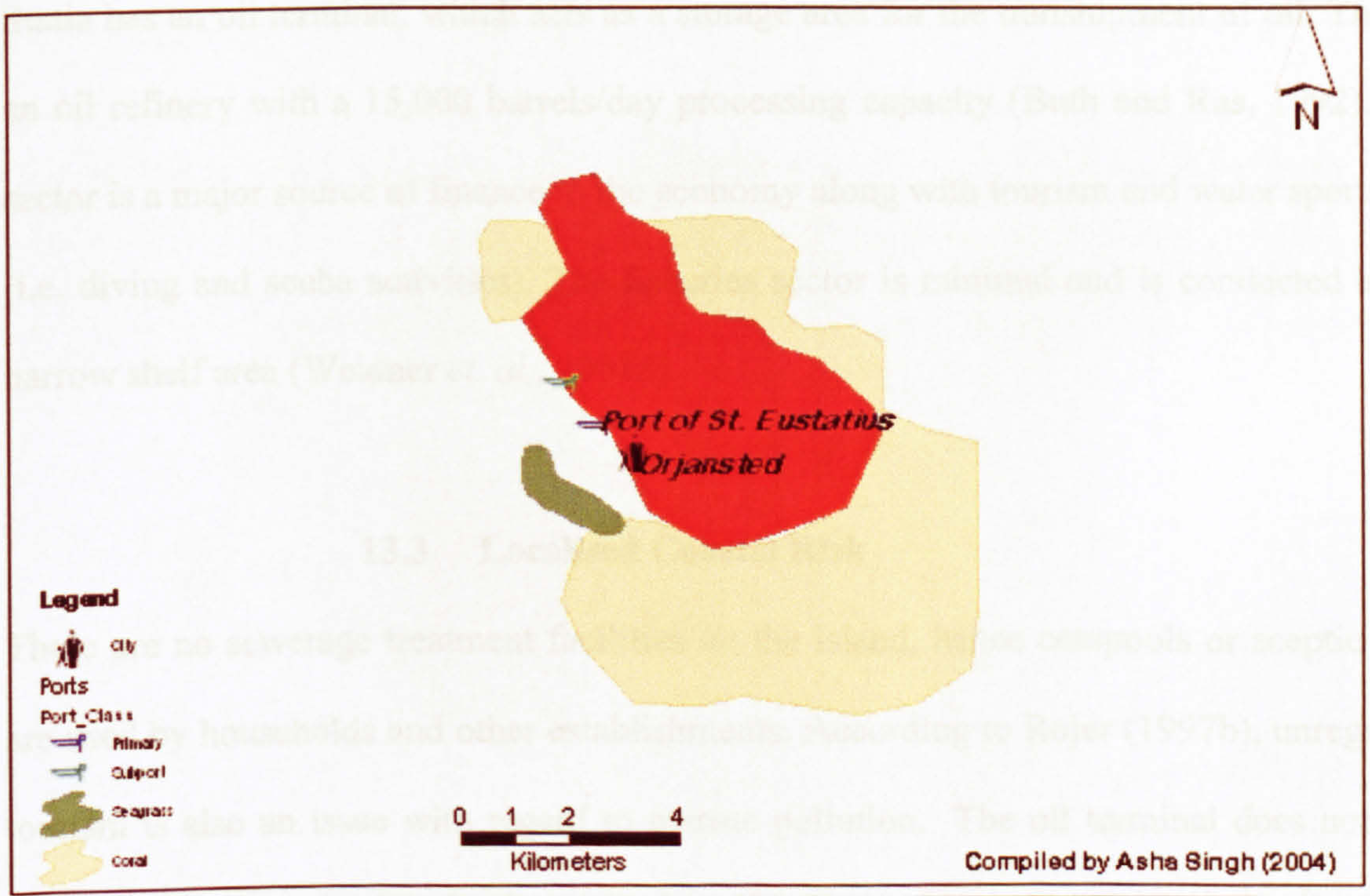
The rugged landscape and abundant rainfall in the higher areas provides a relatively high abundance of flora and fauna. This has allowed Saba to cater to the ecotourism segment of the tourist market. The large jurisdictional claims to Saba Bank has allowed a vibrant fisheries sector. However, a large area of the bank has Ciguatera, thus fishing is confined to restricted areas only.

12.3 Localised Coastal Risk

There are many areas of permanent deforestation in Saba owing to poor animal husbandry practices in the past (Romeijn, 1987). Increased surface runoff is manifested in suspended sediments in times of heavy rainfall. However, according to Buth and Ras (1992), this does not pose any threat to the marine area. Leacheate, which can have negative impacts on the marine environment enters the marine area from landfills. Overfishing of the resources in the Saba Bank is a problem however, the Dutch authority has made strides in patrolling the area for foreign fishermen (Weidner *et. al.*, 2001d).

N.B: Statistical data presented on CD: Profile_12_Saba

13. ST EUSTATIUS



Area	21 sq km
Capital	Orjansted
Population & Density	Total 2025, 96/sqkm
Location	17^0, 49' N, 63^0, 98' W
Language	Dutch

Figure 13: Showing Features of St Eustatius

13.1 General Description

St Eustatius also known as Statia, has a landscape which is dominated in the south by the Quill, an inactive volcano (Westerman and Kiel, 1961). Statia is 11 km long and 4 km wide and the highest point is Boven at 294 m (Rojer, 1997b). The central part of the island is flat. The coastline is rocky and steep with few sandy beaches. The climate is tropical, receiving annual rainfalls of 1,070 mm (De Palm, 1985), with an average temperature of 27^0C (Anonymous, 2002b).

13.2 Economy in Perspective

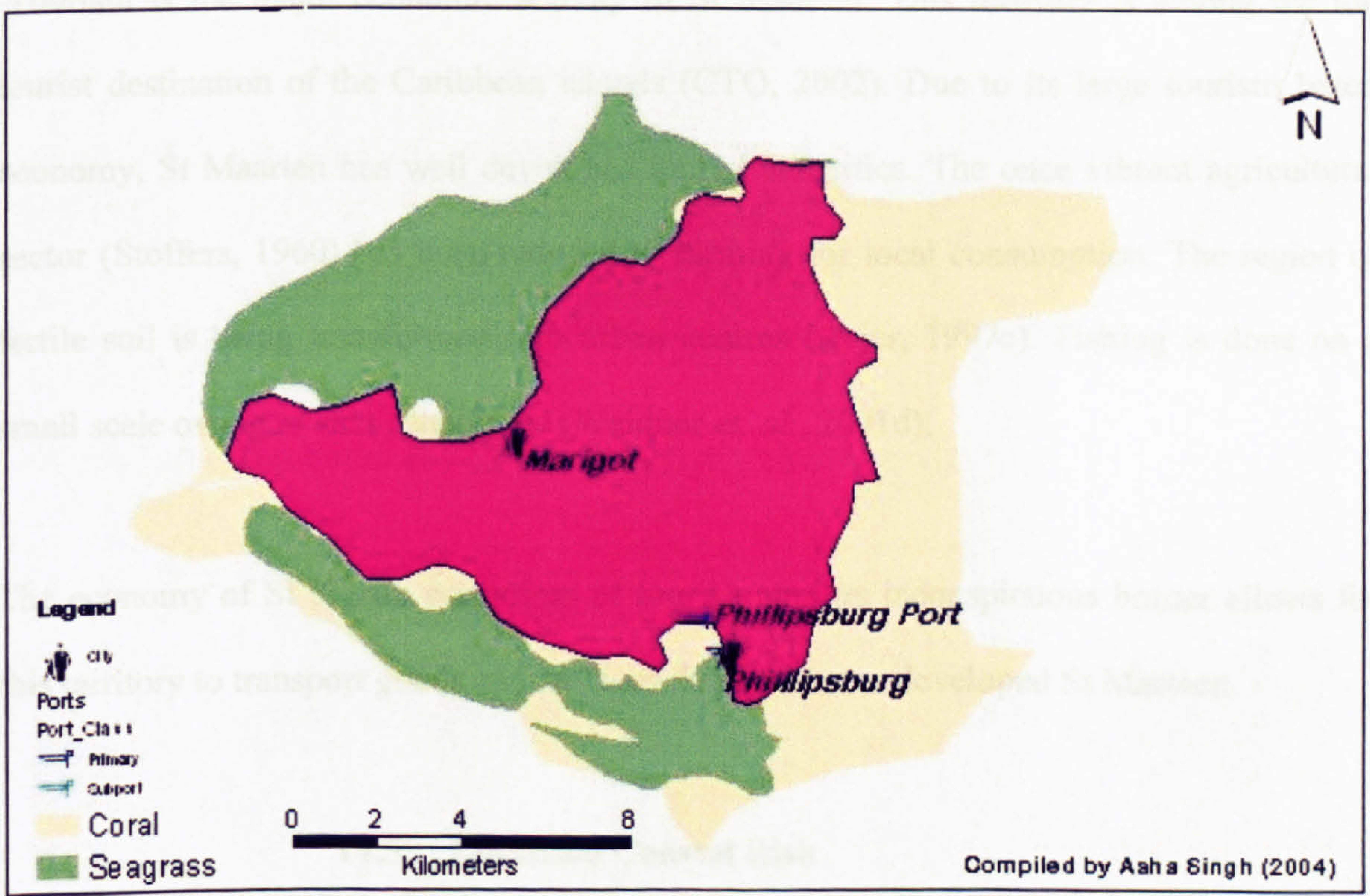
Statia has an oil terminal, which acts as a storage area for the transhipment of oil. There is an oil refinery with a 15,000 barrels/day processing capacity (Buth and Ras, 1992). This sector is a major source of finance to the economy along with tourism and water sports (i.e. diving and scuba activities). The fisheries sector is minimal and is conducted on the narrow shelf area (Weidner *et. al.*, 2001d).

13.3 Localised Coastal Risk

There are no sewerage treatment facilities on the island, hence cesspools or sceptic tanks are used by households and other establishments. According to Rojer (1997b), unregulated tourism is also an issue with regard to marine pollution. The oil terminal does not have any waste facility, thus the Statia Authority only allows ships with segregated ballast tanks to bunker at the facility. However, oil spills and seepages do occur at the terminal (Buth and Ras, 1992). Previous land use practices have resulted in deforestation (Rojer, 1997b), especially in Oranjestad. This deforestation issues causes high erosion rates especially in the months of high rainfall (ECNAMP, 1980). Sediment increase in the marine environment is classified as a major source of marine pollution according to Buth and Ras, (1992). Efforts are being made to reduce the erosion rate.

N.B: Statistical data presented on CD: Profile_13_St_Eustatius

14. SINT MAARTEN & SAINT MARTIN



Area	**34 sq Km / 52 sq km**
Capital	**Philipsburg /Marigot**
Population& Density	**Total 30 293, 890/sqkm**
Location	**18^0, 00' N, 63^0, 10' W**
Language	**Dutch /French**

Figure 14: Showing Features of St Maarten and St Martin

14.1 General Description

St Maarten is a dependent territory of the Dutch while its neighbour St Martin is a French dependent island. St Maarten is irregular in shape with many bays that form beaches and lagoons. The topography is described as hilly with Flagstaff being the highest point reaching 386m (Rojer, 1997c).

The climate is tropical with an annual rainfall of 1,060 m (CBS, 2004a) and no distinct rainy season. The average temperature is 27^0C. January and August are the coldest and warmest months respectively (De Palm, 1985). St. Martin shares similar characteristics in terms of climate and topography, with its highest point being Mount Paradise at 400 m (Rojer, 1997c).

14.2 Economy in Perspective

Tourism is the major economic activity in St Maarten. This territory is among the top tourist destination of the Caribbean islands (CTO, 2002). Due to its large tourism based economy, St Maarten has well developed tourist amenities. The once vibrant agricultural sector (Stoffers, 1960) has been reduced to farming for local consumption. The region of fertile soil is being transformed into urban centres (Rojer, 1997c). Fishing is done on a small scale owing to small shelf area (Weidner *et. al.*, 2001d).

The economy of St Martin comprises of tourism and its inconspicuous border allows for this territory to transport goods and services from the more developed St Marteen.

14.3 Localised Coastal Risk

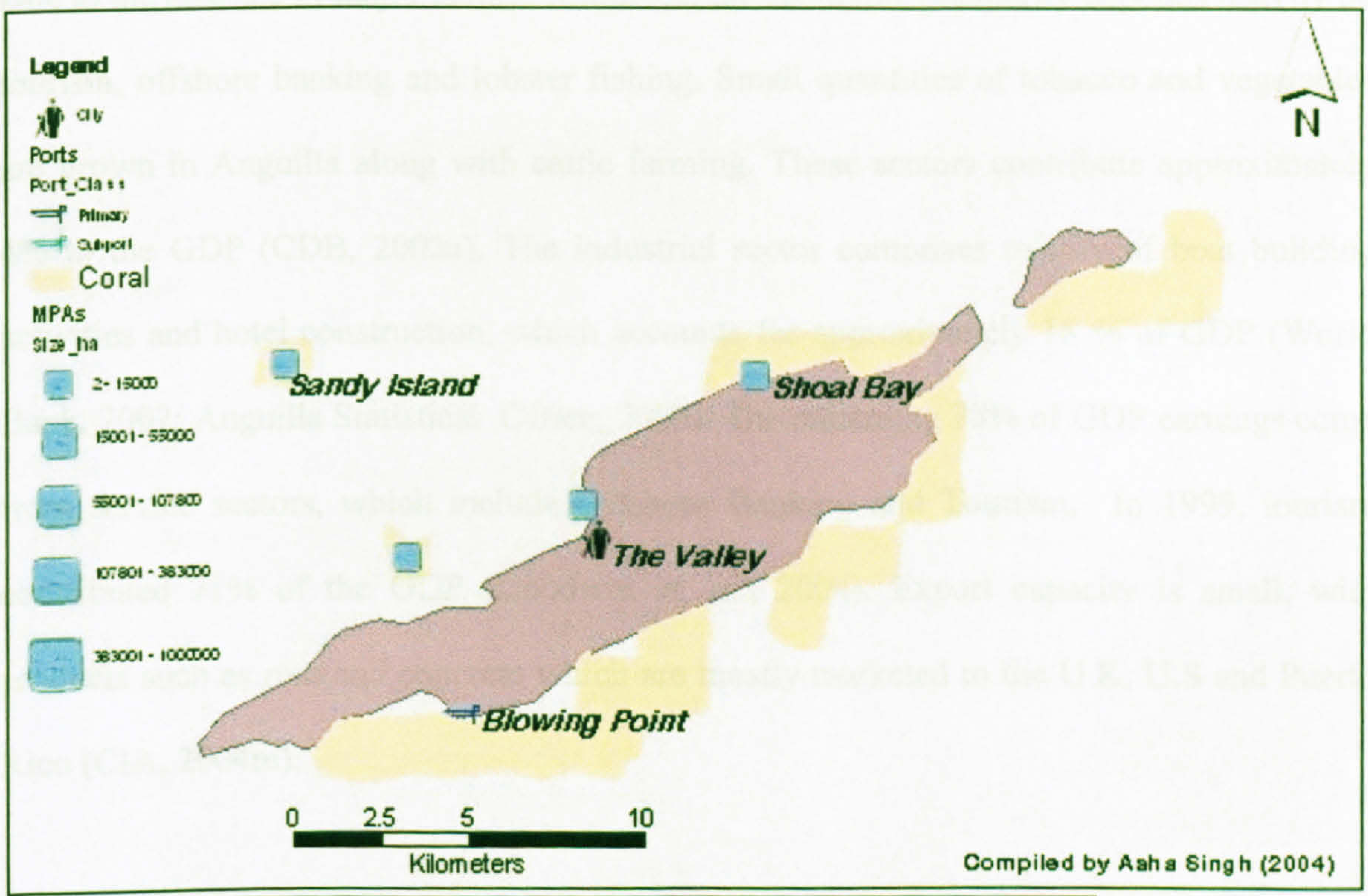
The heavy reliance on tourism has placed a huge burden on limited land area. To date, zoning laws are repelled, and new plans (EcoVision/AID Environment, 1996), have been initiated to accommodate the growing tourism sector. However, no information exists on the possible threat to the marine environment from these land based activities. In addition, the developed tourism sector has attracted a large number of illegal migrants to St Maarten, which has resulted in unplanned settlements and commitment coastal stress.

Major hotels on the island have independent sewerage systems. However, sewage from the resident population is a major source of marine pollution (Buth and Ras, 1992). In 1991, the first sewerage treatment facility was constructed with a treatment capacity for 3,500 households (Buth and Ras, 1992). This facility is inadequate for St Maarten's population which results in waste being disposed into cesspools and sceptic tanks. In some areas, there are uncontrolled and untreated sewage discharges into the marine areas. Inadequate facilities on the island results in the sail boats dumping their wastewater in the marine area (Buth and Ras, 1992). There is also leacheate from the landfill site at Great Salt Pond which enters the marine environment.

Statistical and environmental information for St Martin is unavailable.

N.B: Statistical data presented on CD: Profile_14_St_Maarten

15. ANGUILLA



Area	**102 sq km**
Capital	**The Valley**
Population& Density	**Total 10 000, 98/sqkm**
Location	**18^0,15' N, 63^0, 10' W**
Language	**English**

Figure 15: Showing Features of Anguilla

15.1 General Description

Anguilla is a dependent territory of the United Kingdom and is the most northerly of the leeward island chain. It has a fully extended EEZ and 61 km of coastline (CIA, 2004n). This island has several offshore cays and is fringed with more than thirty-five beaches (Anguilla Tourist Board, 2004). It is a low-lying island of coral and limestone formations, with the highest elevation being Crocus Hill at 65 m (Slayden, 2004). The island has sparse scrub oak with few trees (Carty and Petty, 1997). There are also few commercial salt ponds.

The climate is sub–tropical with an average temperature of 27° C and mean annual rainfall of 914 mm (Federal Research Division, 2004).

15.2 Economy in Perspective

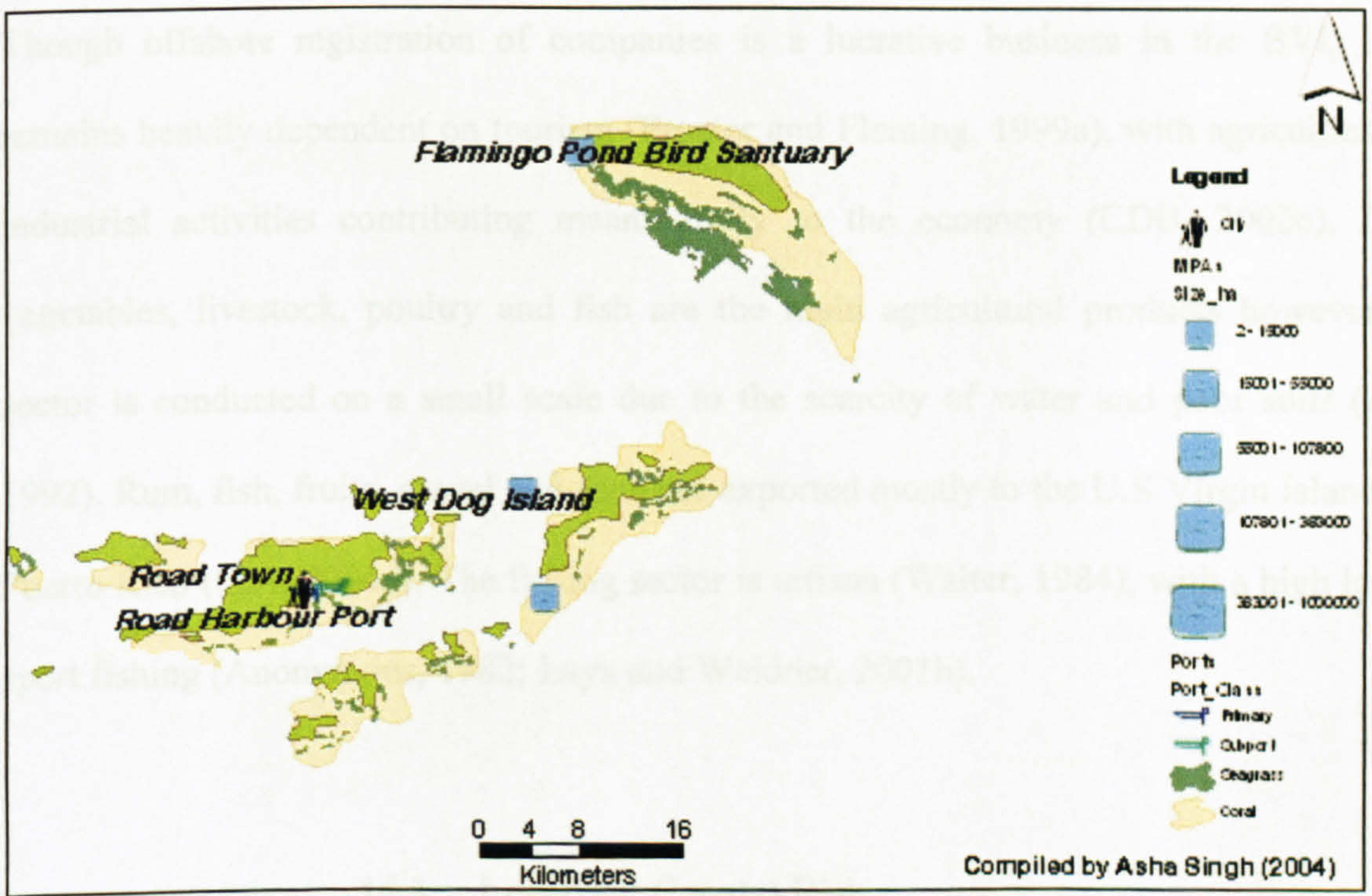
Due to the absence of major natural resources, the economic prosperity depends heavily on tourism, offshore banking and lobster fishing. Small quantities of tobacco and vegetables are grown in Anguilla along with cattle farming. These sectors contribute approximately 4% to the GDP (CDB, 2002a). The industrial sector comprises mainly of boat building activities and hotel construction, which accounts for approximately 18 % of GDP (World Bank, 2002; Anguilla Statistical Office, 2003). The remaining 78% of GDP earnings come from service sectors, which include Offshore Banking and Tourism. In 1999, tourism contributed 71% of the GDP (Goodwin *et. al.*, 2004). Export capacity is small, with products such as rum and concrete which are mostly marketed to the U.K, U.S and Puerto Rico (CIA, 2004m).

15.3 Localised Coastal Risk

Sewerage disposal is conducted mainly through septic tanks as there are no sewerage systems on the island (UNEP, 1998). Increased tourism activity has spurred growth in the construction sector, and further development in the coastal areas is causing sedimentation in marine areas. Beach erosion is also a huge concern in Anguilla (COSALC, 1996a). The largely artisan fishing industry targets lobsters and finfish (Richardson, 1984), mainly to supply the growing tourism sector. In the past majority of these catches were exported to Puerto Rico and St Marteen (Laya and Weidner, 2001c). However, these stocks have been on the decline and now efforts are being made to exploit pelagic fishing through a British funded programme called Offshore Fishery Development Project (OFDP).

N.B: Statistical data presented on CD: Profile_15_Anguilla

16. BRITISH VIRGIN ISLAND



Area	**153 sq km (made up of 50 islands)**
Capital	**Road Town**
Population & Density	**Total 18 667, 122/sqkm**
Location	**18^0, 30' N,64^0, 30' W**
Language	**English**

Figure 16: Showing Features of British virgin Islands

16.1 General Description

The British Virgin Islands (BVI) is a dependent territory of the United Kingdom consisting of a group of fifty (50) coral and volcanic islands (Procter and Fleming, 1999a), of which sixteen (16) are inhabited. This country has 80 km of coastline with 203 nm maritime claims (CIA, 2004d). The coral islands are relatively flat, while the volcanic islands are steep and hilly. The highest point in this territory is Mount Sage at 521m (Here VI, 2000), which is located in Tortola. The climate of the BVI is sub-tropical with an average temperature that ranges between 26-31° C during the summer, and 22-28° C during the winter (Caribe Dreamin, 2002). The annual rainfall is 684 mm (Lazell, 1980).

16.2 Economy in Perspective

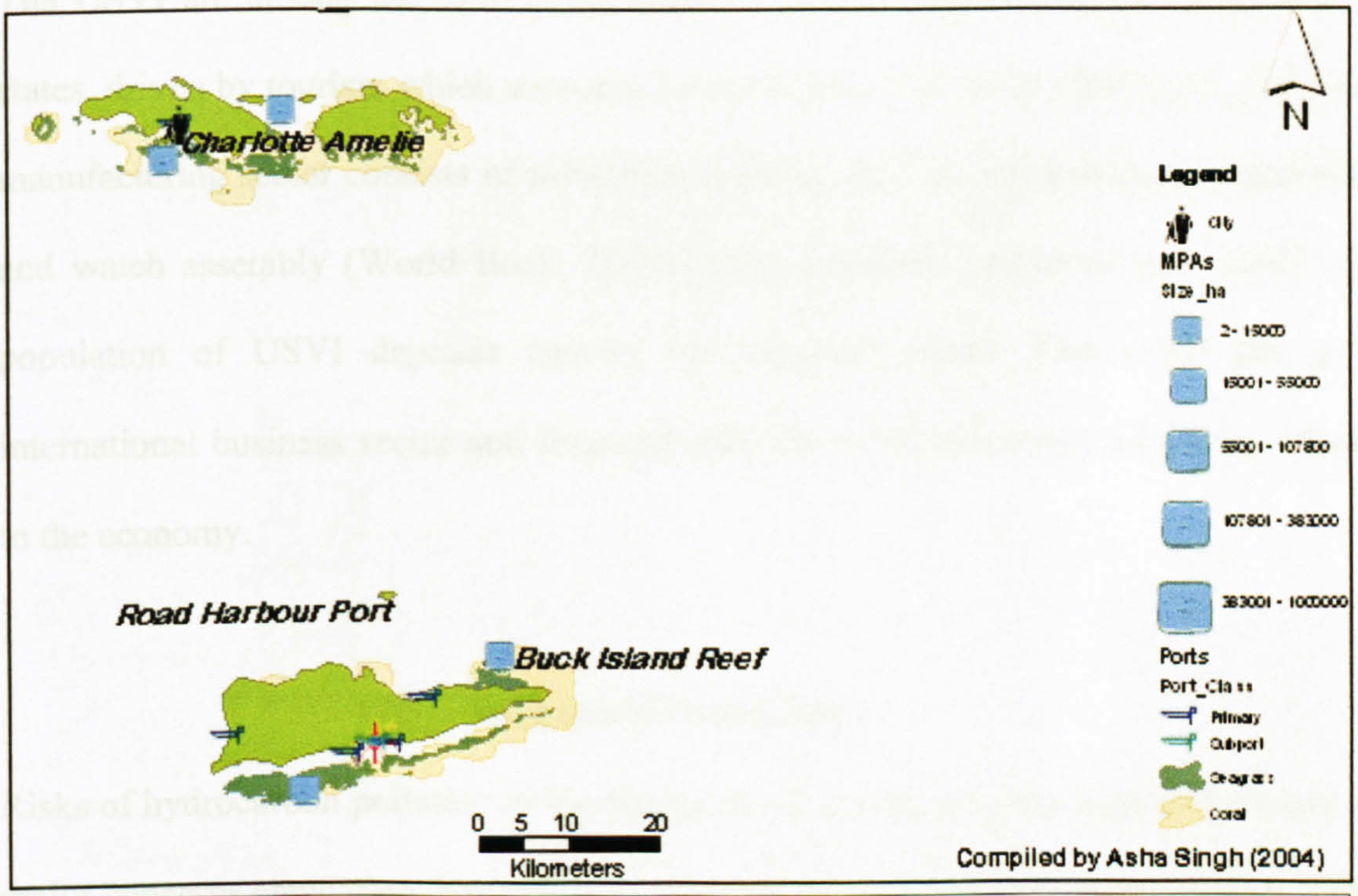
Though offshore registration of companies is a lucrative business in the BVI, it still remains heavily dependent on tourism (Procter and Fleming, 1999a), with agricultural and industrial activities contributing meaningfully to the economy (CDB, 2002c). Fruits, vegetables, livestock, poultry and fish are the main agricultural products however, this sector is conducted on a small scale due to the scarcity of water and poor soils (Anon, 1992). Rum, fish, fruits, gravel and sand are exported mostly to the U.S Virgin Islands and Puerto Rico (CIA, 2004d). The fishing sector is artisan (Walter, 1984), with a high level of sport fishing (Anonymous, 1982; Laya and Weidner, 2001b).

16.3 Localised Coastal Risk

Accelerated tourism development has resulted in the rapid depletion of coastal resources (Anon, 1992). This has caused widespread beach erosion, loss of mangroves, and damage to coral reefs and sea grass beds (Myers *et. al.*, 1993). An issue of extreme concern is marine pollution of the coastal areas. This pollution is caused by solid and liquid waste discharge from urban centres and industrial waste (Anon, 1992). Most alarming however, is the threat that these problems will increase in magnitude due to a continued tourism investments. Thus far, effective environmental policies are still lacking. The fisheries sector has witnessed a decline in catch due to over fishing (CFD, 1992). This decline also includes the tourist activity of sport fishing which is becoming an issue in the BVI (CFD, 1997).

N.B: Statistical data presented on CD: Profile_16_British_Virgin_Islands

17. U.S VIRGIN ISLANDS



Area	**352 sq km (made up of 54 islands and Cays)**
Capital	**Charlotte**
Population & Density	**Total 105 000, 298/sqkm**
Location	**18^0, 20' N, 64^0, 50' W**
Language	**English**

Figure 17: Showing Features of US Virgin Islands

17.1 General Description

The U.S Virgin Islands (USVI) are made up of a number of islands which form an overseas territory of the United States of America. The topography is mostly hilly and mountainous. Its highest point is Crown Mountain reaching a height of 474 m (VINOW, 2004). The coastline length is 188 km, with a maritime claim of 200 NM (CIA, 2004u).

The climate is subtropical which is tempered by easterly trade winds with relatively low humidity (Colon-Dieppa *et. al.*, 1998). There is little temperature variation with a rainy season from May to November (Anonymous, 2004b). The average temperature ranges from 77°F in the winter to 83°F in the summer (Department of Tourism, 2004).

17.2 Economy in Perspective

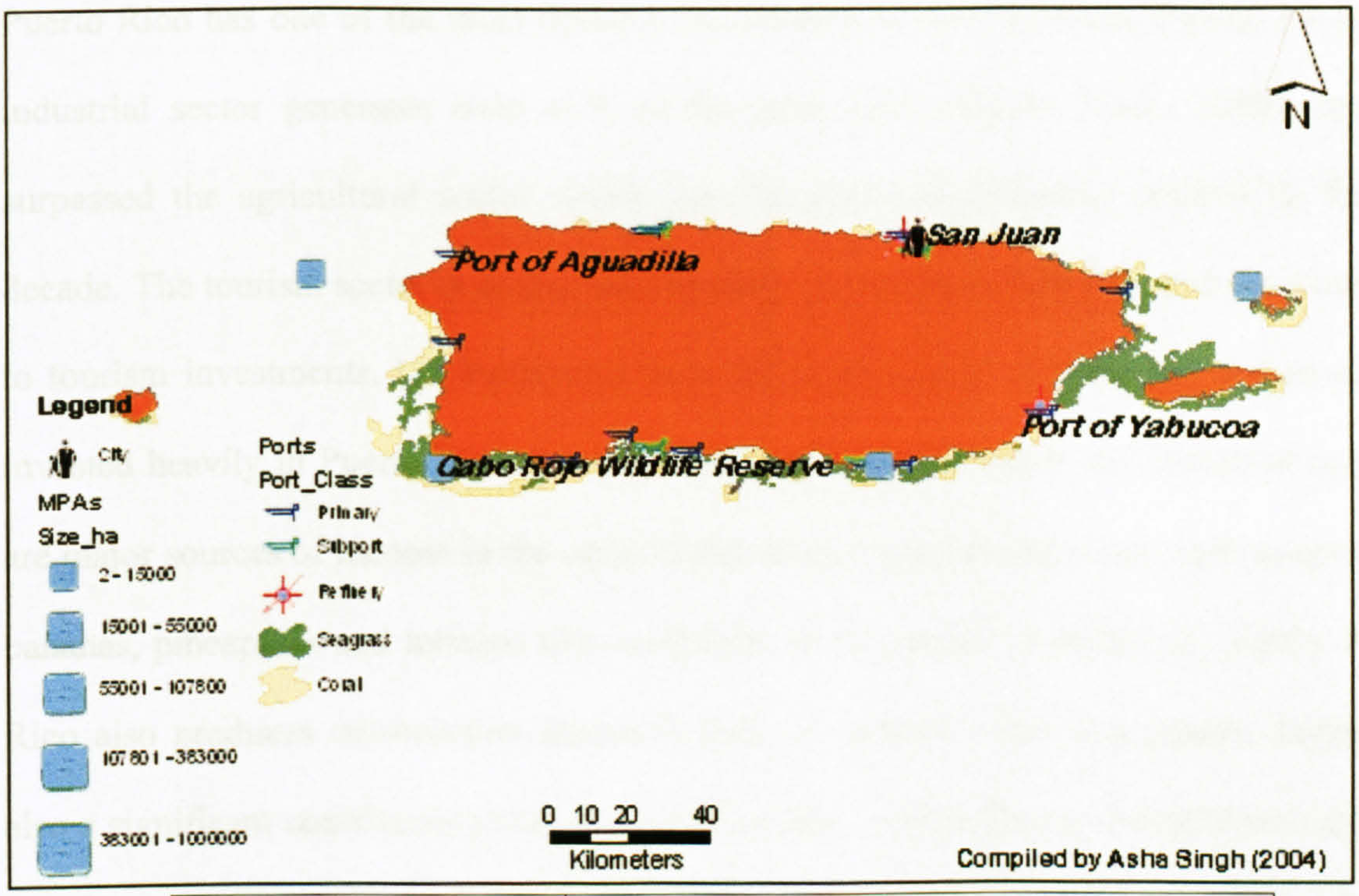
The USVI are among the most economically opulent countries of the Caribbean island states, driven by tourism which accounts for more than 70% of its GDP (CIA, 2004u). The manufacturing sector consists of petroleum refining, textiles, electronics, pharmaceuticals, and watch assembly (World Bank, 2002). The agricultural sector is very small and the population of USVI depends heavily on imported goods. The small but growing international business sector and financial offshore services provide additional incentives to the economy.

17.3 Localised Coastal Risks

Risks of hydrocarbon pollution in the marine environment are very high and are one of the major concerns emanating from the activities within this state. Data from 1967 to 2000, has revealed that approximately 40% of major spills within the Caribbean has occurred in the USVI (refer to Chapter Two). This may be attributed to the oil refinery sector in St Croix, which is one of the largest in the world. The tourism sector is progressively increasing which may lead to degradation of the nearby marine environment. Coastal development, shoreline modification, mangrove and sea grass removal, sedimentation, and sewerage are major issues in the USVI (USVI-CRI, 1999). Destructive fishing techniques and over fishing of herbivorous fish is causing stock depletion in the USVI (DeGraf and Moore, 1987).

N.B: Statistical data presented on CD: Profile_17_US_Virgin_Islands

18. PUERTO RICO



Area	**9 104 sq km**
Capital	**San Juan**
Population & Density	**Total 3 675667, 404/sqkm**
Location	**18^0,15' N, 66^0, 30' W**
Language	**Spanish**

Figure 18: Showing Features of Puerto Rico

18.1 General Description

Puerto Rico is an overseas territory of the United States of America, but has been granted a large degree of sovereignty. It is a very mountainous country, with mountain ranges extending from east to west of the island. Its highest point is Cerro de Punta at 1,338 m (Daly *et. al.*, 2003). Puerto Rico has an indented coastline of 501 km (CIA, 2004s) with full maritime claim.

The island experiences a tropical climate with little seasonal temperature change (Calversbert, 1970). The average annual temperature is 27°C with annual rainfall of 1,500 mm (National Weather Service, 2002). It has many small rivers. The northern belt is fertile while the southern belt is relatively dry (CIA, 2004s).

18.2 Economy in Perspective

Puerto Rico has one of the most dynamic economies in the Caribbean region. Its diverse industrial sector generates over 41% of the total GDP (World Bank, 2002), and has surpassed the agricultural sector which was the principal economic activity in the last decade. The tourism sector is encouraged by duty-free access to the US, and tax incentives to tourism investments. US businesses have taken advantage of these tax incentives and invested heavily in Puerto Rico since the 1950s. Dairy production and livestock products are major sources of income in the agricultural sector. Agricultural crops such as coconuts, bananas, pineapples and tobacco also contribute to this sector (FAOSTAT, 2000). Puerto Rico also produces construction materials such as cement, sand, and gravel. Tourism is also a significant contributor to the economic coffers, with millions of tourist arrivals each year, (see statistical information). Special emphasis is being placed on capitalising on the cruise market, as Puerto Rico has the second largest port for cruise ships in the world (Fontanez, 1998).

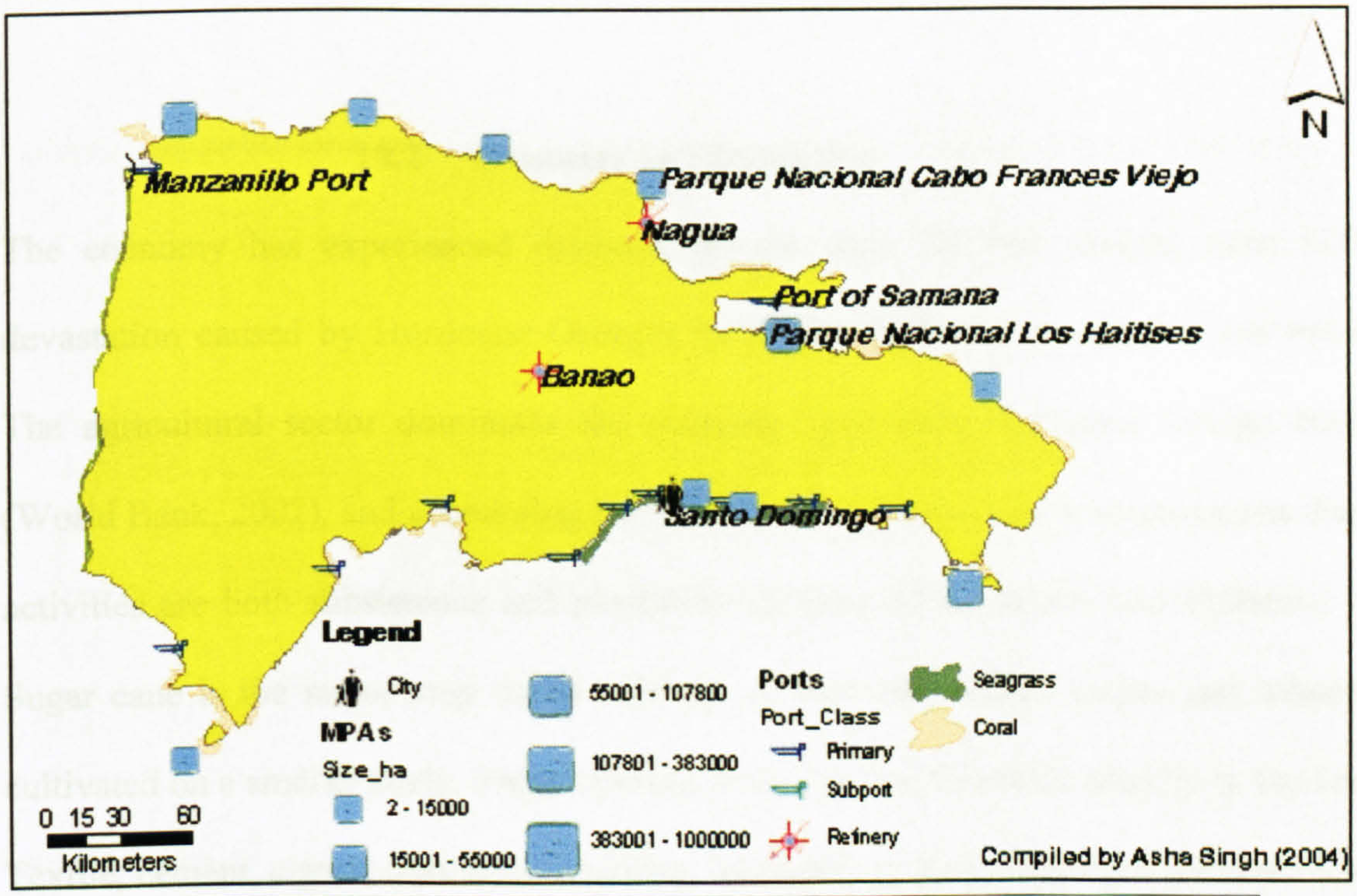
18.3 Localised Coastal Risks

Contamination and pollution of coastal areas are major concerns in Puerto Rico. Majority of the pollution emanates from the industrial sector (Hunter and Arbona, 1995). The threat to the environment has prompted local environmental movements to file court proceedings to force companies to adhere to standards, in an effort to minimise pollution (Pizzini, 2001). Another concern is that large areas of mangroves are being replaced by settlements (Martinez, 1994). The heavy emphasis on tourism, has resulted in issues such as sedimentation and beach modification (Puerto Rico-CRI, 1999). Improper sewage disposal and treatment from the resident population, is also another issue. Puerto Rico is actively diverting from many of its traditional economic sectors and as (Pizzini, 2001)wrote

> *"traditional uses of the coastal zone such as agriculture, harbours, fishing and processing plants will be replaced by tourism and leisure infrastructure, transhipment harbours, shopping malls and technology oriented enterprises."*

N.B: Statistical data presented on CD: Profile_18_Puerto_Rico

19. DOMINICAN REPUBLIC



Area	**48 730 sq km**
Capital	**Santo Domingo**
Population & Density	**Total 7 698667, 158/sqkm**
Location	**19^0, 00' N and 70^0, 40' W**
Language	**Spanish**

Figure 19: Showing Features of Dominican Republic

19.1 General Description

The Dominican Republic occupies two thirds of the island of Hispaniola, with a total coastline length of 1,228 km (CIA, 2004p) and full maritime claims. Mountains cover approximately 80% of its landscape, with the highest point being Pico Duarte at 3,174 m (Orvis, 2003).

The Dominican Republic experiences a tropical maritime climate with seasonal temperature and rainfall variations. Temperatures vary on the island. The lowlands of Dominican Republic register temperatures of approximately 23° C (Country Watch, 2005) but during the summer months, the temperature ranges between 26.7° C and 35 °C

(Anonymous, 2001a). The annual precipitation averages about 1525 mm (Encarta, 1994). The mountainous areas of the north receive more moisture due to the elevation.

19.2 Economy in Perspective

The economy has experienced dramatic growth over the last decade, even with the devastation caused by Hurricane Georges in 1998, which almost crippled the economy. The agricultural sector dominates the economy, providing the most foreign exchange (World Bank, 2002), and accounting for nearly half of the country's employment. Farming activities are both subsistence and plantation systems (Ureta-Bravo and Pinheiro, 1997). Sugar cane is the major crop under cultivation. Bananas, coffee, cocoa and tobacco are cultivated on a smaller scale. Sugar refining is the leading industrial activity in the country. Textile, cement, cigars, cigarettes, fertilizer, molasses, refined petroleum, processed wheat, and rice make up the ever expanding industrial sector. The Dominican Republic has become the fifth largest exporter of textiles in the world (CIA, 2004p). The fishing industry is relatively small involving mostly demersal fishing (Weidner *et. al.*, 2001a). Tourism is a steadily growing industry which contributed approximately 24% of the national GDP in 1999 (Goodwin *et. al.*, 2004).

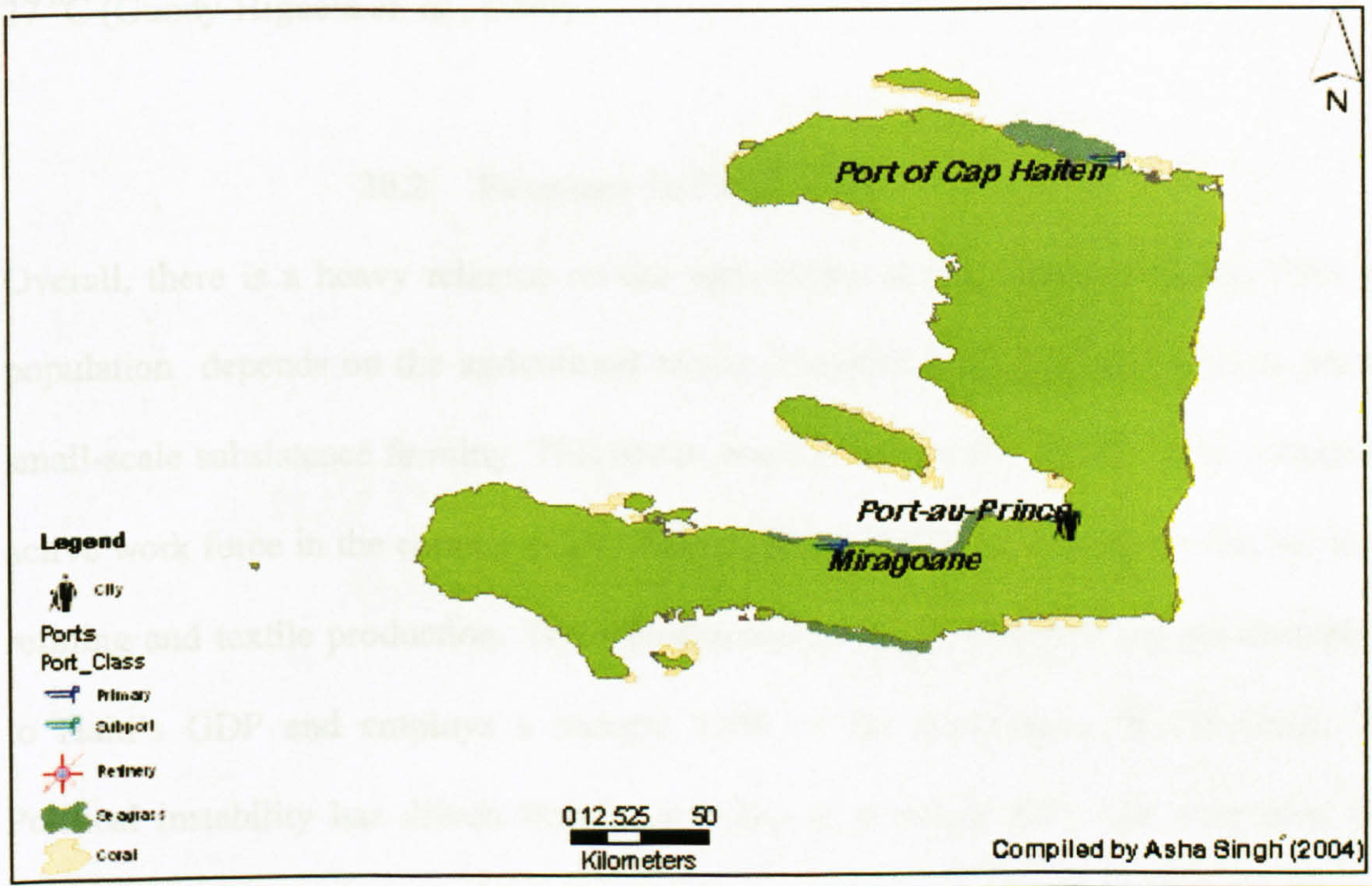
19.3 Localised Coastal Risk

An assessment carried out in the 1980s revealed that only 14% of the country's surface area was covered by forest (Comprehensive Research Inventory and Evaluation System Project, 1984; Brothers, 1997). It is estimated that 20% of the country's total energy needs are supplied by wood (World Bank, 2002). Population pressure due to settlement and agriculture are contributing to forest loss. Research conducted by Sambrook and others in 1999 shows a direct correlation between an increase in population and deforestation (Sambrook *et. al.*, 1999). Deforestation and the present agricultural practices are causing soil erosion and serious sedimentation problems in the coastal waters (IDRC, 2003). To date, there is evidence of coral reef death as a result of sedimentation (Anonymous, 2003b; Rajkumar and Khan, 2003).

Pollution from domestic sewerage continues to be a major problem (Villasol *et. al.*, 1998; Mercada and Lassoie, 2002), with only 27% of the country's nine million people are connected to sewerage systems. The sewerage systems are old and non-functional, according to a study done by PAHO in the early 1990s (UNEP, 1994). In some areas in the Dominican Republic sewerage is being discharged directly into the sea without any form of treatment. Other sources of marine pollution are caused by industries and agrochemicals discharges (Siung-Chang, 1997; Lynch, 1998). These forms of pollution are threat to the ecosystems and water quality of the Caribbean Sea. Solid waste is also a major issue due to of poor collection systems. Huge amounts of solid waste finds its way into the marine environment.

N.B: Statistical data presented on CD: Profile_19_Dominican_Republic

20. HAITI



Area	**27 750 sq km**
Capital	**Port –au-Prince**
Population & Density	**Total 7 468000, 269/sqkm**
Location	**80^0, 20' N 74^0, 30' W**
Language	**French**

Figure 20: Showing Features of Haiti

20.1 General Description

Haiti is an independent island occupying the western end of the island of Hispaniola. It has a 1,771 km of coastline (CIA, 2004r). Over eighty-five percent of this country is mountainous terrain (Pelleck, 1990), with over sixty two percent having a slope greater than 20 degrees (Pelleck, 1992; Smith, 2001).

Haiti's location has fostered a climate that can best be described as being sandwiched between tropical and warm temperate regions (Ministère De L'Environnement, 2001). The climate is heavily influenced by its mountainous terrain (Elrlich *et. al.*, 1986). Area specific rainfalls are influenced largely by orographic factors and as such, the northwest of the island experiences less than 400mm of rain per annum (Weins and Sobrado, 1998). Rainfall in the mountains of the southwest region measures nearly 3,000mm (Ministère De

L'Environnement, 2001). The average temperature in the coastal lowlands ranges from 25-27 ^{0}C (Gundy-Higuera *et. al.*, 1999).

20.2 Economy in Prospective

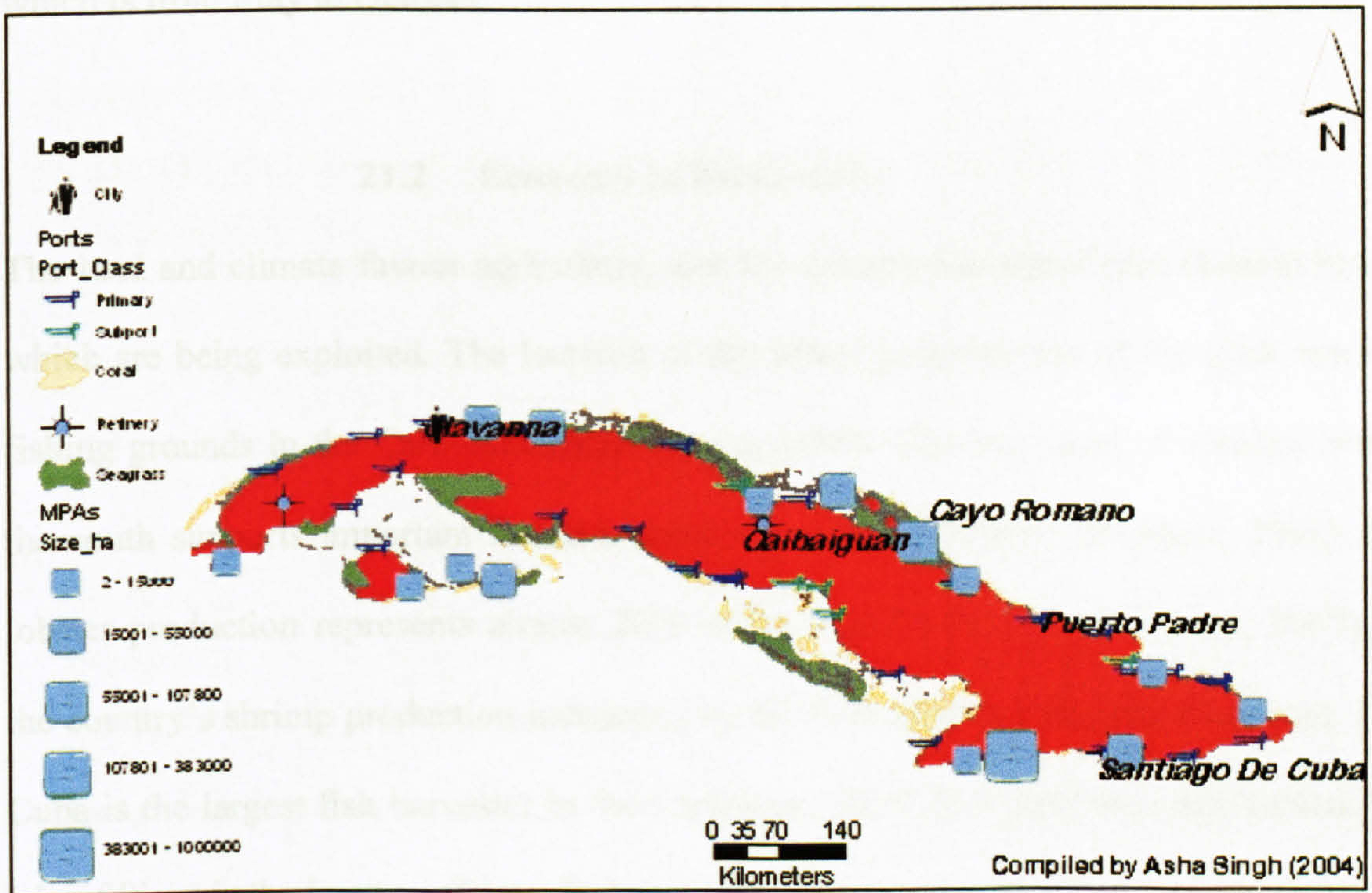
Overall, there is a heavy reliance on the agricultural sector. Approximately, 70% of the population depends on the agricultural sector (Lundahl, 1983), which consists mainly of small-scale subsistence farming. This sector employs about two thirds of the economically active work force in the country (CIA, 2004r). The industrial activities are limited to sugar refining and textile production. The manufacturing sector contributes approximately 15% to Haiti's GDP and employs a meagre 5.8% of the population (World Bank, 2002). Political instability has driven Haiti's economy to a virtual halt. The loss of a vibrant economic base has made Haiti the poorest country in the western hemisphere.

20.3 Localised Coastal Risk

The extensive harvest of trees and shrubs for firewood and charcoal for fuel has devastated Haiti's forests. To date, almost 98 % of the forest has disappeared (Beauval, 2000; Bracken, 2004). This trend of deforestation is described as an "ecological time bomb" (Ross, 2004). Expansion of the agricultural lands (Bethell, 2002), into inappropriate slopes is causing serious erosion and deforestation problems (Pelleck, 1992; Anonymous, 2002a). Inappropriate cultivation techniques are being used which are exacerbating the condition. The disregard of soil conservation practices are causing increase sedimentation of coastal habitats (MDE, 1999). Sewerage systems and sewerage treatment are immensely inadequate, however no information exists on the implications of the lack of sewerage treatments on the marine environment. The ever-increasing population growth is exerting a strain on the resources which is a catalyst for environmental problems in the absence of active policies.

N.B: Statistical data presented on CD: Profile_20_Haiti

21. CUBA



Area	**110 860 Sq km**
Capital	**Havana**
Population & Density	**Total 10, 931333, 99/sqkm**
Location	**21^0, 30' N,80^0, 00' W**
Language	**Spanish**

Figure 21: Showing Features of Cuba

21.1 General Description

Over 1,600 islands and cays (Anonymous, 2001c) make up the state of Cuba, which is the largest island in the Caribbean area. It has a coastline length of 3, 735 km (CIA, 2004o), and a fully extended maritime claims. About a fourth of Cuba is mountainous. These mountainous areas are scattered throughout the island, with its highest point being Pico Turquino at 2,005 m (Schwartz and Hedges, 1991). Cuba is approximately 1,200 km long and 100 km wide. The width of the island varies greatly with an acceding narrow shape in the west.

The climate is moderate sub-tropical (Rios and Cardenas, 2003), with a mean annual temperature of 25 ^{0}C (Anonymous, 2001c). The annual rainfall averages about 1,375 mm

(Naranjo and Cantelle, 1998). Approximately, 60 % of the rain falls during the wet season, which is from May to October.

21.2 Economy in Perspective

The land and climate favour agriculture, and the country has significant mineral reserves, which are being exploited. The location of the island provides one of the most rewarding fishing grounds in the Caribbean SIDS (Joyce, 1996). The large area of shallow water to the south supports important fisheries such as, a lobster fishery (Weidner, 2001). Spiny lobster production represents almost 20% of the world's production (Brisre, 2000), with the country's shrimp production increasing by 60 % in 1998 (Carillo and Contreras, 1998). Cuba is the largest fish harvester in the Caribbean SIDS, (see statistical information). The Isle of Pines is the largest offshore fisheries area in Cuba.

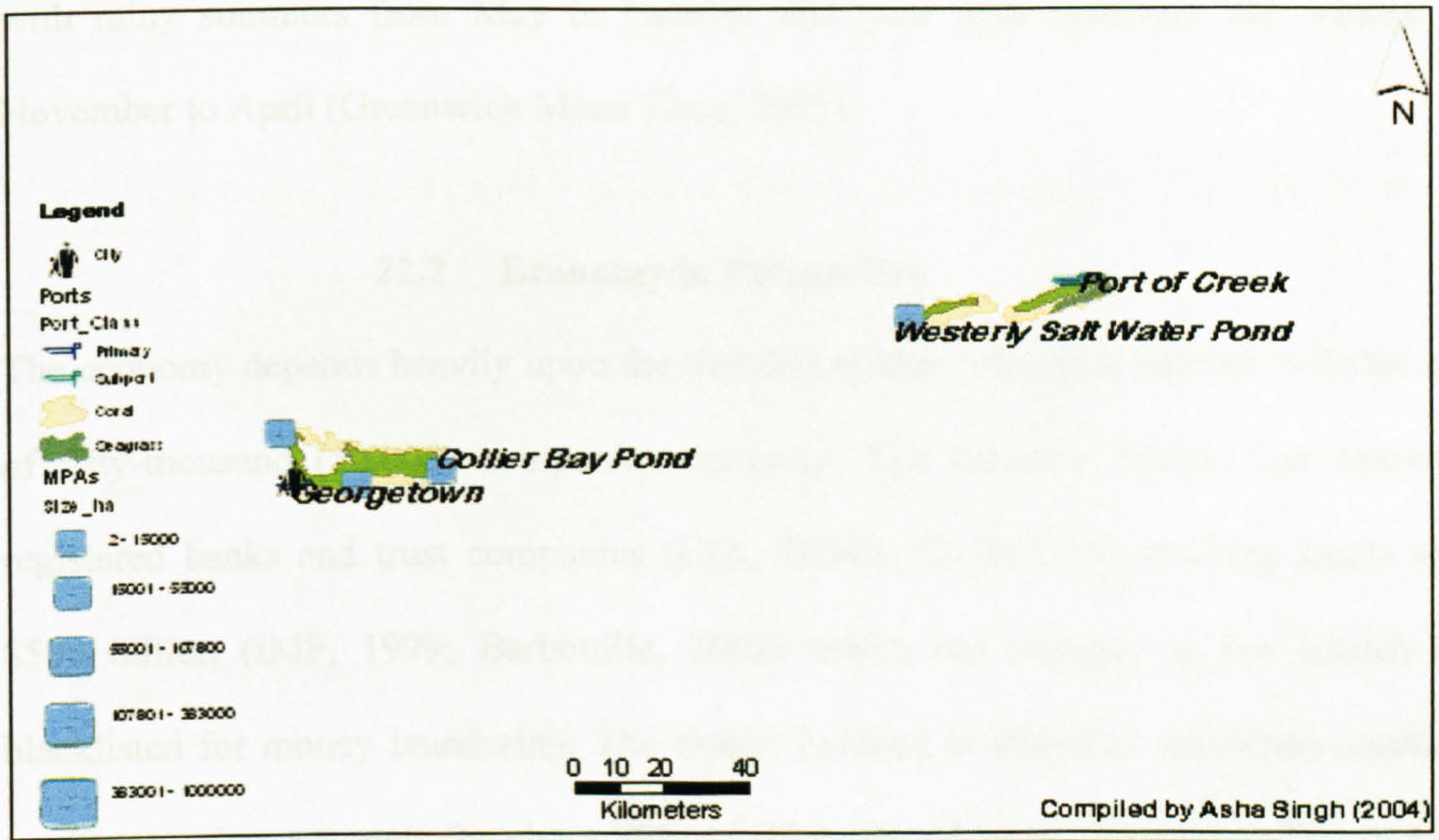
Agriculture, which is mainly sugar cane and tobacco production, was the main economic earner to 1990. This sector has declined drastically and now only contributes approximately 7% to the GDP. The industrial and manufacturing sectors contribute 34.5% to the GDP (World Bank, 2002). The manufacturing sector encompasses the production of cement, agricultural machinery, biotechnology, fertilizer, chemicals and nickel. The services sector contributed an estimated amount of 57.9% to the GDP in 2002 (CIA, 2004o). In the past, tourism has suffered from international sanctions however, this sector is now regaining momentum in the economy, with a growth of 51% in 2004 (CIA, 2004o). In 1996, tourism accounted for 36% of the GDP mainly from excursionists and tourists (Espino, 2000). Overall it has become the leading economic earner since 1994 (Gallo and Tijerina, 2002).

21.3 Localised Coastal Risks

Cuba's coastline is extensively indented with cones and bays. It is bordered by coral reefs and mangroves swamps, with more than 280 white sand beaches. The rapid increase in marine and urban development, especially in the first half of the nineteen century has caused severe damage to the marine environment (Villasol *et. al.*, 1998). Studies conducted in the early 1980s, revealed that the marine environment are severely polluted (PNUD-PNUMA-UNESCO, 1985), particularly the Bay of Havana and Santiago de Cuba. Despite efforts to aid in the recovery of these bays, they are still regarded as the most heavily polluted areas in Cuba (Villasol *et. al.*, 1997; Beltran *et. al.*, 1998). To date, Cuba's major environmental problems are nutrient load, solid waste, oil pollution, and heavy metal contamination (Anonymous, 2001c). Most of the sewerage is discharged into Havana Bay without treatment, hence accounting for the high level of ammoniac nitrogen, nitrates, nitrites, phosphorous, and faecal coliform (UNEP, 1989, 1994). Havana Bay is a direct outflow into the Caribbean Sea causing of the sea. Ships are a major source of pollution in Cuba. Contamination of beach zones by tar balls is evident (Palacios, 1997).

N.B: Statistical data presented on CD: Profile_21_Cuba

22. CAYMAN ISLANDS



Area	**262 sq km**
Capital	**George Town**
Population & Density	**Total 31 333, 119/sqkm**
Location	**19^0, 30' N,80^0, 30' W**
Language	**English**

Figure 22: Showing Features of Cayman Islands

22.1 General Description

The state of the Cayman Islands comprised three islands - Grand Cayman, Little Cayman and Cayman Brac, with the largest being Grand Cayman. It has a coastline of 160 km and 212 NM of maritime claims (CIA, 2004l). The islands are limestone in nature (Jones, 1994), surrounded by coral reef. The Cayman Islands are some of the smallest and most isolated of the Caribbean islands. These islands sit on emerging projections of the Cayman ridges in the Caribbean Sea (Stoddart, 1980). Grand Cayman is the largest and most developed of the islands (Procter and Fleming, 1999b). "The bluff" is the most outstanding feature rising along the length of the Cayman Brac, and reaching a height of over 40 m (Williams, 1995) at the east of the island before falling in a shear cliff into the sea. Little Cayman is about 8 km west of the Cayman Brac and is the lowest lying of the three main islands. Mangrove swamps and dry woodland forest dominates the landscape of the Cayman Islands (Burnt and Burton, 1994). The Cayman Islands experiences a semi humid tropical marine climate, which is highly moderated by the sea (Burton, 1994). It is warm with rainy summers from May to October and cool with relatively dry winters from November to April (Greenwich Mean Time, 2005)

22.2 Economy in Perspective

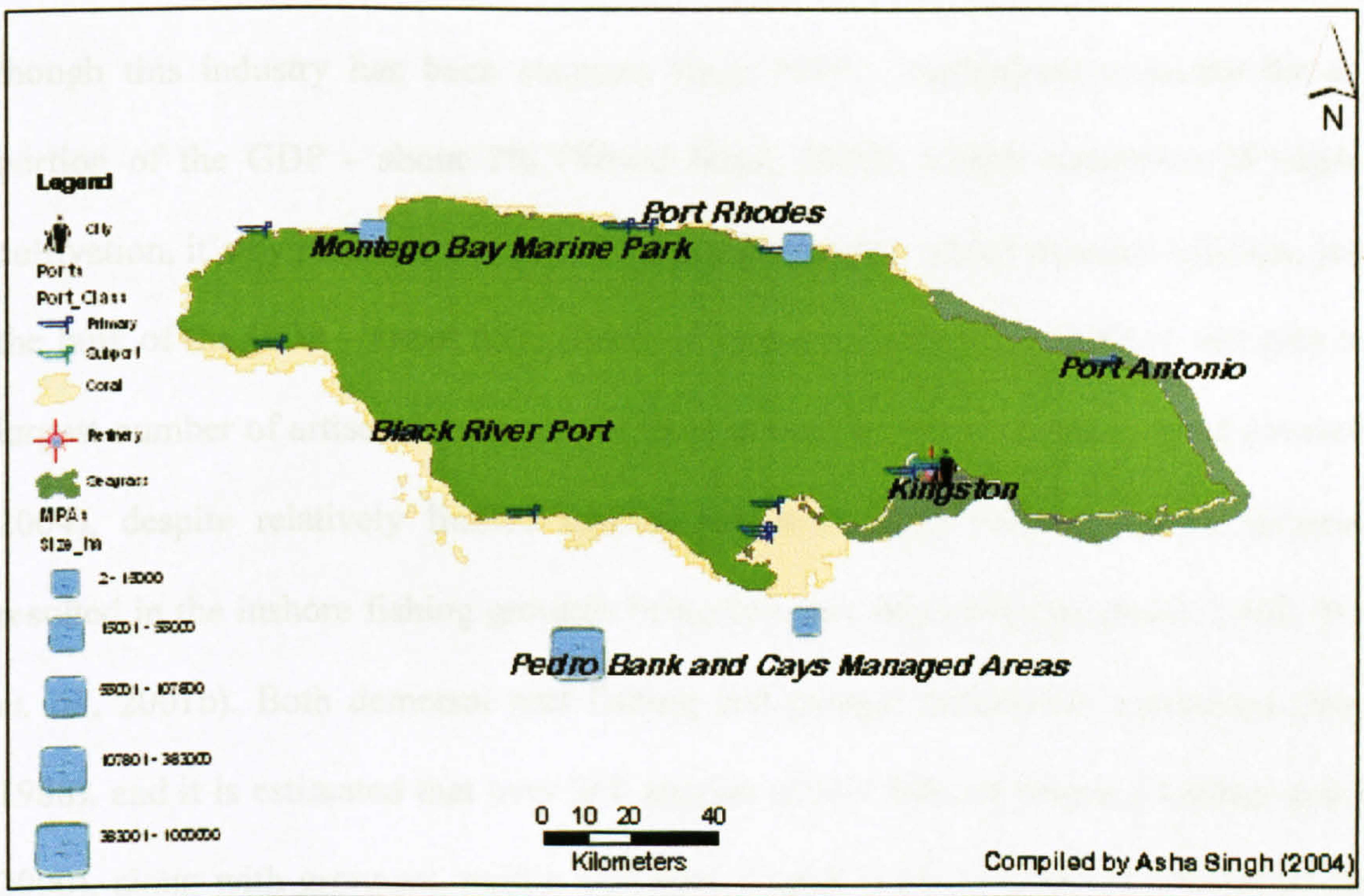
The economy depends heavily upon the thriving offshore financial centres, with an excess of fifty-thousand (50,000) companies currently. The Cayman Islands has almost 615 registered banks and trust companies (CIA, 2004l). To date, the banking assets exceed $500 billion (IMF, 1999; Barbouille, 2002) which has resulted in the islands being blacklisted for money laundering. The tourist industry is aimed at the luxury market. At present, tourism accounts for about 70% of GDP (World Bank, 2002) and 75% of foreign currency earnings (CDB, 2002d). The importation rate is exceedingly high, since approximately 90% of the island's food and consumer goods are imported. The Cayman Islands have one of the highest outputs per capita and one of the highest standards of living in the world.

22.3 Localised Coastal Risks

The Cayman Islands have extensive areas of turtle grass which surrounds the three islands. The extensive area of turtle grass provides a habitat for a population of turtles and other biodiversity (Ebanks-Petrie, 1993). About 60% of the 80 sq km to the north of Grand Cayman is covered with turtle grass (*Thalassia testudium*) interspersed with green algae of the genera *Halomeda penicillus* and *Rhipocephalius,* as well as an abundant population of bivalve molluscs, which provides food for turtles feed (Rigby and Roberts, 1976; Burgess *et. al.*, 1994). The entire population of the Cayman Islands live on the coast. This settlement pattern coupled with the large tourism sector have placed a heavy strain on coastal resources. As such, the coral reefs are suffering from pollution and sedimentation among other factors (Bush, 2000).

N.B: Statistical data presented on CD: Profile_22_Cayman_Islands

23. JAMAICA



Area	**10 939 sq km**
Capital	**Kingston**
Population & Density	**Total 2 473667, 226/sqkm**
Location	**18^0,15' N and 77^0, 30' W**
Language	**English**

Figure 23: Showing Features of Jamaica

23.1 General Description

Jamaica is a mountainous country, except for the lowland coastal areas. It is about 250 km long and 75 km at its widest point. It has a narrow coastal plain with many bays, except along the southern coast. This southern coast has extensive flatlands. Jamaica is mostly limestone in nature (NEPA, 2003), with the highest area being the Blue mountain peak at 2256m (Hodges, 1993). It has a coastline length of 1,022 km (CIA, 2004g) and full maritime claims.

The climate is tropical with little seasonal temperature changes influenced by north and northeast trade winds (Evans, 1973). The average temperature is about 27° C in the lowlands and 22 °C in the mountains (NRCA, 2001). Annual rainfall on the coast and mountainous areas is about 818 mm and 5080mm respectively (Gupta and Amhad, 1999).

23.2 Economy in Perspective

The economy depends heavily on tourism, manufacturing and on a smaller scale bauxite, though this industry has been stagnant since 1995. Agriculture accounts for a small portion of the GDP - about 7% (World Bank, 2002), which comprises of sugar cane cultivation, it's by products and rice. The services sector, which includes tourism, provides the bulk of the GDP – about 65% (Bank of Jamaica, 2003; CIA, 2004g). Jamaica has the largest number of artisan fishermen (14,014) in the Caribbean (CARICOM Fisheries Unit, 2004), despite relatively limited coastal resources. This limited coastal fisheries has resulted in the inshore fishing grounds being severely depleted (Haughton, 1988; Weidner *et. al.*, 2001b). Both demersal reef fishing and pelagic fishing are conducted (Weidner, 1988), and it is estimated that over 200 species of reef fish are targeted (Aiken and Kong, 2000), along with groupers, marlin and tuna. Conch is also a targeted species in Jamaica but has severely declined (Aiken *et. al.*, 1999). The fisheries sector is small (Mattis-Davis and Young, 2001) in terms of its economic contribution.

23.3 Localised Coastal Risks

Coastal mangroves and wetlands are constantly being destroyed due to development of hotels and marinas (NRCA, 1997; Cesar *et. al.*, 2000). Deforestation (Evelyn, 1997; Evelyn and Camirand, 2003), heavy metal contamination (Knight *et. al.*, 1997), marine pollution from industries, agriculture, mining, poor sewerage systems, sedimentation, and solid waste are all environmental problems that have plagued Jamaica's marine environment (NRCA, 2001). These problems have already taken its toll on the marine ecosystems. Important sea grass and reef systems have already being lost (Jameson *et. al.*, 1995). This occurred in polluted areas such as Discovery Bay (Haley and Clayton, 2003) and Kingston Harbour (Wade, 1976; Villasol *et. al.*, 1998). Disposal of waste and untreated wastewater and sewage into the sea in the vicinity of Kingston has severely curtailed diving, leading to a substantial reduction in visitors to the area (Dixon *et. al.*, 2001). In the mid 1990s, beaches in Kingston such as Forum and Port Royal were rendered unsuitable for recreation and were closed due to poor water quality. The closure of these beaches to tourism activities resulted in the closure of Oceana and Forum hotels (Keith Mitchell *pers. comm.*). Overfishing of the reefs is also a noted concern for this country.

N.B: Statistical data presented on CD: Profile_23_Jamaica

APPENDIX TWO

Grouping the Islands by Levels for the Economic Sectors

Percentile Calculation for the Economic Sectors

Urban Population, Agriculture, Energy, Industry, Tourism, Fisheries

FISHERIES

Rank	Country	Av. Marine Fish Prod	%
1	Cuba	66519.18	100.00
2	Trinidad & Tobago	12048.45	95.00
3	Dominican Republic	9442	90.00
4	St Vincent & Grenadines	9161.636	85.00
5	Guadeloupe	8531.364	80.00
6	Jamaica	5875.182	75.00
7	Martinique	4895.636	70.00
8	Haiti	3675.455	65.00
9	Barbados	3109.636	60.00
10	Puerto Rico	1758.818	55.00
11	Grenada	1678.364	50.00
12	Antigua & Barbuda	1417.455	45.00
13	St Lucia	1260.727	40.00
14	Dominica	915.2727	35.00
15	US Virgin Islands	666.7273	30.00
16	British Virgin Islands	302.4545	25.00
17	St Kitts & Nevis	260.4545	20.00
18	Aruba	234.0909	15.00
19	Anguilla	202.6364	10.00
20	Cayman Islands	122.2727	5.00
21	Montserrat	42.45455	0.00

Percentile Rank for Fisheries

AGRICULTURE

Rank	Country	Av. Agriculture Area	%
1	Cuba	6821727.273	100.00
2	Dominican Republic	3628454.545	94.70
3	Haiti	1402090.909	89.40
4	Jamaica	495636.3636	84.20
5	Puerto Rico	334454.5455	78.90
6	Trinidad & Tobago	132636.3636	73.60
7	Guadeloupe	51545.45455	68.40
8	Martinique	34000	63.10
9	St Lucia	20000	57.80
10	Barbados	19000	52.60
11	Dominica	17454.54545	47.30
12	St Vincent & Grenadines	13000	42.10
13	Grenada	12090.90909	36.80
14	Antigua & Barbuda	12000	31.50
15	St Kitts & Nevis	10454.54545	26.30
16	US Virgin Islands	10181.81818	21.00
17	British Virgin Islands	9000	15.70
18	Montserrat	3000	10.50
19	Aruba	2000	0.00
19	Cayman Islands	2000	0.00

Percentile Rank for Agriculture

ENERGY

Rank	Country	Av. Fossil Fuel Used	Percent
1	Cuba	66112756	100.00%
2	Puerto Rico	63080518	94.70%
3	Dominican Republic	28632343	89.40%
4	Jamaica	21230709	84.20%
5	US Virgin Islands	20996424	78.90%
6	Trinidad & Tobago	8077566	73.60%
7	Martinique	4426076	68.40%
8	Guadeloupe	4079767	63.10%
9	Barbados	3216130	57.80%
10	Haiti	2501033	52.60%
11	Aruba	1838271	47.30%
12	Antigua & Barbuda	1168215	42.10%
13	Cayman Islands	813909.1	36.80%
14	St Lucia	524724.5	31.50%
15	Grenada	416050	26.30%
16	St Vincent & Grenadines	315477.3	21.00%
17	St Kitts & Nevis	227469.1	15.70%
18	Dominica	191604.5	10.50%
19	British Virgin Islands	139470.9	5.20%
20	Montserrat	110250	0.00%

Percentile Rank for Fossil Fuel

INDUSTRIES

Rank	Country	Av. Contribution	%
1	Trinidad & Tobago	32.78889	100.00
2	Jamaica	22.30909	92.30
3	St Kitts & Nevis	10.95556	84.60
4	Dominica	8.777778	76.90
5	St Vincent & Grena-dines	8.244444	69.20
6	Grenada	7.333333	61.50
7	Barbados	7.255556	53.80
8	St Lucia	6.844444	46.10
9	Antigua & Barbuda	4.011111	38.40
10	Montserrat	3.277778	30.70
11	Aruba	3.183333	23.00
12	The Cayman Islands	2.2	15.30
13	Anguilla	1.836364	7.60
14	BVI	1.411111	0.00

Percentile Rank for Industrial

TOURISM

Rank	Country	Av. Cruise Arrivals	%
1	US Virgin Islands	1360091	100.00
2	Puerto Rico	1066925	95.80
3	Cayman Islands	717700	91.60
4	Jamaica	642827.3	87.50
5	St Marteen	620948.2	83.30
6	Barbados	455290.9	79.10
7	Martinique	395354.5	75.00
8	Guadeloupe	338018.2	70.80
9	Antigua & Barbuda	280318.2	66.60
10	Aruba	266681.8	62.50
11	Haiti	253960	58.30
12	St Lucia	236263.6	54.10
13	Grenada	220954.5	50.00
14	Curacao	194409.1	45.80
15	Dominican Republic	155488.9	41.60
16	Dominica	146809.1	37.50
17	British Virgin Islands	119845.5	33.30
18	St Kitts & Nevis	101363.6	29.10
19	Anguilla	76816.36	25.00
20	St Vincent & Grenadines	65254.55	20.80
21	Trinidad & Tobago	46018.18	16.60
22	Bonaire	17052	12.50
23	Saba	11351	8.30
24	Montserrat	8600	4.10
25	St Eustatius	6850.667	0.00

Percentile Rank for Cruise Passenger

TOURISM

Rank	Country	Av. Stayover Visitors	%
1	Puerto Rico	3010667	100.00
2	Dominican Republic	2018000	96.00
3	Jamaica	1153000	92.00
4	Cuba	936666.7	88.00
5	Aruba	591000	84.00
6	Guadeloupe	524666.7	80.00
7	US Virgin Islands	508000	76.00
8	St Marteen	475333.3	72.00
9	Barbados	473000	68.00
10	Martinique	421666.7	64.00
11	Cayman Islands	322666.7	60.00
12	Trinidad & Tobago	284666.7	56.00
13	Antigua & Barbuda	251000	52.00
14	B V Islands	220000	48.00
15	St Lucia	214000	44.00
16	Curacao	211333.3	40.00
17	Haiti	143000	36.00
18	Grenada	104333.3	32.00
19	St Kitts & Nevis	75000	28.00
20	St Vincent & Grenadines	62333.33	24.00
21	Dominica	58333.33	20.00
22	Bonaire	49000	16.00
23	Anguilla	38000	12.00
24	Montserrat	14000	8.00
25	Saba	9500	4.00
26	St Eustatius	9000	0.00

Percentile Rank for Stayover Visitors

APPENDIX THREE

The Calculated Territorial Claims for the Islands using GIS

Country	Calculated Territorial Claims (NM)
Aruba	12
Trinidad and Tobago	24
Grenada	12
St Vincent and the Grenadines	12
Barbados	24
St Lucia	12
Martinique	12
Dominica	12
Guadeloupe	12
Montserrat	12
Antigua and Barbuda	12
St Kitts and Nevis	12
Anguilla	12
British Virgin Islands	12
US Virgin Islands	12
Puerto Rico	24
Dominican Republic	24
Haiti	24
Cuba	24
Cayman Islands	24
Jamaica	24

APPENDIX FOUR

Percentile Calculation for the Spatial Pressures

Calculated Spatial Pressure –Cruise Tourism

Country	Coastline Length (km)	*passenger/Area (#/km)*	*Percent*	*Ranking Used*
St Marteen	24	36179	100.00%	High
US Virgin Islands	188	9406	95.20%	High
Aruba	68.5	7155	90.40%	High
Cayman Islands	160	6443	85.70%	High
Barbados	97	5498	80.90%	High
St Lucia	158	2808	76.10%	High
Antigua & Barbuda	153	2807	71.40%	Medium
Puerto Rico	501	2695	66.60%	Medium
B V Islands	80	2356	61.90%	Medium
Curacao	180	1713	57.10%	Medium
Dominica	148	1620	52.30%	Medium
Grenada	121	1490	47.60%	Medium
Anguilla	61	1375	42.80%	Medium
Guadeloupe	306	1282	38.00%	Medium
St Kitts & Nevis	135	1219	33.30%	Medium
St Vincent & Grenadines	85	1014	28.50%	Medium
Jamaica	1022	888	23.80%	Low
Martinique	350	818	19.00%	Low
St Eustatius	17	488	14.20%	Low
Bonaire	136	320	9.50%	Low
Trinidad & Tobago	362	288	4.70%	Low
Dominican Republic	1228	149	0.00%	Low

Calculated Spatial Pressure-fisheries

Country	*Fish/area (mt/km)*	*Percent*	
St Vincent & Grenadines	8.03628545	100.00%	High
Guadeloupe	1.125425404	95.00%	High
Martinique	0.55989906	90.00%	High
Trinidad & Tobago	0.400671125	85.00%	High
Grenada	0.388827314	80.00%	High
St Lucia	0.353528207	75.00%	High
Jamaica	0.350173999	70.00%	Medium
Barbados	0.294708495	65.00%	Medium
Dominica	0.247882402	60.00%	Medium
Antigua & Barbuda	0.2350506	55.00%	Medium
Cuba	0.186005523	50.00%	Medium
Dominican Republic	0.124264765	45.00%	Medium
St Kitts & Nevis	0.085455192	40.00%	Medium
Puerto Rico	0.076520953	35.00%	Medium
Anguilla	0.06190849	30.00%	Medium
Aruba	0.053021973	25.00%	Low
US Virgin Islands	0.046073578	20.00%	Low
Haiti	0.044745458	15.00%	Low
Montserrat	0.020484976	10.00%	Low
British Virgin Islands	0.010210906	5.00%	Low
Cayman Islands	0.009385024	0.00%	Low

Calculated Spatial Pressure -Agriculture

Country	*% of Agriculture Area (sq km)*	*Percent*	
Dominican Republic	76	100.00%	high
Cuba	60	94.70%	high
BVI	59	89.40%	high
Haiti	50	84.20%	high
Jamaica	46	78.90%	high
Barbados	44	73.60%	medium
St Kitts & Nevis	38	68.40%	medium
Grenada	35	63.10%	medium
St Vincent & Grenadines	33	57.80%	medium
Puerto Rico	32	52.60%	medium
St Lucia	31	47.30%	medium
Martinique	30	42.10%	medium
Montserrat	29	36.80%	medium
US Virgin Islands	28	31.50%	medium
Guadeloupe	28	26.30%	medium
Antigua & Barbuda	27	21.00%	low
Trinidad & Tobago	25	15.70%	low
Dominica	23	10.50%	low
Aruba	10	5.20%	low
Cayman Islands	8	0.00%	low

APPENDIX FIVE

Head Tax Debate

St. Maarten denies CTO conference boycott

Thursday, October 16, 2003

PHILIPSBURG, St. Maarten: St. Maarten's Economic Affairs and Tourism Commissioner, Mr. Theo Heyliger, has denied boycotting the 26th Annual Caribbean Tourism Organization (CTO) conference in St. Thomas. "Going or not going to that conference had nothing to do with boycotting. It is not that I didn't want to go. I would have loved to go," he told the Daily Herald today. He denied that St. Maarten wasn't represented at the CTO conference because of the proposal of a US$20 head tax. But the tourism official acknowledged that the levy is clearly not in the best interest of St. Maarten.

The levy being championed by the Caribbean Tourism Organisation as part of efforts to create a sustainable fund to market the Caribbean in global tourism. The proposal has its roots in the private sector and is under consideration by several regional governments. Should St. Maarten decide to implement a US$20 levy or "head tax" for cruise visitors, it could spell economic disaster for the island and its cruise product, said Mr. Heyliger.

Antigua has already rejected the proposal while Dominica is expected to soon follow with a similar announcement. Antigua has built a second pier that can hold four ships, St. Kitts has a pier for two ships and St. Thomas has signed a five-year contract with the Florida-Caribbean Cruise Association (FCCA) agreeing not to raise the head tax in return for a guarantee of an annual growth of 10 per cent. "We have to realize that we are getting more and more competition in the region, competition that is against and will not implement any cruise levy," Mr. Heyliger told the Herald.

"If we lose 60 to 70 per cent, and they pick it up, who are we helping? It means less business for the taxis, for Philipsburg, everybody on this island. It took a lot of effort and time to grow this cruise market into what it is today. Don't take it for granted."

Taken from Caribbean Net News from the Caribbean as of Friday July 29, 2005

http://www.caribbeannetnews.com/2003/10/16/boycott.htm

Tourism conference in St. Thomas concludes with no consensus on head tax

Sunday, October 19, 2003

CHARLOTTE AMALIE, U.S. Virgin Islands: St. Vincent & the Grenadines, Mr. Prime Minister Ralph Gonsalves, yesterday stopped short of saying he approved of the US$20 cruise ship levy instead telling industry officials at the close of the travel conference that the cruise industry should be required to help pay for services ranging from police to garbage collection in different countries. "They are reluctant to provide a fair and reasonable contribution," AP last night quoted Mr. Gonsalves as saying. "We have to engage the cruise ship companies to do somewhat better."

The proposed tax has drawn fire from cruise officials who say it would reduce demand for the industry by increasing ticket prices. Members who support the proposed tax hope it will generate more than US$60 million (EC$160 million) in annual revenue that could be reinvested into the region's tourism industry.

Much of the conference focused on the cruise industry, which accounted for 9 percent of the Caribbean's US$20 billion (EC$53 billion) in revenue last year. The proposed levy comes at a time when island governments will need to invest more in their infrastructure to keep ships coming.

Taken from Caribbean Net News Friday July 29, 2005
http://www.caribbeannetnews.com/2003/10/19/cto.htm

APPENDIX SIX

The Instruments of Ratifications deposited to IMO by Netherlands, France, United Kingdom and USA for the Caribbean Dependencies

With reference to your enquiry on the extension of certain IMO treaties to the dependent territories of various States specified in your email, our records indicate the following:

Dependent territories of the Netherlands

The following information has been provided to IMO by the Netherlands: the Netherlands has tended to extend the provisions of IMO treaties to the Netherlands Antilles and to Aruba only. In the case of Aruba, the provisions of MARPOL 73/78 (including Annexes I and II), and Optional Annexes III, IV and V, have been extended. The Netherlands is not Party to MARPOL Annex VI (the 1997 MARPOL Protocol). The Netherlands has denounced the 1969 CLC Convention, but, in any case, had not extended its provisions to any of its territories. The 1972 London Convention has also been extended to Aruba. OPRC 1990 and the 2000 OPRC/HNS Protocol have not been extended by the Netherlands to any of its territories. The Netherlands is not Party to the 2001 AFS Convention or to the 2004 Ballast Water Convention.

Dependent territories of France

France has provided the following information to IMO: the provisions of MARPOL 73/78 (including Annexes I and II) or Optional Annexes III, IV and V have not been extended by France to any of its dependent territories. France is not Party to MARPOL Annex VI (the 1997 MARPOL Protocol). France has also denounced CLC 1969, but according to information provided, it had not been extended to any of its territories. France has not extended the provisions of the 1972 London Convention to any of its territories. France has not extended the provisions of OPRC 1990 to any of its territories and is not Party to the 2000 OPRC/HNS Protocol. France is not Party to the 2001 AFS or the 2004 Ballast Water Conventions.

Dependent territories of the United Kingdom

The following information has been provided by the United Kingdom to IMO: MARPOL 73/78 has been extended to the Cayman Islands, as have Optional Annexes III and V. The provisions of Optional Annex VI (the 1997 MARPOL Protocol) have not, according to information provided, been extended to any UK territory. The provisions of CLC 1969 had been extended to the Cayman Islands and the British Virgin Islands, but the UK denounced the Convention in 1997 for itself and all dependent territories to which it had been previously extended. The UK has informed that the provisions of LC 1972 have been extended to the British Virgin Islands and the Cayman Islands. OPRC 1990 has not been extended by the UK to any of the territories you specify. The United Kingdom is not Party to the 2000 OPRC/HNS Protocol, or to the 2001 AFS or 2004 Ballast Water Conventions.

Dependent territories of the United States

We have received information from the United States, as follows: the United States abides by article 29 of the Vienna Convention on the Law of Treaties, 1969, which states that "unless a different intention appears from the treaty, or is otherwise established, a treaty is binding upon each party in respect of its entire territory." The United States is not party to the Vienna Convention, but considers this article to be a good reflection of customary international law. The IMO Conventions which have a territorial clause requiring each party to inform the depositary of the application of those treaties to a State's territories and possessions include the 1972 COLREG Convention, the Load Lines and Intervention Conventions and the 1965 FAL Convention.

Therefore, the United States has previously informed IMO only of the application of these treaties to its territories. MARPOL does not have such a territorial clause, neither does OPRC or LC. The United States is Party to MARPOL 73/78, and to its Optional Annexes III and V. It is not Party to Optional Annex IV or to Optional Annex VI (the 1997 MARPOL Protocol). The United States is not Party to CLC 1969. It is party to LC 1972 and to OPRC 1990, but it is not Party to the 2000 OPRC/HNS Protocol, the 2001 AFS Convention or the 2004 Ballast Water Convention.

France (as well as the United States) is not Party to the Vienna Convention. The United Kingdom and the Netherlands are. However, the information I have provided on the extension to its territories with regard to all these States is that which has been provided to IMO by the States concerned.

This information was provided by Geraldine Gibson, Senior Depositary and Administrative Officer, Treaties and Rules Section, Sub-Division for Legal Affairs, Legal Affairs and External Relations Division, IMO, London
Email correspondence 16/05/2005.