COMMONWEALTH
OF THE BAHAMAS

First National Communication on Climate Change

**Submitted to the Secretariat of the
United Nations Framework Convention on Climate Change
for Presentation to the Conference of Parties**

**The Bahamas Environment, Science and Technology Commission
Nassau, New Providence, The Bahamas**

April 2001

CONTENTS

FOREWORD

THE BAHAMAS ENVIRONMENT ,SCIENCE AND TECHNOLOGY COMMISSION

Ministry of Agriculture and Fisheries

April, 2001

The Commonwealth of The Bahamas has a long history of environmental concern. This concern is reflected in the application of the "Precautionary Principal" to environment matters. In the early 1950s, legislation was enacted to protect wild birds and animals, and in 1959 The Bahamas National Trust Act (BNT) was passed. This Act, among other things, established the Bahamas National Trust, a land and sea park in the Exuma Cays, and laid the groundwork for the present national park system in the country. There are now twelve recognized national parks administered by The Bahamas National Trust. The Inagua National Park was established in 1965, under the BNT Act and this proved instrumental in saving the West Indian flamingo from the almost certain extinction predicted by Charles Cory in 1880. These were small beginnings, but in the 1950s no one could have predicted the environmental concerns that now face mankind.

The Government of the Bahamas, in undertaking a legislative strengthening programme to protect, conserve and preserve the natural resources of The Bahamas. In this regard the following Acts and supporting regulations are in draft form:

- A new Fisheries Act,
- A Marine Mammal Act and Regulations,
- Legislation to control the use of Pesticides,
- An Environmental Impact Assessment (EIA) Act and related Regulations, and,
- A Pollution Control and Waste Management Regulations.

Further, Government has implemented the requirement, that large-scale developments in the Bahamas undergo a rigorous Environmental Impact Assessment (EIA) process and has implemented measures to protect the physical landscape and certain indigenous trees of The Bahamas through legislative action.

The Bahamas, like many other small island states, is particularly vulnerable to climate change and the myriad problems associated with it. The natural resource base of The Bahamas is limited, the economy relying on tourism and services. In addition to potential damage to a fragile economy, climate change, increased climate variability and the sea level rise will also impact on the amount of land available for human habitation and agriculture, groundwater resources, supplies and the quality of groundwater resources, and vegetation. Because climate change is a global problem,it must be addressed globally.

Government accepts that marine reserves hold significant potential for protecting diverse and integrated ecosystems, keystone species, research and monitoring sites, for the protection of spawning stocks, and for providing a basis for recruitment of species to wider areas. In this regard the government has embarked on establishing a network of marine protected areas. The goal is to establish some 20% of marine areas of The Bahamas as "no take" reserves. The first five of such areas a have been approved in principal and efforts are under way to define and inventory the areas and to develop and implement the appropriate management plans. Efforts are also under way to expand the national park system. These initiatives also will benefit the worlds' climate system and improve the ability of The Bahamas and the Bahamian natural ecosystems to adapt to climate change, increased climate variability and rising sea levels.

Government is equally convinced that action already taken within its borders represent only the first of many steps that all Parties to the United Nations Framework Convention on Climate Change (UNFCCC) must undertake to address this global problem. Technical and financial resources have been committed nationally and The Bahamas looks forward to a similar commitment by the international community to assist itin this process.

I am pleased to present the First National Communication on Climate Change of the Commonwealth of The Bahamas to the United Nations Framework Convention on Climate Change Secretariat for submission to the Conference of Parties.

James F. Knowles, M.P.,
Minister of Agriculture and Fisheries.

PREFACE

The Bahamas has a long history of scientific observation and study. Christopher Columbus wrote about the plants and animals as he sailed through the islands in 1492. Various travelers have written of their sojourns in The Bahamas, but the most significant early account is that of Mark Catesby, a British naturalist who spent nine months in The Bahamas in 1725. His work, *The Natural History of Carolina, Florida and The Bahama Islands*, provides a relatively comprehensive account of the natural resources of the islands. Sadly, several species described by Catesby are now either extinct (the West Indian Monk Seal) or no longer occur in The Bahamas (the American crocodile, the Scarlet Ibis and the West Indian Manatee). There have also been several studies of the geology of the islands and scientists continue to be attracted by the bird life, the mangrove swamps, the iguanas, and the blue holes.

Climate Change has been called the "most pervasive and truly global of all issues affecting humanity." The world is now concerned, with increasing belief and apprehension, that the pattern of the global climate is being altered by man's own actions. The most crucial environmental issues of the next few decades will be those relating to the earth's atmosphere. During the 1980's, the accumulation of scientific evidence led to increasing concern with the potential consequences of climate change. By 1990, a series of international conferences had issued urgent calls for a global treaty to address the problem of climate change. The Commonwealth of The Bahamas signed the United Nations Framework Convention on Climate Change (UNFCCC) on June 12 1992, and ratified it on September 2 1994.

When considering climate change as it relates to The Bahamas it is important to note that the country is an archipelago of small islands, most of them uninhabited, and that more than 80% of the land surface is only a meter or less above mean sea level. The natural resources of the country are very limited. The economy is built on tourism and services . Bahamians, like other island peoples, have historically had a close personal relationship with the land and the sea. Until the advent of modern tourism and banking industries, most Bahamians relied on the resources of both land and sea for survival. This is still true in most of the Family Islands, where many of the inhabitants are either fishermen, or farmers, or both. Any significant change in climate patterns and mean sea level would cause a drastic change in their life styles. The fact that The Bahamas is not rich in natural resources will accentuate the problems faced by these people, because there is no other means of employment, other than agriculture and fishing, in these islands. Tourism is the main economic activity in The Bahamas but is concentrated on New Providence and Paradise Island, in Grand Bahama, Abaco and a few other islands in the northern part of the archipelago. Climate change would have a devastating effect on tourism in the short-term in the form of damaged beaches and resorts.

The Government of The Bahamas recognizes that future development of the Bahamian people will depend on the responsible economic exploitation of the natural and man-made resources available in the country. This recognition, however, is tempered by the government's effort to eliminate poverty, the ever-increasing demands for employment from the overwhelmingly youthful population, and pressure for more and better government services. The Government of The Bahamas is faced with the dilemma, as perhaps are many other governments, of how to divert scarce economic and human resources from immediately pressing needs, to the more long-term impacts of climate change.

Photography: courtesy of Devin Weech

Map: coutresy of The Department of Lands and Surveys

CONTENTS EXECUTIVE SUMMARY

The Executive Summary of The Bahamas First National Communications (FNC) to the United Nations Framework Convention on Climate Change (UNFCCC) is contained herein.

Note to readers:

Photos provided as a courtesy by various individuals. Their use, without permission, is not permitted.

Annex 3 (List of Scientific Names Referred to in the Text) and References are provided in English only.

FOREWORD

THE BAHAMAS ENVIRONMENT, SCIENCE AND TECHNOLOGY COMMISSION

Ministry of Agriculture and Fisheries

April, 2001

The Commonwealth of The Bahamas has a long history of environmental concern. This concern is reflected in the application of the "Precautionary Principal" to environment matters. In the early 1950s, legislation was enacted to protect wild birds and animals, and in 1959 The Bahamas National Trust Act (BNT) was passed. This Act, among other things, established the Bahamas National Trust, a land and sea park in the Exuma Cays, and laid the groundwork for the present national park system in the country. There are now twelve recognized national parks administered by The Bahamas National Trust. The Inagua National Park was established in 1965, under the BNT Act and this proved instrumental in saving the West Indian flamingo from the almost certain extinction predicted by Charles Cory in 1880. These were small beginnings, but in the 1950s no one could have predicted the environmental concerns that now face mankind.

The Government of the Bahamas, in undertaking a legislative strengthening programme to protect, conserve and preserve the natural resources of The Bahamas. In this regard the following Acts and supporting regulations are in draft form:

- A new Fisheries Act,
- A Marine Mammal Act and Regulations,
- Legislation to control the use of Pesticides,
- An Environmental Impact Assessment (EIA) Act and related Regulations, and,
- A Pollution Control and Waste Management Regulations.

Further, Government has implemented the requirement, that large-scale developments in The Bahamas undergo a rigorous Environmental Impact Assessment (EIA) process and has implemented measures to protect the physical landscape and certain indigenous trees of The Bahamas through legislative action.

The Bahamas, like many other small island states, is particularly vulnerable to climate change and the myriad problems associated with it. The natural resource base of The Bahamas is limited, the economy relying on tourism and services. In addition to potential damage to a fragile economy, climate change, increased climate variability and the sea level rise will also impact on the amount of land available for human habitation and agriculture, groundwater resources, supplies and the quality of groundwater resources, and vegetation. Because climate change is a global problem, it must be addressed globally.

Government accepts that marine reserves hold significant potential for protecting diverse and integrated ecosystems, keystone species, research and monitoring sites, for the protection of spawning stocks, and for providing a basis for recruitment of species to wider areas. In this regard the government has embarked on establishing a network of marine protected areas. The goal is to establish some 20% of marine areas of The Bahamas as "no take" reserves. The first five of such areas a have been approved in principal and efforts are under way to define and inventory the areas and to develop and implement the appropriate management plans. Efforts are also under way to expand the national park system. These initiatives also will benefit the worlds' climate system and improve the ability of The Bahamas and the Bahamian natural ecosystems to adapt to climate change, increased climate variability and rising sea levels.

Government is equally convinced that action already taken within its borders represent only the first of many steps that all Parties to the United Nations Framework Convention on Climate Change (UNFCCC) must undertake to address this global problem. Technical and financial resources have been committed nationally and The Bahamas looks forward to a similar commitment by the international community to assist it in this process.

I am pleased to present the First National Communication on Climate Change of the Commonwealth of The Bahamas to the United Nations Framework Convention on Climate Change Secretariat for submission to the Conference of Parties.

James F. Knowles, M.P.,
Minister of Agriculture and Fisheries.

PREFACE

The Bahamas has a long history of scientific observation and study. Christopher Columbus wrote about the plants and animals as he sailed through the islands in 1492. Various travelers have written of their sojourns in The Bahamas, but the most significant early account is that of Mark Catesby, a British naturalist who spent nine months in The Bahamas in 1725. His work, *The Natural History of Carolina, Florida and the Bahama Islands*, provides a relatively comprehensive account of the natural resources of the islands. Sadly, several species described by Catesby are now either extinct (the West Indian Monk Seal) or no longer occur in The Bahamas (the American crocodile, the Scarlet Ibis and the West Indian Manatee). There have also been several studies of the geology of the islands and scientists continue to be attracted by the bird life, the mangrove swamps, the iguanas, and the blue holes.

Climate Change has been called the "most pervasive and truly global of all issues affecting humanity." The world is now concerned, with increasing belief and apprehension, that the pattern of the global climate is being altered by man's own actions. The most crucial environmental issues of the next few decades will be those relating to the earth's atmosphere. During the 1980's, the accumulation of scientific evidence led to increasing concern with the potential consequences of climate change. By 1990, a series of international conferences had issued urgent calls for a global treaty to address the problem of climate change. The Commonwealth of The Bahamas signed the United Nations Framework Convention on Climate Change (UNFCCC) on June 12 1992, and ratified it on September 2 1994.

When considering climate change as it relates to The Bahamas it is important to note that the country is an archipelago of small islands, most of them uninhabited, and that more than 80% of the land surface is only a meter or less above mean sea level. The natural resources of the country are very limited. The economy is built on tourism and services.Bahamians, like other island peoples, have historically had a close personal relationship with the land and the sea. Until the advent of modern tourism and banking industries, most Bahamians relied on the resources of both land and sea for survival. This is still true in most of the Family Islands, where many of the inhabitants are either fishermen, or farmers, or both. Any significant change in climate patterns and mean sea level would cause a drastic change in their life styles. The fact that The Bahamas is not rich in natural resources will accentuate the problems faced by these people, because there is no other means of employment, other than agriculture and fishing, in these islands. Tourism is the main economic activity in The Bahamas but is concentrated on New Providence and Paradise Island, in Grand Bahama, Abaco and a few other islands in the northern part of the archipelago. Climate change would have a devastating effect on tourism in the short-term in the form of damaged beaches and resorts.

The Government of The Bahamas recognizes that future development of the Bahamian people will depend on the responsible economic exploitation of the natural and man-made resources available in the country. This recognition, however, is tempered by the government's effort to eliminate poverty, the ever-increasing demands for employment from the overwhelmingly youthful population, and pressure for more and better government services. The Government of The Bahamas is faced with the dilemma, as perhaps are many other governments, of how to divert scarce economic and human resources from immediately pressing needs to the more long-term impacts of climate change.

Photography: courtesy of Philip Weech

CHAPTER 1

NATIONAL CIRCUMSTANCES AND BACKGROUND

Location and population

The Commonwealth of The Bahamas comprises an archipelago of over 700 islands plus more than 200 cays, islets and rocks, spread over approximately 100,000 mi^2 (260,000 km^2) of the Atlantic Ocean. The Bahamas lies east of Florida (U.S.A.), and extends about 750 mi (1,200 km) southeastwards to within 50 mi (81 km) of Cuba and Haiti. Total land area is approximately 5,380 mi^2 (13,934 km^2). The islands have low relief and the highest point is only 206 ft (63 m) above mean sea level, in Cat Island. The potable freshwater resources of The Bahamas occur as three-dimensional lenses in the rock, overlying brackish and saline waters and most within five feet of the land surface. The 1990 census gave a total of 254,685 persons, with a growth rate of 1.9% per annum since 1980. The projection for 1997 was 288,862, and for 2000, 303,069. Some 60% of the population was under thirty years of age. Over 80% of the population resides on two islands: New Providence (where the capital, Nassau is located), and Grand Bahama.

Climate and weather

The climate of The Bahamas is sub-tropical with fairly high mean temperatures and moderate rainfall. Mean annual rainfall varies from about 58 in (1470 mm) to about 34 in (865 mm). Mean daily temperatures fluctuate between 63°F and 90F (17°C and 32°C) with May to October considered the summer months. These are also the wetter months. Hurricanes are regular occurrences in The Bahamas during the Atlantic hurricane season (June 1 to November 30). Hurricane Andrew damaged several islands in 1992, and Floyd struck The Bahamas in September 1999, leaving major damage on a number of islands. Tropical storms and hurricanes occur most frequently in September, October, August and November, in that order. Storm surges may cause serious flooding.

History and government

The island of San Salvador is generally accepted as the site where Columbus landed in 1492. The islands remained uninhabited until the 1640's, when Englishmen from Bermuda settled some of the islands with their African slaves. American Loyalists formed a second wave of settlers. There was prosperity during the American Civil War and during that time the first hotel in the Bahama Islands was opened.

Constitution

A new constitution, adopted in 1964, led to internal self-government, after centuries of British rule. Majority rule came in 1967, and independence on July 10 1973. The House of Assembly is the fourth oldest parliament in the English-speaking world. The Head of State is H.M. Queen Elizabeth II who is represented by a Governor-General. The legislature is a two-chambered system based on the Westminster model, with members of the House elected and representing a constituency. The two major political parties are the ruling Free National Movement (FNM) and the Progressive Liberal Party (PLP). The Prime Minister is the leader of the party winning the most seats. Cabinet is composed of Ministers appointed by the Prime Minister.

Local Government

Local government was established in 1996 and elections first held in the 23 Family Island Districts in July 1996. Implementation of local government acknowledges that central government, distant from so many communities, cannot respond adequately to the short-term needs of those communities. New Providence, the centre of government, is not included in the system of local government.

Economy

The economy is dominated by the tourism sector which is the principal contributor to gross domestic product (GDP) and accounts for 50% of GDP. The financial services sector is the second largest contributor to GDP. The banking and finance sector accounts for approximately 15% of GDP, and the majority of banks and trust companies are engaged in the management of assets of wealthy clients. The Bahamas is one of the world's fastest growing of the larger ship registry centres, with nearly 1,600 vessels. A number of the major cruise lines have their ships registered in The Bahamas.

The shallow water banks of The Bahamas are rich in fish. The agriculture and fisheries sectors combined account for 3 to 5 % of GDP. The fisheries sector contributes 2-3% of GDP. No-take zones are being established and long-line fishing is prohibited. Agriculture's contribution to the economy of The Bahamas is relatively small (1-2% of GDP). The sector produces substantial quantities of broilers and eggs, but some 85% of the food consumed in The Bahamas is imported.

There is a small but growing industrial sector, and Grand Bahama is home to several industries and crude oil storage for transhipment. New Providence is home to brewing, distilling and light manufacturing. There are a number of companies producing paper products, furniture and bedding, and a small food processing industry.

Electrical energy is produced mainly through the combustion of fossil fuel products such as gas/diesel oil and residual fuel oil (bunker "C"). Liquefied petroleum gas is used for cooking, while diesel oil and gasoline (petrol) are used for transportation. There is no use of biomass for electricity generation, little use of solar energy for water heating, and no use of solar energy for the generation of electricity.

Environment

The Bahamas is recognized as a leader in environmental legislation in the Wider Caribbean Region. Twelve national parks have been established, and it is intended to expand the system. The Bahamas Environment, Science and Technology (BEST) Commission was established in 1994, based in the Office of the Prime Minister, to advise on policies to ensure sustainable development and the conservation of biodiversity. Although more than 96% of the total area of The Bahamas is in marine and deep-water ecosystems, much of the biodiversity of these ecosystems has yet to be described.

Land use and forestry

Bahamian soils are thin, coarse-textured and fragile, and quickly become exhausted. Various attempts at commercial agriculture have been tried, and some have had some success. Land use has changed dramatically on New Providence over the past thirty years with the building of several large resort hotels, and large tracts of land have been cleared for housing, business complexes and roads. On Grand Bahama also a great deal of land clearing and construction has taken place. The forest resources of The Bahamas comprise pine forest, coppice forests and mangrove forests, with approximately 80% of forest resources on state lands (Crown land). Pine forests are considered the most productive of the three forest types, and pine is now a protected species. Coppice (hardwood) forests are found in the central and southern Bahamas.

Photography: courtesy of Philip Weech

Table 1 National Circumstance: The Bahamas

CRITERIA	1990	1994
Population	254,685	274,600 (Estimate)
Relevant area	Total: 260,000 km^2 Land: 13,940 km^2	Total: 260,000 km^2 Land: 13,940 km^2
GDP at current market price	Not available	Not available
GDP per capita at current market price	Not available	Not available
Estimated share of the informal sector in the economy in GDP (%)	Not available	Not available
Share of industry in GDP (%)	Not available	Not available
Share of services in GDP (%)	Not available	Not available
Share of agriculture in GDP (%)	*3-5%	*3-5%
Land area used for agriculture	24,323 ha (Estimated)	20,344 ha (Census)
Urban population as % of total population	70	70
Livestock population	Not available	Cattle (non-dairy): 796 Sheep: 6,292 Goats: 13,580 Pigs: 4,777 Poultry: 750,000
Forest area (kha)	Pine forest 227.8 Coppice forest 701.8 Mangrove forest 690.4	Pine forest 227.8 Coppice forest 701.8 Mangrove forest 690.4
Population in absolute poverty		
Life expectancy at birth	Male Female	Male 70.7 Female 77.4
Literacy rate		98%

* Agriculture and Fisheries

Note: Parties may also report on the rate of change of the above indicators to the extent possible; data in this table should be as disaggregated as possible and include information on individual sectors.

CHAPTER 2

NATIONAL INVENTORYOF GREENHOUSE GASES

Introduction

In accordance with Article 4.1(a) of the United Nations Framework Convention on Climate Change (UNFCCC), all Parties are required to update and report on their national inventory of greenhouse gases (GHG). A National Climate Change Committee (NCCC), comprising government and non-governmental representatives, was formed and first convened in March 1996, to undertake preparation of this First National Greenhouse Gas Inventory for The Bahamas. GHG emissions, and their removal by sinks, have been calculated for 1990 and 1994 for The Bahamas. Electricity generation and the transportation sector are the two most significant sources of GHG emissions in The Bahamas. There is no primary fuel production in the Bahamas and all fossil fuels are imported. International marine and air bunkering fuels, and the storage and transmission of fossil fuel, represents fuel exported through The Bahamas.

Inventory process

The NCCC held a series of workshops, and compiled a list of potential greenhouse gases sources organized into four broad categories: energy activities, agriculture, land use, land use changes and forestry, and waste (solid and liquid). The NCCC also identified data sources and agreed on a procedure for the conduct of the national inventory. Data for sectors other than energy were provided by the Central Bank and directly by the Department of Statistics, and other government ministries and departments. Oil imports were approximately 4.5 million barrels of energy in 1990, and 4.4 million barrels in 1994. Gas/diesel oil accounted for just over a third of the total, and gasoline and residual fuel oil each account for just under 30% each.

Photography: courtesy of Philip Weech

Emissions of greenhouse gases

Electrical power in The Bahamas is generated through the combustion of imported liquid fossil fuels. The storage of fuel and international bunkering represents a smaller fraction of fuels in the sector, and is reported separately. Data on carbon dioxide emissions from fossil fuels for 1990 and 1994, by type of fuel, are presented in Table 2.1. Carbon dioxide emissions produced by the consumption of gas/diesel oil and residual fuel oil for electricity generation, account for some 65% of total CO^2 emissions in The Bahamas.

The local transport, agriculture, forestry and fisheries sectors make insignificant contributions to total CO^2 emissions and were not covered in this exercise. The industrial sector was not a significant source of emissions. However, some three (3) million long tons of fuel are stored each year for transshipment outside The Bahamas at the oil storage facility in Grand Bahama. This is the primary source of fugitive emissions, estimated at three (3) Gg of non-methane volatile organic carbon (NMVOC) compounds in both 1990 and 1994 (Table 2.2). Carbon dioxide (CO^2) emissions from bunkering aviation and marine fuels are shown in Table 2.3.

Table 2.1 Carbon dioxide emissions from fossil fuel energy sources in The Bahamas for 1990 and 1994 (Gigagrams of CO^2)

Fuel type	1990	1994	% Total
Gasoline	470.7	476.5	25.2
Jet Kerosene	55.0	43.6	2.6
Gas/diesel oil	802.4	593.5	37.1
Residual fuel oil	424.8	696.9	29.8
LPG	39.7	40.8	2.1
Other oils	101.5	14.9	3.1
Total (Gg Co2)	1894.1	1866.2	

1. 1 A Gigagram (abbreviated to Gg) is 1,000,000,000 (109) grams, or 1,000 metric tones.

Table 2.2 Estimated emissions of other greenhouse gases in The Bahamas for the years 1990 and 1994 (Gg).

Year	Methane (CH4)	Nitrous oxide (N2O)	Carbon Monoxide (CO)	NMVOC's
1990	2	0	4	3
1994	1	1	4	3

Table 2.3 Carbon dioxide emissions from international bunkering in The Bahamas (Gg CO2).

	1990	1994	% Total
Aviation	492	341	54
Marine	404	305	46
Total all Bunkers	896	645	

Agriculture, forestry and land use

The Bahamas depends almost entirely on imports to feed Bahamians and tourists. Livestock numbers are small and there is no cultivation of rice or prescribed burning of savannas or crop residues. There is some slash-and-burn farming but the acreage is very small. Insignificant amounts of fuel wood and charcoal are used for cooking. Enteric fermentation by livestock, manure management, and agricultural soils all produce emissions on a very small scale. No estimate is made for feral animals (dogs, cats, pigs, donkeys and horses), and domestic animals (pets) have been excluded. Estimates of carbon dioxide, methane and nitrous oxide emissions from the agricultural sector for 1990 and 1994 are estimated to total less than 1 Gg.

Photography: courtesy of Philip Weech

Liquid waste disposal is mainly by septic tanks. The large tourism sector, and a high standard of living, is responsible for the estimated 1 Gg of methane (CH_4) emissions. Solid waste is disposed of into unlined public dumps across the Bahamas. The estimated per capita waste stream from all sources was estimated at 2.6 kg per day but it is estimated that only 70% of this is disposed of in a public facility.

Photography: courtesy of Philip Weech

Forests are critical components of the climate system as they have potential for sequestering greenhouse gases. The Bahamas has three types of forest: pine, coppice hardwood, and mangrove. Agriculture accounts for 50,250 ac (20,344 ha) or 78.5 mi2 (203.4 km2) of land, according to the 1994 Agricultural Census, which is only about 1.5% of total land.

CHAPTER 3

INITIAL VULNERABILITY AND ADAPTATION ASSESSMENT

Vulnerability

The Bahamas' contribution to greenhouse gas (GHG) emissions is low by global standards, but the country is extremely vulnerable to the effects of global climate change and sea level rise, as some 80% of the landmass is within 5 ft (1.5 m) of mean sea level. This initial national assessment of vulnerability and adaptation (V&A) is a first step and is limited in its scope: it is therefore a "living" document.

Based on predicted emission levels of green house gases, global climate models predict a mean temperature rise of about 3 ºF (1.7 °C) in 50 years. Analysis of Bahamian weather data shows that mean daily maximum temperatures for July have increased at the rate of 3.6 ºF (2 °C) per 100 years, and more recently at the rate of 4.8 ºF (2.6 °C) per 100 years. The models also predict increased heavy rain events, where total rainfall increases, and more intense droughts elsewhere. Bahamian data show that over the past 95 years, rainfall in Nassau has decreased at a rate of 4.2 in (107 mm) per 100 years, but since 1959, has been increasing at a rate of 21.8 in (554 mm) per 100 years. Global predictions indicate that sea level is expected to rise at a rate of 0.06 in (1.5 mm) per year, with a sea level rise of about 8 in (20 cm) by 2060. Examination of records from neighboring countries indicates that rises of 6 to 10 in (15.2 to 25.4 cm) per 100 years can be expected. Models also predict increased severity of tropical storms.

Vulnerability and adaptation assessment

The Government of The Bahamas commissioned a study of the effects of climate change in The Bahamas by Global Change Strategies International (GCSI). This study examined the available hydro-meteorological data for selected islands of The Bahamas, and confirmed the predictions of the global circulation models. An initial V&A assessment, using Pacific Island Climate Change Assistance Programme (PICCAP) procedures, which relies on expert review, was undertaken. This analysis identified the sensitive sectors and considered both direct and indirect impacts of climate change.

Tourism

A rise in sea level would result in beach and coastal erosion and, since most of the tourist hotels are situated along the coast, coastal erosion could directly impact these structures. Coral reefs are important as physical barriers to storm surges and ocean waves, and are currently stressed by over-exploitation, pollution, and non-sustainable practices associated with tourism. Climate change is expected to introduce additional stresses to the reefs. Coral bleaching is associated with increased sea surface temperatures and additional temperature rises are likely to lead to further bleaching.

Health

Impacts on human health, and on the spread of disease vectors as a result of increasing temperatures and humidity, have not yet been quantified, due in part to the inability of global models to predict changes on the scale of a small island state. Changes in the incidence of malaria, dengue and other tropical diseases can be expected.

Water resources

Potable water in The Bahamas is produced primarily by extraction from shallow freshwater lenses. Rise in sea level will put this already threatened natural resource at higher risk, because it will bring the fresh water lens closer to the surface of the land. Inundation of land containing freshwater resources by storm surges will cause further damage. These freshwater lenses are also threatened by pollution.

Photography: courtesy of Philip Weech

Agriculture

Many of the short-term subsistence crops grown in the Family Islands crops are seasonal, and any significant shifts in climatic conditions will affect crop production. Rises in sea level and inundation by storm surges, will result in the loss of agricultural land due to saltwater intrusion and salinization of the soil. On the other hand, increased CO^2 concentrations may have a positive effect on the yield of certain crops.

Fisheries and biodiversity

Damage to reefs and coastal wetlands may impair the "nursery" role of these habitats for commercial fish species, changes in ocean temperatures may impact the migration of fish and other marine life forms. These impacts will affect the biodiversity of Bahamian waters. Terrestrial biodiversity will also be impacted by expected increases in the incidence of flooding, the area of wetlands, and the area of saline soils.

Natural disasters: hurricanes

Hurricane Floyd in 1999 caused severe damage, and the local insurance industry reported payments and outstanding claims totaling over $230 million. The government and public utility corporations found it necessary to engage in extensive repairs to roads, cemeteries, docks, bridges, abutments, utility poles and wires, water mains, etc.

Natural disasters: non-tropical

Storms of non-tropical origin, while of shorter duration and generally localized, can also disrupt operations and endanger life and property. In addition to the above, out-of-season tropical cyclones, though very rare in the Atlantic, can occur. Experience suggests that severe weather phenomena can occur at any time of year in the Bahamian archipelago.

Adaptations options

Climate change presents new challenges due to the speed of the anticipated changes and the magnitude of the investments needed to adapt to predicted changes. In the case of some small islands the only option may be retreat and abandonment of property. The do nothing option or strategy is the one against which all other options may be compared. All too often, however, it is the default option because other options are either not available or are not known.

Across The Bahamas no one option alone is likely to achieve the desired results of reducing vulnerability to climate change. Zoning practices based on vulnerability assessments, restricting types of development, prohibiting activities that exacerbate the impacts, and replacement and provision of increased security for settlements and infrastructure, are options that need to be considered. Costs associated with planned adaptation will be high but the cost of not acting will be measured directly in loss of life, loss of competitiveness in the tourism sector and often at the expense of the environment.

Changes in global weather patterns could reduce demand from the eastern United States and Canada for winter holidays in The Bahamas. Further, the possible introduction of diseases and their spread due to increases in temperature and humidity, are causes for concern. Threats from health-based impacts will probably be manifested mainly in the poorer countries of the region, and migration of persons to and through The Bahamas has potential for introducing diseases.

Initial V&A

V&A assessment generally assumes that climate change will be steady and linear in nature. Catastrophic changes have not been factored into this initial assessment. It also assumes that impacts, both positive and negative, will be measurable and that the resources and knowledge of mitigation and adaptation measures are within the nation's capacity. The cost of adaptation and of acquiring the needed capacity of human resources was not assessed or quantified. There is clearly a need for further studies.

Gaps in research and information needs

There are many gaps in existing data and information, and a lack of tools to assess the physical, social and economic impacts on the most vulnerable sectors of the economy. A listing of research and information needs recognizes ten categories (economic sectors or subject areas) where gaps are considered to exist, and where more information is needed. These categories are Agriculture, Fisheries, Forestry, Geographic information systems, Health, Meteorology and oceanic observations, Physical planning, Public works, Tourism, insurance and commercial, and Water resources and supply. No attempt has yet been made to place topics in any order of priority either between or within categories

Photography, this page: courtesy of Philip Weech

CHAPTER 4

SYSTEMATIC OBSERVATIONS AND CAPACITY BUILDING

Weather Observations

The Bahamas has a long history of weather observations, recorded and reported by individuals who were usually untrained and at widely dispersed locations throughout the islands. Records are often incomplete and the instruments used were of varying type, quality, and accuracy. Of particular interest are reports on tropical cyclones: the Lucayan Indians named those affecting The Bahamas, "hurricanes".

Photography: courtesy G. Burnside Department of Meteorology

In 1935, a network of observing stations was organized by the Bahamas Telecommunications Department, in conjunction with the United States Weather Bureau. Formation of the British Caribbean Meteorological Service in 1951 resulted in a more systematic manner of making observations. The Caribbean Meteorological Service was reconstituted in 1962, and prompted the Government of The Bahamas to establish its own Meteorological Office. This existed from 1963 to 1972. The Bahamas Meteorological Service was created as a separate Department of Meteorology in 1973, under the Ministry of Tourism, and a cooperative upper air observing station with the United States has been maintained since 1978. In 1982, the governments of the United States and The Bahamas agreed to cooperate in the operation and maintenance of a network of meteorological surface observation and reporting stations in The Bahamas. During this time, the number of observing stations was increased to 14, all providing hydro-meteorological information. This coverage is now considered insufficient to adequately monitor the climate of The Bahamas: analysis suggests that at least 60 rainfall stations should be installed throughout the archipelago.

Marine and oceanographic observations

Various marine and oceanographic observations have been made on an ad-hoc basis over the past century. The most notable systematic observations are those of the Caribbean Marine Research Centre (CMRC) (now known as the Perry Institute for Marine Sciences), at Lee Stocking Island in the Exuma Cays. Observations include records of water temperature, water level, and circulation. Sea level recordings have been made by various entities over the past century, but no long-term records exist for any individual site across the Bahamas. A tidal gauge has been maintained and operated by the National Oceanographic and Atmospheric Administration of the United States (NOAA) as part of the Global Sea Level Observing System (GLOSS) network, at Settlement Point Grand Bahama, since 1978.

Under the Caribbean: Planning for Adaptation to Climate Change (CPACC) Project three long-term sea level gauges were provided to The Bahamas, to complement existing national and regional efforts. There are no wave recorders in the Bahamas, even though tropical and non-tropical processes generate significant swells that have caused extensive damage in coastal areas in recent time. An ultraviolet meter was installed at Nassau International Airport in 1999 to measure UVB radiation, but there is a need to install at least two more such recorders, in the central and southeast Bahamas.

Research on climate change

The most notable research activity on global climate change in which The Bahamas is participating, is the CPACC Project managed by the Organization of American States (OAS) and funded by the Global Environment Facility (GEF). Twelve CARICOM states are involved in the CPACC Project, and its principal objective is to build a regional and national capacity in climate change. There is a parallel "Feasibility Study on the Prediction and Amelioration of Socio-Economic Impacts of the El Nino Southern Oscillation (ENSO) in Latin America and the Caribbean".

The El Nino episodes of 1995 and 1998 were, in part, responsible for the feasibility study referred to above. It was during these events that Bahamian coral reefs experienced significant bleaching. Coral reefs are believed to be excellent indicators of climate change, since they respond to changes in temperature, turbidity, and solar radiation. The general objective is to design feasible regional early warning systems to ameliorate the impacts of the El Nino Southern Oscillation (ENSO). Global Change Strategies International (GCSI) of Canada, were contracted in 1999 to undertake a study of climate change in The Bahamas, and this led to a preliminary assessment of the vulnerability and adaptation of The Bahamas to climate change. The study identified data gaps in the hydro-meteorological monitoring system, suggested climate change scenarios that might be used to predict future changes, and commented on assessment of the vulnerability and possible adaptation strategies. This study will form the basis for a national workshop on vulnerability and adaptation.

Storm surges

Observations in The Bahamas suggest that storm surges produces most of the flood damage and drowning associated with tropical storms that make landfall, or that closely approach a coastline. Recognizing this fact government, in association with the World Meteorological Organization (WMO) and the United States Government, applied the Sea Lake and Overland Surges from Hurricane (SLOSH) computer model to The Bahamas. An atlas was produced to provide maps of SLOSH-modeled heights of storm surge and extent of flooding, for various combinations of hurricane strength and direction of storm motion. The model has so far been applied only to the northern and central Bahamas and now needs to be expanded to include the remaining islands of the Bahamas. The findings should be integrated into the Bahamas National Geographic Information System (BNGIS) and be used to guide development in those areas vulnerable to severe flooding.

CPACC components

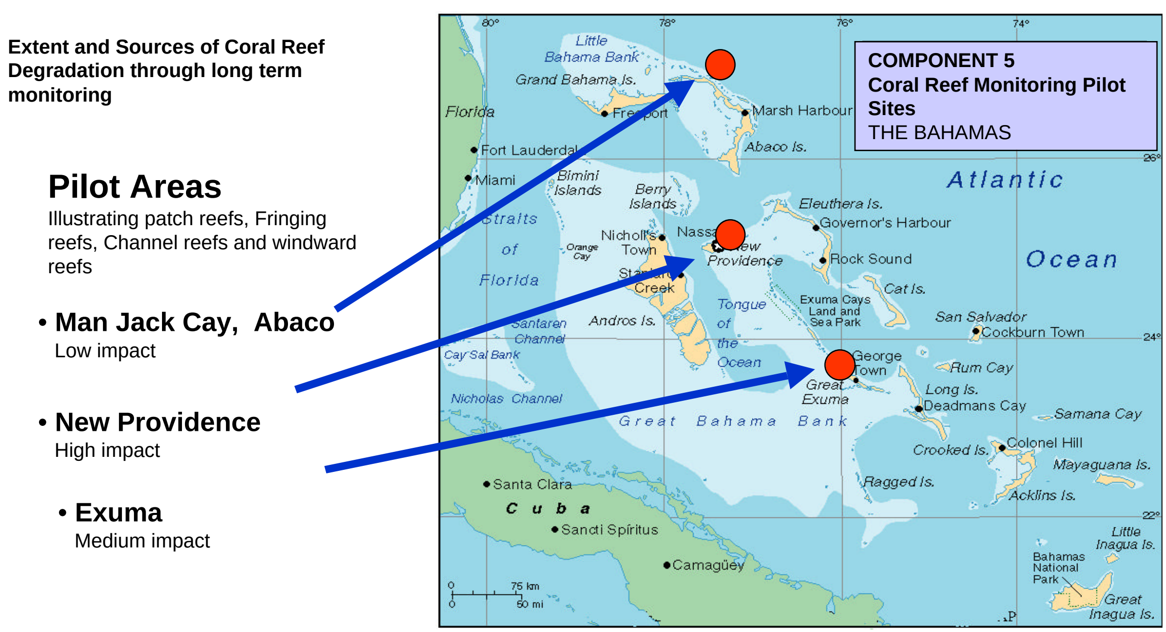
The CPACC Project started in 1997, and a Regional Project Implementing Unit (RPIU) has been established at the Barbados campus of the University of the West Indies. Specific objectives are to strengthen regional capability for monitoring and analyzing climate and sea-level dynamics and trends, and to seek to determine potential impacts of climate change. There are nine components: design and establishment of a sea level and climate monitoring network, establishment of a database and information systems, an inventory of coastal resources and uses, formulation of a policy framework for integrated coastal zone and marine (ICZM) management, coral reef monitoring, coastal vulnerability and risk assessment, economic valuation of coastal and marine resources, greenhouse gases (GHG) inventory and agriculture and water resource vulnerability assessment.

Climate change awareness

The CPACC project has provided a means for training and awareness building and further support for the national effort at public awareness and advocacy on climate change issues in The Bahamas. Focused training in a regional context was facilitated by the project in the execution of its various regional and pilot components.

The lack of a national evaluation of the observed climate change signals in the Bahamas constrained the national awareness, training and public education efforts. The available scientific reports, largely prepared by the Intergovernmental Panel on Climate Change (IPCC), served as the basis of national discussions within the public sector but the scientific material often lacked the required specificity necessary for public dissemination. Consequently, public officers were primarily targeted initially. But persons trained at the national level for execution of the pilot component on coral reef monitoring involved both non-governmental organizations and private sector persons. Public awareness was heightened as a result of the national consultation that preceded the implementation of the CPACC project at a national consultation, held in 1996.

Public addresses by senior government officials have focused on the impacts of climate change and government's efforts to build capacity, to report on involvement in the UNFCCC process, on the status of national efforts under the CPACC project, and on progress in executing the "Enabling Project", funded by the Global Environment Facility (GEF). This project has provided training and assistance directly with the preparation of the First National Communication, with the initial V&A assessment, and with the review of the systematic observation network. Experiences with hurricanes have fostered public debates and increased national and international attention to climate change.



Pilot areas were strategically selected to show high, medium and low impact and how marine near shore communities have changed over time with changes in population and land use.

CHAPTER 5

POLICIES AND MEASURES

Mitigation

The Bahamas recognizes that efforts to mitigate the impacts of climate change require multidisciplinary and cross-sectoral approaches, and must take account of the archipelagic nature of The Bahamas and its natural vulnerability. Efforts at sustainable development, capacity building, and use of appropriate policies and measures can reduce the impacts of climate change. International assistance, adequate financial resources, and the availability of scientific and technological solutions, can reduce vulnerability and provide the means for developing adaptation strategies.

Capacity building

Recent experiences with several major hurricanes have heightened awareness of the country's vulnerability to climate change, and the need for policies and measures to reduce vulnerability. Among the capacity building needs are: development of international negotiating skills, development of vulnerability and adaptation (V&A) assessment skills, and development of the skills needed to translate recommendations into policy options. Government policy at the national level is defined through the work of the BEST Commission, and government realizes the need to preserve the country's natural heritage and to provide for the sustainable use of resources.

Policy and measures

The policy and measures proposed, and currently being employed in The Bahamas, include actions to provide for sustainable development and the sustainable use of natural resources. These measures should include an examination of possible climate change specific measures that can respond to changing conditions, and that would be beneficial to a small island developing state even if climate change does not occur in the manner, or on the time scales, predicted. The latter type of measure is expected to develop as a better understanding and appreciation of the vulnerability of The Bahamas is gained.

Sustainable development

Sustainable development as a concept, has become fashionable only in recent times. A critical element is recognition and acceptance of "the precautionary principle". Government's policy on sustainable development has yet to be fully defined in a single policy document but elements of policy exist in, for instance, the National Biodiversity Strategy and Action Plan. The Prime Minister has made a number of statements on environmental issues, including sustainable development, in a series of national addresses. Elements of policy include measures to reduce the vulnerability of human settlements by, inter alia, providing for the adoption of a land-use plan for New Providence, facilitating public participation in planning and land-use matters, and formalizing the requirements for environmental impact assessments.

Marine Protection

Government recognizes that marine parks can provide protection for diverse and integrated ecosystems and for the protection of spawning stocks, so as to provide a basis for recruitment of species to wider areas. Government has agreed, as policy, that as much as 20% of the shallow water habitats of Bahamian marine resources will be protected as no-take zones and that a network of marine protected areas will be established.

Preservation of the physical landscape

Government enacted the "Conservation and Protection of the Physical Landscape of The Bahamas Act in 1997" and regulations that protect twelve species of tree, and provided for improved regulation of the cutting or excavation of hills for fill, and for the indiscriminate land clearing of virgin vegetation for development.

The BEST Commission

The Bahamas Environment, Science and Technology (BEST) Commission is the primary government agency for creating framework strategies for sustainable development, for implementing the environmental impact assessment process, and for developing databases of environmental information. BEST has received significant assistance from the United Nations Environment Programme (UNEP) through grants from the Global Environmental Facility (GEF), for CPACC (Caribbean Planning for Adaptation to Climate Change), for the preparation of a National Biodiversity Strategy and Action Plan and for a National Biodiversity Data Management Project. BEST also received technical assistance through an Organization of American States (OAS) consultancy, with the legislative basis for environmental impact assessment (EIA).

Measures to respond to climate change

Policy options available to The Bahamas to respond to climate change are limited. The future for most small island states is uncertain because they often lack fossil fuel resources, indigenous science and technology capability, and they must depend on imports of technology. They also lack any real adaptation options other than abandonment, retreat, or accommodation to climate change. Initial assessment of the vulnerability to climate change in The Bahamas is rather bleak. It is expected that fuel imports and GHG emissions will to rise as the population grows and the demand for energy, in response to climate change, increases. There will be increased dependence on imported technologies for water production, health impacts from heat stress will increase, and there is the possibility of a higher incidence of tropical diseases. More frequent disruptions and damage to infrastructure and human settlements from hurricanes and storm surges will occur, and this will be reflected in increased insurance and rebuilding costs. Land degradation and increases in the areas subject to flooding, will occur, and there will be a loss of freshwater resources.

Policies and measures for GHG reductions

The Bahamas is not a significant source of GHG emissions so that efforts to reduce GHG emissions will have only a very minor impact globally. However, there is a need to reduce the drain of foreign reserves used to acquire imported fossil fuels and there would be health benefits from reduced emissions. Importation of fuels for electricity generation is expected to increase over time, driving up emissions, if measures are not taken to reverse or slow this trend. Options include:

- use of insulation to lower cooling needs,
- solar tinting of windows to reduce heat build up,
- encouragement of off-peak consumption by price adjustment,
- use of solar heating and power generation.
- reduction or elimination of duty on "energy friendly" consumer products,
- use of ocean thermal energy conversion (OTEC), wind farms and ocean turbines to generate power,
- use of cleaner fuels in local transport vehicles,
- replacement of gasoline powered vehicles with electric vehicles, and
- improvements to the mass transit system.

In addition The Bahamas should review ways of achieving GHG reductions in the international bunkering and shipping sectors, which would have global benefits, and explore the feasibility of importing electricity from Florida via submarine cables.

Photography: courtesy Philip Weech

Carbon sequestration

The extensive shallow marine areas sequester carbon dioxide through chemical, mechanical and biological processes. An estimated 370 to 739 kg CO^2 per year is sequestered over a 277 km^2 area of shallow marine banks around Abaco. This equates to a carbon sequestration of some 121,968 to 243,930 Gigagrams (Gg) of CO^2 over the entire shallow water banks of The Bahamas. Unfortunately, the scientific basis to enhance these processes is not well understood, and there is uncertainty as to the potential benefits globally. It is clear however, that efforts to protect coral reefs will have the benefit of reducing stresses on the marine systems, and on the process that work to sequester carbon in marine systems.

Forests also sequester CO^2 by photosynthesis, and Bahamian forests include pine, coppice (or hardwood), and mangrove forests. A Forestry Act has been drafted which would provide, inter alia, for the scientific management of pine and coppice forests which should enhance their effectiveness in carbon sequestration. Actions of the National Creeks and Wetlands Restoration Initiative (NCWRI) will serve to enhance the carbon sequestering functions of the mangrove forests. The Bahamas has also drafted new legislation to provide for modern management of the water sector through a new Water and Sewerage Corporation Act. The Act would work cooperatively with the Forestry Act and the NCWRI to protect the well fields and ecosystems provide services in water resources conservation.

Financial implications

There is a need to provide adequate financial resources directed at public awareness, education, training and development, that is critical to the successful implementation of any policy and measures in the energy, forest, water, transport sectors. Several of the measures proposed will initially impact negatively on government revenues from the energy sector, and on tax revenues from concessions in customs duty. External financial resources will be required in order to undertake the cost: benefit analyses, and the pre-feasibility and socio-economic impact analyses.

CHAPTER 6

RECOMMENDATIONS

The following recommendations are considered necessary for The Bahamas to adequately meet the challenges of climate changes and sea level rise. No attempt at prioritization has been made.

Capacity building

Training is required at the tertiary level in fisheries, hydrology, information technology, marine ecology, meteorology, natural resource economics, oceanography, policy formulation and terrestrial ecology. An inventory and economic valuation of coastal resources needs to be undertaken. Training in the preparation of greenhouse gases (GHG) inventories and in the conduct of vulnerability and adaptation assessment is required. Institutional recommendations include strengthening of the Bahamas Environment, Science & Technology (BEST)Commission's information technology capacity, and of the Bahamas National Geographic Information System Centre (BNGISC).

Data collection and monitoring

Recommendations include formulation of guidelines to ensure compatibility of national data with the reporting requirements of international organizations, incorporation of additional data requirements into data collection instruments, where necessary, to meet reporting deadlines set by international organizations, a national repository for the storage, archiving and retrieval, of census and survey data, and introduction of a system to monitor changes in land use.

Meteorology and oceanic observations

Additional recording stations are considered necessary in The Bahamas to adequately monitor climate change. These sea level monitoring stations, wave recorders at selected sites, a system of UV-B bio-meters to assess the likely impacts of UV radiation on human health, application of the Sea Lake and Overland Surges from Hurricanes (SLOSH) computer model to all islands of The Bahamas, to provide maps for various scenarios.

Scientific research, monitoring and data collection

Scientific research and reviews of literature, establishment of baselines, and monitoring, is required for several areas. These include

Coral reefs

Monitoring of coral reefs for the impacts of climate change is already underway (under the CPACC Project) but needs to be expanded. Studies of the role of coral reefs and calcareous algae in sequestering carbon dioxide, and studies on the role of carbonate deposition in sequestering carbon dioxide.

Fisheries

The impact of increasing sea surface temperatures on important fish species, and of the impact of changes in the Gulf Stream on migratory species needs to be assessed.

Forests

Assessment of the effects of salinization of the soil, and rising water tables, on the growth and biodiversity of pine and coppice forests, and on coastal and inland mangrove communities.

Agriculture

The vulnerability of the sector to soil salinization, loss of lands to inundation and to periodic salt-water flooding, needs to be assessed. Agricultural production systems adapted to saline soil, to atmospheric CO2 enrichment and increased temperatures, needs to be evaluated.

Geographic information systems

The Bahamas National Geographic Information System Centre should be the repository for all digitized data sets of spatial information.

Health

Epidemiological monitoring of human diseases that may increase as a result of climate change will be needed, and assessment of the likely effects of heat and humidity stress.

Public works

Public facilities (docks, piers, coastal roads, and buildings) at risk of damage from storm surges, inundation and inland flooding should be identified, and strategies developed to minimize vulnerability.

Water resources and supply

A programme of water quality monitoring for fresh, saline and hyper-saline waters is needed in order to assess their vulnerability to sea level rise.

Economics

Economic evaluations of the impact of various climate change scenarios on the tourism, commercial and property insurance sectors are needed, and economic analyses of the options for the generation of electrical power, and alternative power sources for motor vehicles.

Climate change awareness

Public awareness of the reality and consequences of climate change, given the vulnerability of The Bahamas, is essential, among all sectors of the community, using town meetings and the print, radio and television media.

Collaboration

The Bahamas is presently participating in the CPACC Project, in the "Feasibility Study on the Prediction and Amelioration of Socio-Economic Impacts of the El Nino Southern Oscillation (ENSO) in Latin America and the Caribbean". It is recommended that such regional collaboration continue.

DEFINITIONS AND ABBREVIATIONS

CARICOM: Caribbean Community. CARICOM is essentially two organizations in one. The Community deals with functional matters of regional cooperation while the Common Market is the economic branch. The members are Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, Montserrat, St Lucia, St Kitts and Nevis, St Vincent and the Grenadines, Suriname, Trinidad and Tobago The Bahamas is not a member of the Common Market. Haiti is expected to become a member in July 2001. Anguilla, the British Virgin Islands, and Turks and Caicos, are associate members.

Commonage land: Land held in common by the inhabitants of the Family Islands who were born there. These lands were originally granted to commoners of the islands for services rendered the Crown. Until recently, such lands were used exclusively for farming but are now used for residential purposes.

CPACC: Caribbean Planning for Adaptation to Climate Change.

El Nino: A warm current that periodically flows along the western coast of South America, usually forming around December or January. It results in temporary reversals of airflows and surface ocean currents in the equatorial Pacific ocean, abnormal warming of surface waters of the coast of Peru, leading to disturbances of global weather patterns.

GHGs: Greenhouse gases: those gases capable of absorbing terrestrial radiation and therefore responsible for the greenhouse effect. The main greenhouse gases are water vapour, carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O) and the wholly anthropogenic chlorofluorocarbons (CFCs).

Family Islands: The major populated islands other than New Providence and Grand Bahama. These are Abaco, Acklins, the Berry Islands, the Bimini Islands, Cat Island, Crooked Island, Eleuthera, the Exuma Islands and Cays, Great Inagua, Long Island, Mayaguana, Rum Cay and San Salvador

Ghyben-Hertzberg Lenses: Freshwater lenses in oceanic islands that are made up of three layers: an upper layer of drinkable (potable) water, a transition layer, in which salinity increases downward, and a saline layer in which salinity increases rapidly downwards. Water is ideally abstracted only from the upper layer, but over-pumping can to the intrusion of saline water. Freshwater moves outwards from the centre of the lenses towards the ocean and this flow carries away salt water that might otherwise enter and spoil the lens.

IPCC: Intergovernmental Panel on Climate Change.

New Providence/Nassau/Paradise Island: Nassau is often used synonymously with New Providence. Nassau is the capital city of The Bahamas, and New Providence is the island on which Nassau is located. Paradise Island, formally Hog Island, is located a few hundred yards north of New Providence and is separate from, but linked by two bridges to, New Providence. Paradise Island is a major tourist area. The sea between New Providence and Paradise Island forms Nassau Harbour.

OAS: Organization of American States. Comprises thirty-four member states in the Americas and the Caribbean.

Saffir-Simpson Scale: Based on wind speeds, the scale is designed to show the level of damage that can be expected from hurricanes. There are five categories which range from category 1 (wind speed 74 to 95 mph, damage minimal) to category 5 (winds in excess of 156 mph and damage catastrophic.

SIDS: Small Island Developing State(s).

Units of measurement: Units of length used in this communication are inches (in), feet (ft) and miles (mi), along with the metric equivalents of metre (m) and kilometer (km). Units of area used are square miles (mi^2) and square kilometers (km^2). Wind speeds are in knots (kt), which are nautical miles per hour. Conversion factors used are: 1 in = 25.4 mm; 1 ft = 0.348 m; 1 mi = 1.61 km; 1 mi^2 = 2.59 km^2. Temperatures are given in degrees Fahrenheit (˚F) and in degrees Centigrade (˚C).

Annex 1

NATIONAL CLIMATE CHANGE COMMITTEE

In order to coordinate The Bahamas' national response to the issue of climate change at the local, national, regional and international levels, and to provide a mechanism for responding to its obligations under Articles 4 and 12 of the UNFCCC, the National Climate Change Committee (NCCC) was established as a sub-committee of The Bahamas Environment, Science and Technology (BEST) Commission, Office of the Prime Minister.

The Ambassador for the Environment serves as an ex-officio member of the NCCC. Other members of the committee are appointed by the BEST Commission, and comprise senior public servants, public and private sector policy advisors, and representatives of non-governmental organizations. The NCCC Chairman is on the Board of Directors of the BEST Commission, to ensure coordination of the committee's work with national governmental policies.

The first meeting of the NCCC was convened on March 6 1996. The committee has met frequently since its inception and organized a national workshop in 1998 to increase public awareness of climate change. Committee membership has remained consistent during the four years of operation. The following is a list of Committee Members:

- Mr. Philip S. Weech, Senior Hydrologist, Water and Sewerage Corporation (Chairperson).
- Mr. Arthur W. Rolle, Deputy Director, Department of Meteorology (Deputy Chairperson).
- Mr. David L. Cates, Deputy Permanent Secretary, Ministry of Foreign Affairs (Secretary).
- Mr. Michael Braynen, Director of Fisheries, Ministry of Agriculture and Fisheries (1997-present).
- H.E. Earl Deveaux, M.P., Ambassador for the Environment and Chairperson of the BEST Commission (2000-2001).
- Dr. John Hammerton, BEST Commission (1998-2000).
- Mr. Patrick Hanna, Bahamas Electricity Corporation.
- Mr. Colin Higgs, Director of Fisheries, Ministry of Agriculture and Fisheries (1996-1997).
- H. E. Lynn Holowesko, Ambassador for the Environment, and Chairperson of the BEST Commission (1996-1999).
- Mr. Lambert Knowles, Bahamas Association of Professional Engineers and George V. Cox and Associates.
- Mr. Reginald Lobosky, President, Bahamas Chamber of Commerce (1995-1997).
- Mr. Neil McKinney, President, Bahamas Chamber of Commerce (1997-1999).
- Mr. Dwight King, Ministry of Public Works.
- Ms. Melanie Roach, Director, Department of Public Works.
- Mr Bismark Coakley, President, Bahamas Chamber of Commerce (1999-present).

At the first meeting Mr. Philip Weech was elected Chairperson, Mr. Arthur Rolle was elected Vice-chairperson, and Mr. David Cates was elected Secretary. These office holders have not changed since the inception of the NCCC. Mr. Michael Braynen succeeded Mr. Colin Higgs as Director of Fisheries; Mr. Neil McKinney succeeded Mr. Reginald Lobosky as President of The Bahamas Chamber of Commerce; and Ambassador Deveaux succeeded Ambassador Holowesko as Ambassador for the Environment in January 2000, and in February 2001, the BEST Commission portfolio was transferred to the Ministry of Agriculture and Fisheries. The Minister is the Hon. James F. Knowles, M.P. The Permanent Secretary, Mr. Colin Higgs, is the Ambassador for the Environment.

National Climate Change Committee
photograph: courtesy Bahamas Information Services

Standing, left to right:
Mr. Arthur Rolle (Deputy Chairman NCCC), Mr. Patrick Hanna (AGM B.E.C.), Mrs. Nakira Gaskin-Wilchcombe (BEST), Dr. John Hammerton (FNC Editor), Mr. Michael Braynen (Director of Fisheries), Mr. Lambert Knowles (Engineer).

Seated, left to right:
Mr. Donald Cooper (US BET),Mr. James P. Bruce (Consultant GCSI), Mr. Philip S. Weech (Chairman NCC), Ambassador T. Neroni Slade (Chairman AOSIS), Dr. Davidson Hepburn (Consultant NCCC).

Annex 2

ACKNOWLEDGEMENTS

The National Climate Change Committee (NCCC) gratefully acknowledges the work of committee members in compiling this report, all of whom served on a voluntary basis. These persons have substantive posts in either the public service or the private sector, and preparation of this report was, therefore, outside the scope of their regular work. Their determination is indicative of the importance accorded to environmental issues in The Bahamas.

The Committee would be remiss if it did not acknowledge the work of the late Mrs. Catherine Benjamin. Although ill for a number of years, and at times confined to home, Mrs. Benjamin worked untiringly in the BEST Commission as its first coordinator. Holding the rank of Deputy Permanent Secretary, she was, in the early years of the Commission, also responsible for the relief efforts following the passage of hurricane Andrew. Mrs. Benjamin did not serve on the NCCC, but she was largely responsible for setting up the BEST Commission and its subsidiary committees.

The Committee thanks Senator, formally Ambassador, Lynn Holowesko, for her support and encouragement while Chairperson of the BEST Commission from 1994 to 2000. Senator Holowesko has a lifelong interest in environmental issues, and was twice President of The Bahamas National Trust, from 1976 to 1982 and from 1984 to 1991.

Ambassador Earl Deveaux, M.P., Chairman of the BEST Commission from January 2000 to February 2001, and a former Minister of Agriculture and Fisheries, was also very supportive of the Committee's work since his appointment.

The Hon. James F. Knowles, M.P., assumed responsibility for the BEST Commission effective February 2001, and has been, and continues to be, understanding and supportive of the work of the NCCC.

Ms. Teresa Butler, Permanent Secretary in the Office of the Prime Minister, is thanked for her constant understanding and guidance during the work of the NCCC. The staff of the BEST Commission, especially Ms. Lorca Bowe and Ms. Maria Heild, is acknowledged, especially in arranging committee meetings and circulating documents.

Thanks go to Mrs. Eleanor Philips (Department of Fisheries) and Mr. Jeffrey Simmons (Department of Meteorology) for undertaking the initial vulnerability and adaptation assessment, reported in Chapter 3.
Many other persons contributed to the preparation of this document, some unknowingly.

Special thanks go to:

Mr. Errol Bethel (Parliamentary Registrar) for information on the electoral process,
Mr. Timothy Bethel (Bahamas National Trust) for information on the National Parks System,
Mrs. Barbara Burrows (Acting Permanent Secretary in the Cabinet Office) for information on hurricane damage, and facilitating the work of the NCCC,
Dr. Richard Cant (Acting General Manager, Family Island Water Environment, Water and Sewerage Corporation) for providing information and support,
Mr. Clarence Cleare (Ministry of Local Government) for information on the local government system.
Mr. David Cates (Deputy Permanent Secretary in the Ministry of Foreign Affairs, and Secretary to the NCCC) for diligently compiling the first draft if this First Communication.
Dr. John L. Hammerton (now retired but formerly a member of staff of the BEST Commission and one-time member of the NCCC) for undertaking the revision and editing of this First Communication.
Mr. Oris Russell (retired Permanent Secretary) for information on the Bahamian flora.
Mr. Carl Smith (Director of Agriculture) for information on the Bahamian flora.
Ms Patrice Williams and Ms Grace Turner (Department of Archives) for information on the history of The Bahamas.
Comptroller of Bahamas Customs, for data on imports.
Governor of the Central Bank of The Bahamas, for data on oil imports.
Director of Meteorology and staff, for provision of meteorological data and general support.
Director and staff of the Department of Statistics, for census data and data on imports,
Esso Standard Oil SA Ltd for information on oil imports.
General Manager and staff of the Bahamas Electricity Corporation for information on generating capacity and demand.
General Manager and staff of the Water and Sewerage Corporation, for facilitating the work of the NCCC in many ways.
Ministry of Foreign Affairs, for general support and for facilitating the work of the NCCC.
Shell Bahamas Ltd for information on oil imports.
Texaco Bahamas Ltd for information on oil imports.

Preparation of the Report has truly been a team effort and a capacity building activity.

Annex 3

LIST OF SCIENTIFIC NAMES OF MARINE AND TERRESTRIAL ANIMALS AND PLANTS REFERRED TO IN THE TEXT

Birds
Bahama parrot *Amazona leucocephala bahamensis*
Bobwhite *Colinus virginianus*
Chukar *Margarops fuscatus*
Cuban grass-quit *Tiaris olivacea*
Kirtland's *Warbler Dendroica kirtlandii*
Northern mockingbird *Mimus polyglottos*
Ring-necked pheasant *Phasianus colchicus*
West Indian flamingo *Phoenicopterus ruber*
Whistling duck *Dendrocygna aborea*
White crown pigeon *Columba leucocephala*

Terrestrial mammals
Bahama hutia *Geocapromys ingrahamii*
Raccoon *Procyon lotor*

Mark Catesby: Bahama hutia

Iguanas
Iguana *Cyclura spp.*
(including C. baelopha, C. carinata, C. cychlura, C. rileyi)

Scale fish of commercial importance
Amberjack *Seriola dumerili*
Bonefish *Albula vulpes*
Blue marlin *Makaira nigricans*
Dolphin *Coryphaena hippurus*
Jacks *Caranx spp.*
Lane snapper *Lutjanus syngaris*
Nassau grouper *Epinephelus striatus*
Sail fish *Istiophorus platypterus*
Swordfish *Xiphias gladius*
Tuna *Thunnus thynnus*
Wahoo *Acanthocybium solanderi*
White marlin *Tetrapturus albidus*

Other marine species of commercial importance
Spiny lobster *Panuluris argus*
Queen conch *Strombus gigas*

Turtles
Cat Island freshwater turtle *Trachemys terrapenInagua*
Green turtle *Chelonia midas*
Hawksbill turtle *Eretmochelys imbricata),* and
Inagua freshwater turtle *Trachemys stejnegeri*
Leatherback turtle *Dermochelys coriacea*
Loggerhead turtle *Caretta caretta*

Dolphins
Bottlenose dolphin *Tursiops truncatus*
Atlantic spotted dolphin *Stenella longirostris*
Spinner dolphin *Stenella plagiodon*

Whales (migratory)
Beaked shortfin whale *Globicephala macrohynchus*
Humpback whale *Megaptera novaeangliae*
Minke whale *Balaenoptera acutorostrata*
Sperm whale *Pyseter caodon*

Sharks
Hammerhead shark *Sphyrna mokarran*
Tiger shark *Galeocerdo cuvieri*
Nurse shark *Ginglymostoma cirratum*
Mako shark *Isurus oxyrinchus*
Lemon shark *Negaprion brevirostris*

Native and naturalized plants
Black mangrove *Avicennia germinans*
Brazilian pepper tree *Schinus terebinthifolius*
Button wood *Conocarpus erectus*
Caribbean pine *Pinus caribea*
Casuarina *Casuarina equisetifolia*
Horseflesh *Lysiloma sabicu*
Lignum vitae *Guaicum sanctum*
Mahogany *Swietenia mahagoni*
Paper bark tree *Melaleuca quinquenervia*
Poison wood *Metopium toxiferum*
Red mangrove *Rhizophora mangle*
Turtle grass *Thalassia sp.*
White mangrove *Laguncularia racemosa*
Wild fig *Ficus spp.*
Wild tamarind *Lysiloma latisiliquum*

Introduced crop species
Avocado *Persea americana*
Beans *Phaseolus spp.*
Breadfruit *Artocarpus communis*
Cassava *Manihot esculenta*
Corn *Zea mais*
Guava *Psidium guajava*
Gooseberry *Phyllanthus acidus*
Guinep *Melicocca bijuga*
Hog plums *Spondias mombin*
Hot pepper *Capsicum spp.*
Mamey *Mammea americana*
Mango *Mangifera indica*
Melon *Cucumis melo*
Pigeon pea *Cajanus cajan*
Pineapple *Ananas comosus*
Sapodilla *Manilkara zapota*
Scarlet plum *Spondias purpurea*
Soursop *Annona muricata*
Sweet potato *Ipomoea batatas*
Sugar apple *Annona squamosa*
Water melon *Citrullus vulgaris*

The West Indian Monk Seal (*Monachus tropicalis*) is now extinct, while the American crocodile (*Crocodylus acutus*), Scarlet Ibis (*Guara rubra*) and West Indian Manatee (*Trichechus manatus*) are no longer recorded in The Bahamas. Freshwater fish of the genus *Gambusia* have been introduced and are found in ponds and potholes on most islands.

Reference: BEST (1995).

REFERENCES

Albury, P. 1978. *The story of The Bahamas*. London, Macmillan.

BEST. 1995. *Bahamas Biodiversity Country Study Report*. Bahamas Environment, Science and Technology Commission, Office of the Prime Minister. Nassau, Bahamas.

BEST. 1998. *National biodiversity strategy and action plan*. Bahamas Environment, Science and Technology Commission, Office of the Prime Minister. Nassau, Bahamas.

Bohlke, J.E. and C. Chaplin. 1993. *Fishes of The Bahamas and adjacent tropical waters* (2nd ed.). Austin: University of Texas Press.

Britton, N. L. and C.F. Millspaugh. 1920. *The Bahamas flora.* New York: published by the authors.

Brown, L. and J.F. Downhower. 1993. *The eyes of Andros*. Bahamas Naturalist: 7, (1), 5-10.

Brudenell-Bruce, P.G.C. 1975. *The birds of New Providence and the Bahama islands*. London: Collins.

Bryant, D., L. Burke, J.W. McManus and M. Spalding. 1998. *Reefs at risk: A map-based indicator of threats to the world's coral reefs.* Washington, DC: World Resources Institute.

Campbell, D. 1978. *The ephemeral islands.* London: Macmillan.

Cant, R.V. 1996. *Water supply and sewerage in a small island environment: The Bahamian experience*. Small Islands Marine Science and Sustainable Development Coastal and Estuarine Studies, 51, 329.

Cant, R. 1997. *Developing water supply strategies for The Bahamas.* Bahamas Journal of Science: 4, (2), 5-7.

Cant, R.V. and P.S Weech. 1986. *A review of the factors affecting the development of Ghyben-Hertzberg lenses in The Bahamas.* Journal of Hydrology: 84: 333-343.

Cant, R.V., P.S. Weech, and E.E. Hall. 1989. *Saltwater intrusion in The Bahamas: a case study of the Great Lucayan water - way, Grand Bahama, The Commonwealth of The Bahamas.* Nassau, Bahamas: unpublished report. 9 pages.

Carter, T.R. 1994. IPCC *Technical guidelines for assessing climate change impacts and adaptations.* Working Group II of the Intergovernmental Panel on Climate Change (IPCC). 59 pages.

Carew, J.L. 1997 *Rapid sea-level changes at the close of the last interglacial (substage 5e). Recorded in Bahamian Island Geology: Comment and Reply.* Geology: 25, 527.

Cates, D.L. 1998. *Alligators, Seals and Iguanas. In: The Bahamas Handbook and Businessman's Annual.* Nassau, Bahamas: Dupuch Publications. Pages 111-121.

Cates, D.L. 1997. *Mark Catesby and The natural history of Carolina, Florida and the Bahama Islands.* Journal of The Bahamas Historical Society: 18, 2-10.

Catesby, M. undated. *Natural history of Carolina, Florida and the Bahama Islands.* Two volumes. London: Published by the Author, 1729-1747.

Central Bank. 2000a. *Central Bank of The Bahamas 1999 Annual Report.* Nassau, Bahamas: Central Bank of The Bahamas.

Central Bank. 1997. *Quarterly Statistical Digest. 6, (2).* Nassau, Bahamas: Central Bank of The Bahamas.

Cleare, C.B. 2000. *Local government profile.* Ministry of Local Government, Nassau, Bahamas: unpublished paper.
Coenen, C. 1995. *Observations on the Bahamian rock iguanas of the Exumas.* Bahamas Journal of Science: 2, (2), 8-14.

Correll. D. and H. Correll. 1982. *Flora of The Bahamas archipelago.* Germany: Gantner Verlag K-G.

Department of Agriculture and Department of Statistics. 1996. *Second census of agriculture 1994. Final Results.* Nassau, Bahamas: Department of Agriculture and Department of Statistics.

Department of Meteorology. 1977. *Rainfall of New Providence.* Nassau, Bahamas: Department of Meteorology. 57 pages.

Department of Statistics. 1998. *The Bahamas in Figures 1997.* Nassau, Bahamas: Department of Statistics.

Deveaux, E. 1999. *Sustainable use of The Bahamas' marine environment.* Address to the 3rd US Coral Reef Task Force Meeting, St. Croix, USVI, November 2-3. Unpublished.

Dupuch Publications. 2000b. *Bahamas handbook and businessman's annual 2000.* Nassau, Bahamas: Dupuch Publications.

Eneas, G. 1998. *Agriculture in The Bahamas. Its historical development 1492-1992.* Nassau, Bahamas: Media Publishing.

Fairbridge, R.W., R.N. Young, C.G.A. Harrison and M.M. Ball. 1961. *Geology of The Bahamas.* In: *The Encyclopedia of World Regional Geology Part I: Western Hemisphere.* Stoudesburg, Pennsylvania: Dowden Hutchinson and Ross: 109-114.

Foos, A. 1994. *Water Budget for Cockburn Town, San Salvador.* Bahamas Journal of Science: 2, (1), 31-35.

Gamble, D.W., M.E. Brown, D. Parnell, D. Brommer and P.G. Dixon. 2000. *Lessons learned from Hurricane Floyd damage on San Salvador.* Bahamas Journal of Science: 8, (1), 24-31.

Hearty, P.J. 1998. *Enigmatic boulders of Eleuthera: geological evidence tells of catastrophic waves in The Bahama.* In: *The Bahamas Handbook and Businessman's Annual 1998.* Nassau, Bahamas: Dupuch Publications. Pages 122-132.

Hearty, P.J. and P. Kindler. 1995. *Sea-Level highstand chronology from stable carbonate platforms (Bermuda and The Bahamas).* Journal of Coastal Research: 11, (3), 675.

Higgs, L. 1978. *Bush medicine in The Bahamas.* Nassau, Bahamas: published by the author.

Ingraham, H.1999a. *Environmental enhancement.* Broadcast address by the Prime Minister of The Bahamas, May 2. Nassau, Bahamas.

Ingraham, H. 1999b. *Reconstruction effort following hurricane Floyd.* Communication to Parliament by the Prime Minister of The Bahamas. October 13. Nassau, Bahamas.

Ingraham, H. 2000a. *Hurricane Floyd recovery efforts and hurricane Floyd tree replacement and beautification programme.* Communication to Parliament by the Prime Minister. February 23. Nassau, Bahamas.

Ingraham, H. 2000b. *Contribution on a resolution to return to Nassoak Limited 208.41 acres of land acquired by the Government in 1989 for development of a freight terminal at Clifton, New Providence.* Communication to Parliament by the Prime Minister. May 17. Nassau, Bahamas.

IPCC. 1996. *Revised IPCC guidelines for national greenhouse gas inventories.* Intergovernmental Panel on Climate Change.

Jelesnianski, C.P. 1967. *Numerical computation storm surges with bottom stress.* Monthly Weather Review, 95, 740-756.

Kindler, P. and P. Hearty. 1996. *Carbonate petrography as an indicator of climate and sea-level changes: new data from Bahamian quaternary units.* Sedimentology: 42, 381.

Little, B.G, et. al. 1971- 1976. *Land Resources of the Commonwealth of The Bahamas. Volume 1 Abaco; Volume 2 Eleuthera; Volume 3 Cat Island; Volume 4 Andros; Volume 5 Grand Bahama; Volume 6 Great Exuma, Little Exuma and Long Island; Volume 7 Crooked Island and Acklins; Volume 8 Mayaguana and Inagua.* Nassau, Bahamas.

Martin, H. and J.P. Bruce. 1999. *Effects of climate change: hydrometeorological and land-based effects in The Bahamas.* Ottawa, Canada: Global Change Strategies International, Inc.

Martin, H. and J.P. Bruce. 2000. *Effects of climate change: hydrometeorological and land-Based effects in The Bahamas: Final report.* Ottawa, Canada: Global Change Strategies International, Inc.

Ministry of Foreign Affairs. 1992. *Report of The Commonwealth of The Bahamas to the United Nations Conference on Environment and Development.* Nassau, Bahamas: Ministry of Foreign Affairs.

Ministry of Health and Ministry of Commerce, Agriculture and Industry. 2000. *National Food and Nutrition Policy and Agenda for Action.* Nassau, Bahamas: Ministry of Health and Ministry of Commerce, Agriculture and Industry. Unpublished Draft.

National Research Council. 1990. *Saline agriculture. Salt-tolerant plants for developing countries.* Washington, DC: National Academy Press.

Neumann, A.C. and P.J. Hearty. 1996. *Rapid sea-level changes at the close of the last inter-glacial (substage 5e) recorded in Bahamian island geology.* Geology: 24, (9), 775.

Neumann, AC. and Land, L.S. 1975. *Lime mud deposition and calcareous algae in the bight of Abaco, Bahamas.* A budget. Journal of Sedimentary Petrology, 45, (4), 763-786.

Patterson, J. 19977. Native Trees of The Bahamas. Nassau, Bahamas: published by the author.

Rappaport, E.N. and F.C. Sheets. 1993. Hurricane Andrew. Bahamas Journal of Science: 1, (1), 2-9.

Rolle, A. W. 1990. A storm surge atlas for the northern and central Bahamas New Providence and vicinity). Nassau: the National Weather Service of The Bahamas. 21 pages plus Appendix.

Russell, C. 1998. The future of forestry in The Bahamas. Bahamas Journal of Science: 5, (3), 2-11.

Russell, C. 2000. Bahamas country report: forestry outlook study for the Caribbean. Nassau, Bahamas: Department of Lands and Survey. Mimeographed.

Sealey, N.E. 1994a. Bahamian Landscapes. Nassau, Bahamas: Media Publishing.

Sealey, N.E. 1994b. Rainfall distribution in New Providence for 1993. Bahamas Journal of Science: 1, (3), 33-35.

Sealey, N.E. 1995. Rainfall distribution in New Providence for 1994. Bahamas Journal of Science: 2, (2), 32-34.

Sealey, N. E. 1996. Rainfall distribution in New Providence for 1995. Bahamas Journal of Science: 4, (1), 35-36.

Sealey, N. E. 1997. Distribution of rainfall in New Providence for 1996. Bahamas Journal of Science: 5, (1), 36.

Sealey, N. E. 1998. Distribution of rainfall in New Providence for 1997. Bahamas Journal of Science: 5, (2), 34-36.

Sealey, N. E., P. Balfe and N. Wardle. 1999. Rainfall distribution on New Providence for 1997-1998. Bahamas Journal of Science: 6, (2), 55-57.

Shaklee, R.V. 1997. Historical hurricane impacts on The Bahamas: Part I: 1500-1749.Bahamas Journal of Science: 5, (1), 7-9.

Shaklee, R.V. 1998. Historical hurricane impacts on The Bahamas: Part II: 1750-1799. Bahamas Journal of Science: 5, (2), 16-20.

Shaklee, R.V. 1998. Historic weather at Nassau. Bahamas Journal of Science: 6, (1), 23-30.

Shaklee, R.V. 2000. Historical hurricane impacts on The Bahamas: 1800-1850. Bahamas Journal of Science, 8, (1), 16-24.

Shattuck, G. (ed.). 1905. The Bahama Islands. Baltimore, Maryland: Baltimore Geographical Society.

Smith, D., L. Miller and J. Miller. 1994. The Butterflies of the West Indies and South Florida. Oxford and New York: Oxford University Press.

Suplee, C. 1999. El Nino la Nina nature's vicious cycle. National Geographic 195, (3), 72-95.

United Nations. 1994. Earth Summit. Programme of action for small island developing states. Global conference on the sustainable development of small island developing states, Bridgetown, Barbados, April 26 to May 6 1994. New York. United Nations.

United Nations. 1992. Agenda 21: programme of action for sustainable development. Rio Declaration on Environment and Development. Statement of Forest Principles. United Nations Conference on Environment and Development, Rio de Janeiro, Brazil, June 3-14., 1992. New York. United Nations.

UNFCC. 1999. Compendium of decision tools to evaluate strategies for adaptation to climate change. Bonn: UNFCC Secretariat.

Watson, R.T., M.C. Zinyowera and R.H. Moss (Eds). 1998. The Regional Impacts of Climate Change. An assessment of vulnerability. A special report of IPCC working group II. Published for the Intergovernmental Panel on Climate Change. Cambridge University Press, United Kingdom.

Weech, P.S. 1999. Situational analysis of water resources: country report for The Bahamas. Nassau: Report for the Water Sector in The Bahamas. Unpublished: 15 pages.

White, A. 1998. A birder's guide to the Bahama islands and Turks and Caicos. American Birding Association.

Williams, P.M. 1999. Chronological highlights in the history of The Bahamas 600 to 1900. Nassau, Bahamas: published by the author and The Bahamas Historical Society.

Woods, C.A, (ed.). 1989. Biogeography of the West Indies past, present and future. Gainesville, Florida: Sandhill Crane Press, Inc.

CHAPTER 1

NATIONAL CIRCUMSTANCES AND BACKGROUND

1.1 GEOGRAPHY, GEOLOGY AND POPULATION

Photography: courtesy of Philip Weech

"Though all the others [islands] we have seen were beautiful, green and fertile, this [probably Crooked Island] was even more so. It has large and very green trees, and great lagoons, around which these trees stand in marvelous groves. Here and throughout the island, the trees and plants are as green as in Andalusia in April. The singing of small birds is so sweet that no one could ever wish to leave this place. Flocks of parrots darken the sun and there is a marvelous variety of large and small birds."

Christopher Columbus, 1492. (1)

1.1.1 Location

The Commonwealth of The Bahamas consists of an archipelago of islands atop the Bahama platform, which extends more that 840 miles (mi)/ 1,335 kilometers (km) from the coast of Florida to the island of Hispaniola. The platform comprises a series of thick, shallow carbonate banks, known as the Little and Great Bahamas Banks, horizontally aligned, that have built up along the subsiding continental margin of North America. The archipelago comprises over 700 islands plus more than 200 cays, islets and rocks, spread over approximately 100,000 square miles (mi^2) / 260,000 square kilometers (km^2) of the Atlantic Ocean. The Bahamas lies between latitudes 21˚ and 27˚ north and longitudes 72˚ and 79˚ west, about 50 mi (81 km) east of Florida (U.S.A.), and extending about 750 mi (1,200 km) southeastwards to within 50 mi (81 km) of Cuba and Haiti. Insulated from the North American continent by the Straits of Florida, and cooled in the summer months by the northeast trade winds, The Bahamas suffers neither extreme heat nor cold. The climate is greatly influenced by the Gulf Stream as it flows north through the Straits of Florida.

Geographically and geologically the archipelago includes The Bahamas and the Turks and Caicos Islands. The Turks and Caicos Islands were administered from Nassau until 1848, when they were placed under colonial administration from Jamaica. The Bahamas and the Turks and Caicos Islands have common features and many plant and animal species, mostly birds and fishes, in common.

(1) Christopher Columbus (1492) "discovered" The Bahamas and wrote about the plants and animals as he sailed through the islands in 1492. He also described the many islands and tieir attributes in his journal

The total land area of The Bahamas is approximately 5,382 mi^2 (13,940 km^2). The largest of the islands is Andros, with an area of 2,300 mi^2 (5,957 km^2), some 80% of which is less than 3.3 feet (ft) (1.0 m) above mean sea level. Harbour Island, with an area of 1.5 mi^2 (3.9 km^2) and Spanish Wells, with an area of 0.5 mi^2 (1.3 km^2), are the two smallest permanently inhabited islands. Thirty islands and cays are inhabited, among which there are great disparities in terms of the economies, standards of living and size of population. All populated islands have basic infrastructure such as schools, roads, electricity and running water.

1.1.2 Geology

> "The Bahama Islands may not only be said to be rocky, but are in reality entire rocks, having their surface in some places thinly covered with a light mold, which in a series of time has been reduced to that consistence from rotten trees and other vegetables. … It is amazing to see trees of a very large size grown out of rock where no soil is visible and the rock solid and compact before the roots found way to separate them…the fibres of the trees insinuate, and as they swell and grow bigger, widen the crevasses, which with the assistance of wind and rain, admit the roots penetration."
> *Mark Catesby, 1725.* [(2)]

Photography: courtesy of Philip Weech

There is evidence that in the Pleistocene Epoch the sea level around the Bahamas stood about 300 ft (91 m) lower than it does at present. Subsequently, the sea level rose to a level at least 15 ft (4.6 m) above present mean sea level. In more recent times (Holocene Epoch) the sea reached its present level. Fairbridge et al. (1961) provide a useful general account of the geology of The Bahamas.

All the islands of The Bahamas have generally low relief. The highest point is 206 ft (63 m) in Cat Island. The highest point in Abaco is about 120 ft (37 m) above mean sea level, and in Grand Bahama it is only 68 ft (21 m). The highest point in Andros 71 ft (21.6 m) above mean sea level and the greater part of that island, the largest in the archipelago, is less than 20 ft (6 m) above sea level. New Providence has ridges rising to about 100 ft (31 m) with a summit height of 127 ft (39 m) above mean sea level. This low relief reflects variations in sea level during the Pleistocene Epoch. During the time that the sea level was falling, there was dune formation and the building of recessional beach ridge systems. The low platform of marine limestone is thus partially covered by lithified Aeolian dune ridges, by beach ridges, and by small areas of unconsolidated or partially consolidated calcareous sands. Hearty and Kindler (1995) and Kindler and Hearty (1996) have researched the petrography of the carbonates and reported on the sea level changes.

(2) Mark Catesby (1725) was a British Naturalist who spent nine months in The Bahamas in 1725. His published work provides a relatively comprehensive account of the natural resources of The Bahamas circa 1725.

Geophysical data indicate that the shallow marine carbonates of the Little and Great Bahama banks are between 3.2 mi (5.4 km) and 6 mi (10km) thick, depending on the location. These banks are separated by a series of deep-water channels. It is usually upon the margins of these banks that the islands of The Bahamas occur unevenly. The islands are usually long and narrow, oriented from northwest to southeast with central ridges extending to up to about 100 ft (31 m), but see above. The upper portions of the islands have been exposed several times in the geological past as a result of sea level fluctuations in the Pleistocene Epoch. Radiocarbon dating of the carbonate rocks has shown them to be between 5,000 and 1,000,000 years old. Carew (1997) and Neumann and Hearty (1996) have made valuable contributions to knowledge of sea level changes in The Bahamas in the last interglacial.

In the early 1970s, the larger islands of The Bahamas were studied in detail by the Land Resources Division of the (then) Ministry of Overseas Development of the United Kingdom, under the auspices of the Ministry of Agriculture. The reports (Little et al., 1971 to 1976) include detailed surveys of the geology, landforms, soils, water resources, vegetation and land use.

1.1.3 Hydrogeology

The rock in which the sustainable and exploitable groundwater resources of The Bahamas occur, extend down to 110 ft (40 m) in the zones of the Pleistocene and Holocene limestone and lime sands. These rocks were formed as a result of wave action, the chemical precipitation of calcium carbonate and the deposition of oolitic and skeletal sands of marine origin. The surface geology is dominated by Pleistocene limestone and features include shallow marine deposits, and littoral and wind blown deposits that have been cemented by the solution of calcium carbonate in fresh rainwater during periods of low sea level, followed by re-precipitation within the inter-granular pores at the time of lower sea levels.

The groundwater resources of The Bahamas comprises the freshwater, brackish, saline and hypersaline waters found in the near and deep subsurface, and in the lakes and ponds that occur on the surface. The freshwater resources occur as three-dimensional lens-shaped bodies, which overlies brackish and saline waters. It is incorrect to conceive of these Ghyben-Hertzberg lenses (see Definitions and Abbreviations for a fuller description of these lenses) as occurring in subterranean lakes, rivers or ponds. Groundwater saturates the rock and all its pores, fissures and interconnected cavities. The shape, size and thickness of the freshwater bodies are controlled by the size, shape, orientation and subsurface geology, and the amount of rainfall. More than 90% of freshwater lenses are within 5 ft (1.5 m) of the land surface.

Saltwater intrusions periodically occur from storm surge events, but also from canalization for development of residential lots (Cant et al., 1989). The supply of fresh water continues to pose a problem as development occurs and demand increases, and as a result of the proliferation of septic tanks (Cant, 1996, 1997). Weech (1999) also discusses water resources in The Bahamas, and Foos (1994) has proposed a water budget for Cockburn Town in San Salvador.

Photography: courtesy of Philip Weech

1.1.4 Population

The 1990 census indicated a population of 254,685 and an annual growth rate from 1980, of 1.9%. The projected population for 1997 was 288,862, and for 2000, 303,069. The population is youthful, with some 60% under 30 years of age. The population is concentrated on just two islands: New Providence, where the capital city of Nassau is located, had 67% and Grand Bahama, home to the second largest city of Freeport, had 16% of the population. The remaining islands are sparsely populated. The estimated population in 1997 was 288,862, and is projected to be 303,069 in 2000. Some thirty islands and cays are inhabited. Table 1.1.1 lists the islands and their population as determined by the 1990 census.

Table 1.1.1 Land Area, population and population density of the principal islands of The Bahamas.

Island	Area (mi^2)	Population (1990 census)	Population density (per mi^2)
New Providence	80	171,542	2144
Grand Bahama	530	41,035	77
Abaco	649	10,061	16
Acklins	192	428	2
Andros	2300	8,155	4
Berry Islands	12	634	53
Bimini Islands	9	1,638	182
Cat Island	150	1,678	11
Crooked Island	93	423	5
Eleuthera	187	8,017	43
Exuma & Cays	112	3,539	32
Harbour Island	3	1,216	405
Inagua	599	985	2
Long Island	230	3,107	14
Mayaguana	110	308	3
Ragged Island	14	89	6
Rum Cay	30	53	2
San Salvador	63	486	8
Spanish Wells	10	1,291	129
Other Islands / Cays	9	---	---
All Bahamas	**5,382**	**254,685**	**47**

Source: Department of Statistics.

New Providence, which is about 80 mi^2 (207 km^2) in area, had a population density of 2,144 per mi^2 (827 per km^2) in 1990, compared with a national average of 47 per mi^2 (18 per km^2). Grand Bahama with an area of 530 mi^2 (1373 km^2) had a population density of 77 per mi^2 (30 per km^2). The remaining islands, called the Family Islands (formerly known as the Out Islands), are more sparsely populated (Table 1.1.1) and economic activity in many of them is limited. Many lack resources of fresh water and soil, and agricultural initiatives have failed. At present, fishing provides a good income and there is growth in the ecotourism sector.

Many of the Family Islands have suffered population depletion as a result of the dramatic success of the tourism sector that began in the 1950s in New Providence, and in the 1960s in Grand Bahama. Subsequently the banking and financial services sectors developed in New Providence from the 1960s onward, and the industrial sector in Freeport in the late-1960s. These have served as major employment magnets attracting large numbers of people from the Family Islands. The long-term result has been stunted development in most of the Family Islands and a disparity of incomes and standards of living between the two urban centres on the one hand, and Family Island settlements on the other. The rapid population growth and infrastructure development in New Providence has stretched its natural resource base to its limits in critical areas such as water resources and the availability of land for human habitation and for recreation.

1.2 CLIMATE

"The Bahama Islands are blessed with a most serene air, and are more healthy than most other countries in the same latitude."
Mark Catesby, 1725.

1.2.1 Weather conditions

The climate of The Bahamas is sub-tropical with fairly high temperatures but only moderate rainfall. Throughout the islands, the average annual rainfall varies from about 34 inches (in) / 865 millimetres (mm) to about 58 in (1470 mm). There is a distinct northwest to southeast gradient of decreasing rainfall. Rainfall seasonality is marked, with a dry season generally extending from November to April, with the period December to March particularly dry. Sealey (1994) et seq., Sealey et al. (1999), and Department of Meteorology (1977) have described the rain-fall distribution patterns for New Providence. During the wet season rain generally falls on 10 to 20 days during each month, while during the rest of the year, when rainfall is generally less than 2 in (50 mm), rain falls on fewer than 10 days each month. In the more southerly islands, July is drier than May, June, August, September and October, giving an almost bimodal rainfall distribution. Parts of these islands are distinctly arid with xerophytic vegetation and little agricultural potential.

Mean daily temperatures fluctuate between 60˚F and 90˚F (17˚C and 32˚C) although maximum and minimum temperatures fluctuate over a much wider range from 41˚F to 96˚F (5˚C to 36˚C). May to October are considered the summer months in The Bahamas, when mean daily temperatures exceed 77˚F (25˚C). These months are also the wetter months. In general the more southerly islands are significantly warmer in the winter months than the more northerly islands.

The winter months of December to March are much cooler and drier, but a feature during this time is periodic cold fronts. These systems pass through the islands on an average of one every week, bringing a mass of cool dry arctic air, giving periods of cool, dry and windy weather. November and April can be considered transitional months between the two main seasons. These months are almost identical in temperature and rainfall, but the minimum temperature in April is lower, and the rainfall in November, is higher. The reason for these slight differences is that during an active winter, a few cold fronts can still affect the islands in April, and hurricanes can still affect The Bahamas in November, the last month of the hurricane season. The predominant wind direction is northeasterly from October to April and southeasterly from June to August.

Detailed weather data for New Providence is given in Table 1.2.1. This gives means and extreme values of weather elements at Nassau International Airport, for the 30-year period 1961 to 1990. Since New Providence is located almost in the middle of the archipelago, the data in Table 1.2.1 can be regarded a reasonable "average" of weather conditions in The Bahamas

Table 1.2.1 Means and extreme values of weather elements, 1961–1990, for Nassau International Airport, New Providence.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mean daily max. temperature (˚F)	77.3	77.5	79.7	81.8	84.6	87.3	89.1	89.3	88.4	85.4	81.8	78.7
Mean daily min. temperature (˚F)	62.1	62.5	63.8	66.2	69.8	73.3	74.7	74.8	74.4	71.9	68.0	63.8
Highest max. temperature (˚F)	86.4	88.7	87.8	91.2	92.3	93.2	93.4	95.0	93.2	91.8	90.0	86.7
Lowest min. temperature (˚F)	41.4	45.8	44.6	48.6	55.5	59.0	64.2	64.4	59.5	59.9	52.0	41.5
Mean relative humidity (%)	78	78	76	74	77	79	77	79	81	80	78	78
Mean dew point (˚F)	62.6	62.6	63.5	64.9	69.6	73.5	74.6	75.0	74.7	71.8	67.6	64.0
Monthly rainfall (in)	1.86	1.59	1.57	2.12	4.58	9.17	6.21	8.50	6.75	6.91	2.23	2.04
Maximum rainfall in a day (in)	4.62	3.47	3.48	11.23	3.48	6.55	4.08	6.23	5.31	8.07	2.68	4.64
Number of rain days	8	6	6	5	10	15	17	18	17	16	9	8
Mean wind speed (kt)	8.0	8.6	8.9	8.3	7.9	7.2	7.1	6.9	6.2	7.4	8.1	7.8
Sunshine mean daily hours.	7.1	7.6	8.3	9.2	8.7	7.7	8.8	8.6	7.1	7.2	7.4	6.9

Source: Department of Meteorology.

From Table 1.2.1, it can be noted that there is a correlation between dew point and relative humidity on the one hand, and mean maximum and minimum temperatures and mean temperatures on the other. The duration of daylight, the interval between sunrise and sunset, varies from 10 hours 35 minutes in late-December to 13 hours 41 minutes in late-June. The average hours per day of bright sunshine are shown in the Table 1.2.1: on average there are at least seven (7) hours of bright sunshine per day year round, although it is not uncommon to get a spell of cloudy weather for two or three consecutive days at any time of the year.

1.2.2 Tropical storms and hurricanes

Photography: courtesy of Philip Weech

"I have never heard that any of the Bahama Islands are subject to earthquakes…The winds blow three-quarters of the year east, and between south and east…August and September are blowing months, and are attended with hurricanes, at which time the winds are very changeable, shifting suddenly to all points of the compass."

Mark Catesby, 1725.

Photography: courtesy of Philip Weech

Hurricanes are frequent occurrences in the weather systems affecting The Bahamas during the period June 1 to November 30, which is the Atlantic Hurricane Season. Nearly every year several storms or hurricanes come close enough to the islands to require the posting of warnings and alerts. The occurrence of hurricanes has been documented in Bahamian history from the early settlement of the islands (Shaklee, 1997, 1998a, 1998b). Severe damage was reported from many islands, especially during the 1920s.

Based on the historic record, it is thought that at the beginning of the twentieth century there were fewer hurricanes than later in the century, but it is impossible to be sure about this because at the beginning of the century, sophisticated detection, tracking and communications systems did not exist. At that time, hurricanes were reported only when they were observed from ships, or when they made landfall. It is unlikely that all hurricanes that made landfall in The Bahamas, especially those affecting the more remote and uninhabited Family Islands, were reported. During the hurricane months experienced inhabitants would watch changing weather patterns and their barometers, for falling barometric pressure, as indicators of approaching storm systems. Often they had only a few hours to prepare, and often damage to buildings, boats and crops was severe. During the period 1900 to 1999, forty-three hurricanes hit the Bahamas, a mean of 4.3 per decade. Only during the 1900s, 1920s, 1930s and the 1940s did the numbers of hurricanes exceed this mean. The strongest hurricane was recorded in 1947 and measured 5 on the Saffir-Simpson Scale (sustained winds in excess of 155 miles per hour (mph) / 245 knots per hour (kph). This was the only category 5 hurricane to affect The Bahamas for the century, and it moved across northern Abaco and Grand Bahama before striking Florida. The year 1933 was the most active year, with four hurricanes recorded as moving through The Bahamas. Of the forty-three hurricanes during the 1900 to 1999 period, fifteen have been termed “major” (category 3 or higher on the Saffir-Simpson Scale), which is a little more than a third of the total. Eight of these occurred in the last fifty years, during which period only four other “minor” hurricanes struck The Bahamas.

During the 1990s, two major hurricanes, Andrew in 1992 and Floyd in 1999, struck The Bahamas. Andrew was a relatively small but powerful hurricane that did considerable damage to North Eleuthera, Harbour Island, Spanish Wells, Current Island and the Berry Islands, before moving over South Florida, where it devastated Homestead and the surrounding areas (Rappaport and Sheets, 1993). Hurricane Floyd struck the Bahamas in September 1999, leaving major damage on Cat Island, Eleuthera, Abaco and Grand Bahama. A number of other islands were damaged to a lesser extent, including Long Island, San Salvador, Exuma, South Andros and the Berry Islands. Also during 1999 Dennis caused some damage on Abaco and Hurricane Irene, while passing over South Florida, caused minor damage to Abaco. Recovery efforts made necessary by the 1999 season will be ongoing in the foreseeable future (Ingraham, 1999b, 2000).

Paths of all hurricanes and tropical storms in the North Atlantic area from 1871 to the present, are given in United States Weather Bureau Technical Papers (Tropical Cyclones of the North Atlantic Ocean), which is updated every five years. Data on the numbers of tropical storms and hurricanes whose centre has passed within 100 mi (160 km) of The Bahamas from 1871 to 1999 (129 seasons) are summarized in Table 1.2.2. The data indicate that tropical storms and hurricanes most frequently occur in the months of September, October, August and November, in decreasing order. Probability is calculated as the number recorded for any one month divided by the number of Atlantic hurricane seasons.

Table 1.2.2 Number of hurricanes and tropical storms over the period 1871-1999 (129 hurricane seasons) by months.

Hurricanes & Tropical Storms	May	June	July	Aug.	Sept.	Oct.	Nov.	Total
No. per month	3	5	11	43	52	50	22	186
Probability per month	0.02	0.04	0.09	0.33	0.40	0.39	0.17	

Table 1.2.3 Number of hurricanes over the period 1886-1999 (114 hurricane seasons) by months.

Hurricanes	May	June	July	Aug.	Sept.	Oct.	Nov.	Total
No. per month	1	0	3	21	28	19	6	78
Probability per month	0.01	0.0	0	.0	0.18	0.25	0.17	0.05

Table1.2.4 Number of tropical storms over the period 1986-1999 (114 hurricane seasons) by months.

Tropical Storms	May	June	July	Aug.	Sept.	Oct.	Nov.	Total
No. per month	2	4	7	14	19	28	12	86
Probability per month	0.02	0.04	0.06	0.13	0.17	0.25	0.10	

From 1886 onward hurricanes were distinguished from tropical storms, and data on the numbers of hurricanes and the number of tropical storms, are summarized in Tables 1.2.3 and 1.2.4 respectively. The data indicate that, in August and September, more than half of all tropical cyclones (storms plus hurricanes) affecting the Bahamas become hurricanes, whereas in other months the proportion is about one-third. The number of storms and hurricanes affecting any one part of The Bahamas is, of course, very much stated above, and the number of cases of hurricane force winds affecting any one locality is much less still. For example, hurricane conditions might be expected at Nassau, New Providence, once in nine years.

Storm surges are often associated with the movement of hurricanes across land, where the central low-pressure core of the storm pushes a wall of water ahead of it. Non-tropical processes also generate storm surges, with waves traveling long distances over the open ocean, and interacting with the ocean-facing side of the islands. The surge of water often lasts for several days, with the height of the waves being a factor of the interacting site, the strength of the non-tropical process, and the ocean wind dynamics at the site. Typical non-tropical processes create the “rages” of Abaco and North Eleuthera, as they face the open Atlantic Ocean. These rages occur often in the winter months as intense low-pressure systems move eastward into the North Atlantic Ocean. Rolle (1990) has produced an atlas of storm surge scenarios for the central and northern Bahamas.

Geological evidence suggests that storm surges in the past have changed the coastline in certain areas of The Bahamas. On North Eleuthera, for example, huge boulders up to 1,000 cubic meters (m^3) in volume are thought to have been moved onshore by storms approximately one hundred thousand years ago (Hearty, 1998). The presence of chevron-shaped coastlines, and evidence of inland flood levels, supports this theory. More recently, in 1991, the “Halloween storm”, struck at the Glass Window in North Eleuthera, and a newly constructed reinforced bridge deck, weighing several hundred tons, was moved off its abutments by an Atlantic Ocean surge that also caused coastal flooding across the entire northern Bahamian archipelago.

1.3 HISTORY AND GOVERNMENT OF THE BAHAMAS

1.3.1 History

The island of San Salvador is generally accepted as the site where Christopher Columbus landed on October 12 1492. The Lucayans, a branch of the Taino Amerindians living in parts of the Caribbean, inhabited the Bahama Islands at that time. They had migrated to The Bahamas from Cuba and Hispaniola during the period 600-800 A.D. These aboriginal people were captured by the Europeans and transported into slavery on the island of Hispaniola, and to pearl fisheries off the coast of Venezuela. They died out as a result of enslavement and lack of immunity to European diseases. Albury (1978) and Williams (1999) have written useful historical accounts of The Bahamas.

Following the demise of the Lucayans the Bahama Islands remained uninhabited until the late 1640's. The early settlers were Englishmen from Bermuda seeking religious freedom and accompanied by their African slaves. By the early 1700's New Providence had developed sufficiently to become a pirate haven. The British government appointed a former privateer, Woodes Rogers, as the first Royal Governor whose mandate included eliminating piracy.

The Colony remained sparsely populated, the inhabitants making a meagre living from subsistence farming and fishing. American Loyalists formed a new wave of settlers, arriving in the islands after the American Revolutionary War. The Loyalists attempted to establish cotton plantations on several islands, but these ventures soon failed, due in part to the poor soil and to insect pests.

Bahamian history is characterized by periods of booms and busts. Prosperity was experienced during the American Civil War, when Nassau was used as a trans-shipment point for cotton from the Confederacy being exported to Europe, and for firearms and other supplies going the other way into the Confederacy. During this era the first hotel in the Bahama Islands, the Royal Victoria, was opened in Nassau. Clandestine smuggling activities resumed during prohibition in the 1920's, and again in the 1980s and 1990s when The Bahamas was used as a transhipment point for the illegal drug trade. After prohibition was repealed in 1932, Bahamians began to create the superb tourism industry of today. Since the mid-1990s the country has experienced an unprecedented economic boom.

There were major changes in the country beginning in 1953 with the development of party politics, and the extension of voting rights to non-property owners and, later, to women. A new constitution was adopted in 1964 leading to internal self-government. Majority rule came in 1967, when the Progressive Liberal Party (PLP) defeated the United Bahamian Party (UBP). The PLP was to remain in power until 1992. The Bahamas became an independent country on July 10, 1973.

The Commonwealth of the Bahamas is a small island state within the Commonwealth of Nations, formerly the British Empire. The Bahamas was a British Colony for over three hundred years and many British traditions are still retained, especially in the judicial, legal and government sectors. The Bahamas has a stable, democratic government. The Bahamas House of Assembly, first convened in 1729, is the fourth oldest parliament in the English-speaking world.

In addition to membership of the Commonwealth of Nations, the country is a member of the United Nations and of a number of the agencies of the United Nations system; the Organization of American States (OAS); the Caribbean Community (CARICOM); and the Association of Caribbean States (ACS).

1.3.2 National Government

HM Queen Elizabeth II is Head of State and is represented by the Governor-General. The Bahamas legislature is a two-chamber system based on the Westminster model, with a House of Assembly and a Senate. Members of the House of Assembly are elected and represent a constituency, of which there were 40 at the last election held in March 1997. Elections are held every five years with universal adult suffrage for citizens of The Bahamas who are over eighteen years old and resident in The Bahamas. The major political parties are the ruling Free National Movement (FNM) and the Progressive Liberal Party (PLP). The party winning the majority of seats in the election forms the government. The Prime Minister is the leader of the winning party and he/she must be a member of the House of Assembly.

The Cabinet is composed of Ministers and Ministers of State, appointed by the Prime Minister, and are responsible for running their government ministries. Each ministry has a Permanent Secretary, a career public servant, who is responsible for the day-to-day operation of the ministry. Members of the Senate are appointed by the Governor-General, on the advice of the Prime Minister and Leader of the Opposition. There are currently sixteen Senators.

1.3.3 Local Government

The Local Government Act of 1996 established a system of local government, and elections were first held in the twenty-three Family Island Districts on July 26 1996. The elected officials assumed responsibility for the administration of the day-to-day affairs of their communities during August 1996. Local Government is intended to deepen the democratic traditions of the country by transferring decision-making authority to communities, and by making government more accountable. Implementation is an acknowledgement that a central government, distant from communities in the Family Islands, cannot respond adequately to their daily needs. Cleare (2000) has provided an account of local government, and the Parliamentary Registrar (the official responsible for the conduct of all elections) provided additional information (Bethel 1999: personal communication).

The effect of local government has been to widen the base of power in Family Island communities by empowering the people through implementation of the Act. In order to broaden and diversify the group eligible for election, the government allowed certain categories of public servants to seek election for local government office without jeopardizing their jobs, tenure of employment and opportunity for promotion in the public service. Local government elections are held every three years. The island of New Providence is not included in the system of local government.

1.4 THE ECONOMY

1.4.1 Introduction

Photography: courtesy of Devin Weech

The Bahamian economy is driven by the tourism sector. Banking and the financial services sector is the second largest contributor to gross domestic product (GDP). The agricultural, fisheries and industrial sectors are comparatively small, and there is a growing industrial sector.

Government is the largest single employer. When totaled, the public service plus the government (utility) corporations (the Bahamas Electricity Corporation, the Bahamas Telecommunications Corporation, the Bahamas Hotel Corporation, the Broadcasting Corporation of The Bahamas, Bahamasair Holdings (the national airline), and the Water and Sewerage Corporation) employ approximately 25,000 persons. Government has announced plans to divest itself of the corporations and to invite private investment.

1.4.2 Tourism

> “[The] healthiness of the air induces many of the sickly inhabitants of Carolina to retire to them [Bahama Islands] for the recovery of their health.”
> *Mark Catesby, 1725*

Tourism dominates the economy of The Bahamas: it generates approximately 50% of gross domestic product (GDP) and provides employment, directly and indirectly, for about 50% of the working population. The latter is expected to increase to approximately 60% by the year 2010. It is estimated that the tourism industry contributed $1.5 billion US dollars to the economy in 1998, when 3.5 million tourists visited the country. About 1.6 million of these were “stop-over” visitors, staying in a hotel. A similar number were cruise ship visitors. Stopover visitors represent a population equivalence (based on year-round residence) of 23,800 persons, using a duration-of-stay of 5.8 days per visitor.

It is expected that the tourism sector will continue to grow in the future. However, growth will be determined by how well the sector, and the country, adjusts its tourism offerings to the changing preferences of consumers.   It is recognized that tourism is a high impact industry, as construction of large resorts can damage both the land and the marine environments, and there are associated problems, such as sewerage and garbage disposal, generation of electricity, and the provision of potable water for the tourist population as well as for the resident population.

The majority of tourists visit Nassau, and in recent years there have been major developments at the cruise ship port, and at the international airport. The recently opened Atlantis Hotel on Paradise Island, and renovations of facilities there and at Cable Beach, have made The Bahamas the largest tourist destination in the Caribbean in terms of hotel rooms. Freeport is also an important tourist destination, with recent major construction projects and a cruise ship facility.

Photography: courtesy of Devin Weech

Smaller, more exclusive destinations are the islands of Abaco, Harbour Island, Exuma, and Andros. The Ministry of Tourism has promoted The Bahamas as an ecotourism destination. The country is the largest oceanic-archipelagic nation in the tropical Atlantic. It has many blue holes and extensive limestone cave systems, as well as the world's largest breeding colony of the West Indian flamingo, and a rare sub-species of the Cuban parrot. The country offers a wealth of ecotourism opportunities in its many islands and cays. The twelve state-supported national parks and private sanctuaries provide opportunities for bird watching, nature treks, and identifying native flora. These parks are operated under the auspices of The Bahamas National Trust, a non-governmental organisation seeking to protect the environment.

The eco-tourism market presents an opportunity for small economies, such as The Bahamas, as it allows the participation of many Bahamians in the development of tourism without impacting negatively on the cultural, environmental and historical resources of the country. Bahamians in the Family Islands are encouraged to develop small-scale resorts. It is estimated that while traditional tourism is expected to grow by between 4% and 5% in the next decade, eco-tourism (or nature based tourism) is expected to increase by 20% to 25% during the same period.

Photography: courtesy of Philip Weech

1.4.3 Banking and finance

The banking and finance sector accounts for approximately 15% of GDP. The majority of banks and trust companies are engaged in the management of assets of wealthy clients. These institutions are generally non-resident or offshore companies that generate no Bahamian dollar earnings, and cover their expenses by bringing in foreign exchange. Foreign investors enjoy complete freedom of repatriation on their investments and profits.

Photography: courtesy of Philip Weech

1.4.4 Ship registry

The Bahamas has become one of the world's fastest growing of the two or three largest ship registry centres. Nearly 1600 vessels, including cargo and cruise ships, freighters, tankers and tugboats are registered in The Bahamas. The Merchant Shipping Act of 1976 governs the ship registry. The country actively encourages ship owners of all nationalities to register their ships under the Bahamian flag. A number of major cruise lines have their ships registered in The Bahamas.

In an effort to register more small cruise ships, luxury yachts and charter boats government has reduced tariffs and fees for these vessels. Ships engaging in foreign trade that are under twelve years old and weigh over 1,600 net tons are eligible for Bahamian registration. Under certain circumstances special permission may be obtained from the Minister of Transport for registration of ships under 1,600 net tons, or over twelve years old.

1.4.5 Fisheries

> "The water is so exceeding clear, that at the depth of twenty fathom, the rocky bottom is plainly seen, and in calm weather I have distinctly and with much pleasure beheld variety of fish sporting amidst groves of corallines and numerous other submarine shrubs, growing from the rocky bottom, amongst infinite variety of beautiful shells, fungus, and astroites, etc."
>
> *Mark Catesby, 1725*

In The Bahamas, the important commercial species of fish and other marine fauna, and a large number of species with little or no commercial value, live on the extensive shallow water banks. Particularly important commercially is the spiny lobster. Other commercially important species include the queen conch, the Nassau grouper, the lane snapper, jacks and bonefish. There are also a number of important offshore pelagic game fish including blue marlin, tuna, wahoo, sailfish, swordfish, amberjack, dolphin and white marlin.

Photography: Conch Shells (Strombus gigas) courtesy of Philip Weech

The waters surrounding The Bahamas are home to four species of sea turtles: the loggerhead, the green turtle, the hawksbill turtle and the leatherback turtle. Three species of dolphin occur, the bottlenose, the Atlantic spotted and the spinner, and four species of migratory whales, minke, sperm, beaked shortfin and humpback, are occasionally seen. There are several species of sharks including hammerheads, tiger sharks, nurse sharks, makos and lemon sharks. These marine species are of great importance to the biodiversity of the country and have significant potential for eco-tourism. Annex 3 lists the scientific names. On the island of Abaco efforts are underway to develop a whale-watching programme.

The Fisheries Resources (Jurisdiction and Conservation) Act of 1977 established an exclusive fishery zone of 200 miles from the baseline from which the territorial sea is measured. The purpose of the Act is to conserve the fisheries resources of the country and to regulate the exploration and exploitation of those resources. Marine mammals, sea turtles and spiny lobster are protected by law.

Fisheries regulations set limits for game fishing and long-line fishing is prohibited. Fisheries management is complex as it requires local, regional and international cooperation, and must also address concerns about endangered species, marine mammals, international shortages, and conflicts with agriculture, coastal development, and tourism.

The exclusive fishery zone is not to be confused with the exclusive economic zone established by the Archipelagic Waters and Maritime Jurisdiction Act of 1993. This Act establishes the archipelagic, territorial and internal waters of the country and the right of innocent passage of ships and aircraft. The Act also establishes the two hundred mile exclusive economic zone of the country and the types of activities that may be conducted therein.

Important components of the Bahamas "sun, sand and sea" tourist package are the numerous beaches throughout the islands. The health of these beaches is directly related to the near shore barrier and fringing reefs that act as natural breakwaters, thereby limiting their erosion by wave action. It is also related to the numerous stony and soft corals that make a significant contribution to the production of sand to replenish the beaches. Corals are increasingly recognized as sources of biomedical chemicals and are the sources of new chemicals currently being tested for anticancer, anti-microbial and anticoagulant properties. Bryant et al. (1998) have produced a world atlas of coral reefs at risk. Commercial fishing is reserved exclusively for Bahamians. However, several foreign investors are involved in aquaculture projects.

1.4.6 Agriculture

Agriculture's contribution to GDP is relatively small and historically of the order of 1% to 2%. Despite this, there is potential for the sector to make a greater contribution, focusing particularly on certain of the minor fruits. Subsistence farming is still important in the Family Islands, growing typically corn, cassava, sweet potatoes, beans and pigeon peas, but the number of farmers has declined in the past two decades and the average age of farmers has increased. The land area under agriculture according to the 1994 Agricultural Census was 50,250 acres (ac) / 20,344 hectares (ha) (Department of Agriculture and Department of Statistics, 1996). The sector produces substantial quantities of broilers and eggs, though all the inputs are imported. There is little red meat produced, though significant amounts of goat and sheep mutton are produced. Essentially all the dairy products consumed are imported, though there is some local manufacture using imported ingredients.

Some 90% of the food consumed in The Bahamas is imported, and food imports account for about 25% of all non-petroleum imports. This includes most of the carbohydrate foods and all the sugar. There is scope for greater local production of fresh fruits and vegetables, but production is seasonal and imports are necessary for much of the year to meet the demands of hotels and restaurants. There are a number of nurseries and landscaping companies.

1.4.7 Industry

There is a growing industrial sector, and several industrial parks in New Providence for light industry and the manufacture of consumer products. Grand Bahama is home to several industries including the manufacture of pharmaceuticals and other chemicals. There is an oil refinery that is no longer in operation, and a crude oil storage facility at Riding Point.

New Providence is home to the industries of brewing and distilling, and light manufacturing including furniture and bedding. There are a few companies producing a range of paper products, a company producing shoes, and several small operations producing garments of various types. There are a few sizeable food processors and several cottage industry food processors, making mainly preserves and pepper sauces. A significant cottage industry is straw work with the products sold locally in a number of crafts markets and in hotels.

Photography: courtesy of Devin Weech

1.5 ENERGY PRODUCTION AND TRANSPORT

Energy is produced mainly through the combustion of fossil fuel products such as gas/diesel oil and residual fuel oil (bunker "C"). Liquefied petroleum gas (LPG) is used for cooking while gasoline (petrol) and diesel oil are used for transportation. These account for 90% of the total carbon dioxide emission. Local transportation,manufacturing industries, commercial and residential buildings, are other users of fossil fuels, but along with agriculture and forestry, contribute insignificant amounts of carbon dioxide. The fishing industry and the mail boat (inter-island shipping) services contribute some carbon dioxide emission, but this is small compared to that of the major users of fossil fuel.

There is no use of biomass for electricity generation, and an insignificant amount is used for cooking, either as fuel wood or as charcoal.

1.6 THE ENVIRONMENT

"This beautiful species [flamingo] was at one time very abundant throughout The Bahama Islands; but of late years they have been so persecuted by the inhabitants that at the present time they are to be found in any numbers only upon the inland ponds and marshes of Inagua and Abaco. They are gradually dying off, or seeking some more inaccessible locality as yet undisturbed by the presence of mankind and in all probability with the next century the Flamingo will be unknown in The Bahamas.

During the month of July they [Bahama parrots] repair in large numbers to the cornfields near Matthewstown [Inagua] and cause great destruction to the crops. At this season they are quite tame, and quantities of them are killed."
Charles Corey, 1880.

1.6.1 Introduction

The natural beauty of the Bahamas is complemented by its rich cultural heritage, the warm hospitality of its people, and a vibrant economy. The Government is cognizant of the urgent need to protect the fragile environment and ecosystems of the country. This is reflected in the report to the United Nations Conference on Environment and Development (UNCED) (Ministry of Foreign Affairs, 1992).

The Bahamas is been recognized as a leader in environmental legislation in the Wider Caribbean Region. The Wild Birds Protection Act of 1952, the Bahamas National Trust Act of 1959, the Fisheries Resources (Jurisdiction and Conservation Act, Amendment No. 2 of 1993), and the Conservation and Protection of the Physical Landscape Act of 1997, were each milestone achievements. Shortly after coming to power in 1992, the present government began to announce a programme aimed at protecting the physical environment and the natural resources of the country.

1.6.2 The BEST Commission

As a part of this programme the Bahamas Environment Science and Technology (BEST) Commission was established in 1994. The Commission is housed in the Office of the Prime Minister, with an Ambassador for the Environment having direct responsibility for its operations. The mandate of the BEST Commission includes:

- coordination of policies and programmes for environmental protection.
- development of science and technology in The Bahamas.
- development of a national conservation strategy and action plan.
- proposing legislation to support the national conservation strategy and plan.
- advising government on the environmental impact of development proposals.
- preparation of a national inventory of natural resources, including species, habitats and ecosystems.
- development of a national system of parks, protected areas and reserves, to provide for in situ conservation.
- coordinating responses to the international environmental conventions to which The Bahamas is party.

Even before signing the Convention on Biological Diversity, The Bahamas reaffirmed that biodiversity and sustainability are fundamental to the success of the development process. It is the role of the BEST Commission to advise the Government on policies and activities that will ensure that development takes place in harmony with sustainable use and the conservation of biodiversity. Two primary stated goals of the Government of The Bahamas are sustainability and the elimination of poverty: both are linked to the conservation and wise use of natural resources.

The Government of The Bahamas has recognised that the environment is critically important to the economy and well being of all generations of Bahamians (Ingraham, 1999a). As a consequence government has begun to incorporate the protection and enhancement of the environment and of biodiversity into the national planning process. Government is committed to the development and implementation of a review and approval process for development, through environmental impact assessment processes. This will include regular monitoring, quality control and enforcement of laws for the protection of natural, including freshwater, marine resources, agricultural lands and general environmental quality.

The Bahamas is signatory to most of the major international environment conventions (see Box 1.6.2.1.) and has national legislation protecting endangered plants and animals and the physical landscape.

INTERNATIONAL LEGAL INSTRUMENTS ON THE ENVIRONMENT TO WHICH THE BAHAMAS IS A CONTRACTING PARTY OR SIGNATORY

- Vienna Convention for the Protection of the Ozone Layer Concluded at Vienna on 22 March 1985 (Ratified on 1 April, 1993)
- Montreal Protocol on Substances that Deplete the Ozone Layer Concluded at Montreal on 16 September 1987 (Ratified on 4 May 1993)
- Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (Ratified on 4 May 1993)
- Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (Ratified 4 May 1993)
- Basel Convention on the Control of transboundary Movements of Hazardous Wastes and Their Disposal. Concluded at Basel on 22 March 1989 (Ratified 12 August 1992)
- United Nations Framework Convention on Climate Change Concluded at New York on 9 May 1992 (Signed 12 June 1992; ratified 2 September 1994)
- Convention on Biological Diversity (Signed 12 June 1992; ratified 2 September 1994)
- Washington Convention or Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES)
- Law of the Sea Convention (1982)
- International Convention for the Prevention of Pollution from Ships (MARPOL 1973 and 1978) (Effective application: 16 February, 1979 and 2 October 1978 respectively)
- International Coral Reef Initiative
- Agenda 21
- The Barbados SIDS Action Plan
- Wider Caribbean Initiative on Generated Waste (MARPOL)
- UNEP Programme of Action
- Action Plan of the Summit of the Americas
- Programme of Action of the UN Commission on Sustainable Development
- Programme of Action of COP II
- International Convention for the Prevention of Pollution of the Sea by Oil (Ratified 22 October 1976)
- Amendments to the International convention for the Prevention of Pollution of the Sea by Oil, 1954, Concerning Tank Arrangements and Limitation of tank Size (Ratified 16 February, 1979)
- Amendments to the International Convention for the Prevention of Pollution of the Sea by Oil, Concerning the Protection of the Great Barrier Reef (Ratified 16 February, 1979)
- Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Use of Outer Space and Under Water (Ratified 11 August, 1976)
- Treaty on Principles Governing the Activities of States in The Exploration and Use of Outer Space Including the Moon and Other Celestial Bodies (Ratified 11 August, 1976)
- International Convention on Civil Liability for Oil Pollution Damage (20 January, 1976)
- International Convention relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (Ratified 30 March, 1983)
- Protocol relating to Intervention on the High Seas in Cases of Marine Pollution by Substances Other than Oil (Ratified 30 March, 1983)
- International Convention on the Establishment of an International Fund for Compensating Oil Pollution Damage as Amended (Ratified 16 October, 1978)
- Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxic Weapons, on their Destruction (Ratified 26 November, 1986)
- United Nations Convention on the Law of the Sea of 10th December, 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (Ratified 16 January, 1997)
- Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region
- Cartagena Convention to Negotiate Final Protocol Concerning Pollution from Land-Based Sources and Activities
- Protocol Concerning Specially Protected Areas and Wildlife in the Wider Caribbean (SPAW)
- Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention)

1.6.3 Biodiversity

"Alligators were sometimes brought in for the table; but it required considerable address and some courage to destroy them. The flesh of an alligator which I tasted was hard, white, and very much resembled the sturgeon's."
Daniel McKinnen, 1804

Mark Catesby:
The Alligator and Red Mangrove

Mark Catesby was among the first to comment on the biodiversity of The Bahamas (Cates, 1997), and his volumes provide a useful insight into the early history of biodiversity in The Bahamas. Campbell (1978) has written a useful account of the islands, and Shattuck (1905) provides a historical perspective. Woods (1989) provides a useful guide to the biogeography of the West Indies. Most of the islands of the Bahamas remain uninhabited to this day, and are visited only infrequently by yachtsmen and boaters. Their environment is relatively undisturbed. However, the disposal of garbage on beaches, in harbours and inlets, and in open water, is a matter of concern. It is not only unsightly but can be harmful and life threatening to animal-life. In small island states maintaining ecosystem characteristics is a challenge as small islands are more prone to loss and extinction of species than larger landmasses. Removal and alteration of one or more components leads to ecosystem change and loss of biodiversity. The poaching of iguanas and snakes for the pet trade is also a matter of concern. These and other concerns are discussed in the National Biodiversity Strategy and Action Plan prepared by the BEST Commission (BEST, 1998).

A full account of the biodiversity of The Bahamas is presented in the Biodiversity Country Study (BEST, 1995), and a summary of some of the marine biodiversity has been given in 1.4.5. Fishweries, above. Approximately 300 species of birds are known to occur in The Bahamas but the majority (169) of these are passage migrants. Some forty species are resident, of which three are endemic and there are twenty-one endemic sub-species. Bahamian birds are part of the West Indian avifauna rather than that of North America. All species of wild birds are protected by the Wild Birds Protection Act of 1952, which establishes hunting regulations on game birds and penalties for violations.

Mark Catesby: The Ilathera Duck

Several species of birds, including the northern mockingbird, ring-necked pheasant, chukar, bobwhite, and Cuban grass-quit have been introduced. Annex 3 contains a list of the scientific names of the species referred to in this chapter. The Bahamas National Trust is promoting bird watching for both Bahamians and tourists. Useful guides to the birds of The Bahamas are Brudenell-Bruce (1975) and White (1998).


Photography: courtesy of Philip Weech

The flora of The Bahamas is varied. Ecosystems range from high coppice (comprising wild figs, mahogany, lignum vitae, poison wood, horse flesh, wild tamarind and other species), to seaside coppice (low growing scrub-brush). Large areas in Abaco, Andros, Grand Bahama and New Providence are covered with pine forests (or "barrens"), with an under storey of shrubs and vines. Mangroves forests occur on the coast and inland in wetlands and salinas: the species include red, black and white mangroves and buttonwood. Britton and Millspaugh (1920) provide an early description of the flora of The Bahamas and a more recent account is that of Correll and Correll (1982). More than 1350 species of flowering plants and fern, representing approximately 660 genera and 144 families, have been described, including 27 genera of orchids and five bromeliad genera (Correll and Correll, 1982). It is thought that only fifteen endemic species of plants are found in the islands. The Bahamian flora has been derived from the Caribbean basin, and particularly from Cuba.

Most Bahamians have traditionally considered Bahamian plants to be "bush" a local term used to denote land and vegetation of little or no commercial value. There was little use of local species in landscaping, therefore. A large number of exotic species of plants have been imported over the year, many of which are now naturalized and several of which have become invasive. Invasives include casuarina (or beefwood), Brazilian pepper tree, and paper bark tree. In 1997, the Government passed The Conservation and Protection of the Physical Landscape Act that protects twelve species of trees considered to be rare or of historic importance. Bahamian trees and shrubs are now being used in greater quantities in landscaping projects. "Bush" is also used to refer to various medicinal plants and Higgs (1978) has documented these and their uses.

Associated with the native flora are many cultivated crop plants including mango, avocado, sapodilla, scarlet and hog plums, guinep, breadfruit, sugar apple, guavas, sapodilla, soursop, gooseberries, mamey, sweet potato, pigeon peas, hot pepper, corn, beans, cassava, melons, and pineapple. These are not native to The Bahamas, but have been cultivated for generations and in some cases have become naturalized.Only one endemic mammal, the Bahama hutia occurs in The Bahamas, but cave bats are also found. Feral dogs, cats, and rats are found on most islands and donkeys, horses, and hogs are found on Abaco and Inagua. Raccoons, introduced in the late 1700s, are found on New Providence and are common in some neighbourhoods where they may be pests.

Other animals found in The Bahamas include several endemic species of iguanas, lizards, butterflies, moths and other insects, land crabs and snakes. Interestingly, in a country where surface freshwater is very rare, freshwater turtles are found on Cat Island and Inagua. The Bahamas, and particularly Andros, abounds in blue holes. Although some research has been done, these are thought to contain many species not yet described and named (Brown and Downhower, 1993).

The majority of The Bahamas' space (more that 96%) is in coastal, marine and deep-water habitats. This vast majority of these remain unexplored and their biodiversity unknown. In marine ecosystems, destruction of coral reefs and sea-grass beds removes food and shelter for many life forms. Similarly, the destruction of mangrove forests removes nurseries for a large number of organisms and for many fish of commercial importance. These forests also provide nesting sites for various bird species.

1.7 LAND USE, LAND USE CHANGES AND FORESTRY

> "…there is Gumme Benjamin of the best and the worst sort, Guacom and Sasparilla and Sasafras, and some of them red wood…"
> *George Gardyner of Peckham, 1651*

Historically large expanses of land on all of the major inhabited islands were used for subsistence farming. This activity virtually eliminated the primeval forests, which existed when Columbus landed in 1492. Traditionally the slash-and-burn method of land clearing has been used. The soils of The Bahamas are very thin, calcareous, fragile and inherently of low fertility and droughty. Once land had been farmed for a few years it became exhausted, and farmers cleared new acreage for planting. Various attempts at commercial agriculture have been tried, including the establishment of cotton plantations in the late 1700s, pineapple productionin the late 1800s, sisal in the late 1800s and early 1900s, tomatoes from the 1940s to the early 1980s, sugar cane in the 1950s, and citrus in the 1980s and 1990s. Some of these projects were successful for a number of years but eventually succumbed because of soil depletion. The citrus groves of Abaco are probably the largest successful ongoing agricultural project in The Bahamas.

Photography: courtesy of Philip Weech

Land use has changed on New Providence over the past thirty years. Virtually all of Paradise Island has been cleared of native vegetation for large-scale hotel developments, along with luxury houses, apartments, condominiums and a golf course. Large areas of water front and lake front land around the island of New Providence have been cleared for hotels, luxury housing complexes, and private houses. Nassau has gone from having three or four small hotels in the 1950s, with only a few hundred rooms, to having dozens of resorts offering a combined total of thousands of rooms. Large tracks of land on the interior of the island have been cleared to make room for housing, business complexes and roads.

On Grand Bahama a great deal of development has also taken place. Most recent is the container transshipment port and cruise ship facilities. In the Family Islands, Abaco is probably the most developed with the more remote islands such a Mayaguana, Acklins, Ragged Island and Crooked Island remaining sparsely populated and largely unchanged.

Photography: courtesy of Philip Weech

During the early twentieth century a sawmill operated on Abaco. By 1943, all the virgin forests of Abaco had been cut, leaving only a few isolated pockets of old growth in the north. Today, although the pine forests of Abaco are extensive and impressive for The Bahamas, the forests are, for the most part, secondary. Once the forests were depleted, the sawmill was moved to Grand Bahama where it operated until the 1970s. Smaller operations were located on New Providence and Andros.

Government recognizes the importance of the Caribbean pine and has made it a protected species. The rejuvenation of the pine forest is of great importance to the many under-storey broadleaf plants, orchids, bromeliads, bracken fern, and vines. Further, pine forests provide important habitat for butterflies, snakes, crabs, and birds, and for the endangered Kirtland's Warbler and, on Abaco, the Bahama Parrot. Many well fields for fresh water are under pine forest. Feral animals such as dogs, cats, rats, raccoons, hogs, horses and donkeys also live in the forests.

The forest resources of The Bahamas have been classified into three distinct types namely pine forest, coppice forests and mangrove forests. Approximately 80% of the forest resources are on state lands (Crown Land) with the remaining 20% in private holdings. The pine forests are considered the most productive and commercially viable forest resource, comprising an estimated 880 mi^2 (2,278 km^2). Russell (1998, 2000) has discussed the future of forestry in The Bahamas and in the Caribbean. Patterson and Stevenson (1977) provide a useful guide to identifying the trees of The Bahamas.

The coppice hardwood forests are found predominantly in the central and southern Bahamas and have been described and inventoried by Little et al. (1971-1976): they comprise various hardwood species harvested in the past for saw logs. The estimated area of coppice forest is 2,709 mi^2 (7,108 km^2). The mangrove forests occur predominantly on the lee shores of most Bahamian islands, and the total area of mangrove forest in The Bahamas is estimated to be some 2,666 mi^2 (6,904 km^2). Significant areas of wetlands, which include mangrove forests, are the north coast of Grand Bahama, the west coast of Andros, the Marls of Abaco, much of Cat Island, and Lake Rosa, Inagua. The latter is protected under the Ramsar Convention.

1.8 NATIONAL CIRCUMSTANCES AND SUMMARY TABLES

Table 1.8.1 National circumstances: The Bahamas.

Criteria	1990	1994
Population	254,685	274,600 (Estimate)
Relevant area	Total: 260,000 km2 Land: 13,940 km2	Total: 260,000 km2 Land: 13,940 km2
GDP at current market price	Not available	Not available
GDP per capita at current market price	Not available	Not available
Estimated share of the informal sector in the economy in GDP (%)	Not available	Not available
Share of industry in GDP (%)	Not available	Not available
Share of services in GDP (%)	Not available	Not available
Share of agriculture in GDP (%)	* 3 - 5%	* 3 - 5%
Land area used for agriculture	24,323 ha (Estimated)	20,344 ha (Census)
Urban population as % of total population	70	70
Livestock population	Not available	Cattle (non-dairy): 796 Sheep: 6,292 Goats: 13,580 Pigs: 4,777 Poultry: 750,000
Forest area (kha)	Pine forest 227.8 Coppice forest 701.8 Mangrove forest 690.4	Pine forest 227.8 Coppice forest 701.8 Mangrove forest 690.4
Population in absolute poverty	Not available	Not available
Life expectancy at birth	Male Female	Male 70.7 Female 77.4
Literacy rate		98%

*Agriculture and Fisheries

***Table 1.8.1** summaries the national circumstances, as required by the UNFCC Guidelines for First National Communications of Non-Annex 1 Parties. Note that estimates, usually based on interpolation, or calculations based on growth rates, are applied where appropriate. In some instances, data are not available. Tables 1.8.2 and 1.8.3 present the summaries of the initial national greenhouse gas inventories of anthropogenic emissions and removals by sinks for 1990 and 1994.*

Table 1.8.2 Initial national greenhouse gas inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol: 1990 (Gg).

	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	SO_2
Total National Emissions and Removals	**1,894**	**-3,600**	**2**	**0**	**0**	**4**	**4**	**0**
1 Energy								
Reference Approach(1)	**1,894**							
Sectoral Approach(1)	**0**		**0**	**0**	**0**	**0**	**4**	**0**
A Fuel Combustion	0		0	0	0	0	0	
B Fugitive Emissions from Fuels	0		0		0	0	4	0
2 Industrial Processes	**0**		**0**	**0**	**0**	**0**	**0**	**0**
3 Solvent and Other Product Use	**0**			**0**			**0**	
4 Agriculture			0	0	0	0		
5 Land-Use Change & Forestry	**0**	**(2) -3,600**	**1**	**0**	**0**	**4**		
6 Waste			**1**	**0**				
7 Other (please specify)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Memo Items:								
International Bunkers			**0**	**0**	**0**	**0**	**0**	**0**
Aviation	0		0	0	0	0	0	0
Marine			0	0	0	0	0	0
CO_2 Emissions from Biomass	**0**							

P *= Potential emissions based on Tier 1 Approach.* ***A*** *= Actual emissions based on Tier 2 Approach.*

(1) *For verification purposes, countries are asked to report the results of their calculations using the Reference Approach and explain any differences with the Sectoral Approach. Do not include the results of both the Reference Approach and the Sectoral Approach in national totals.*

(2) *The formula does not provide a total estimate of both CO_2 emissions and CO_2 removals. It estimates "net" emissions of CO_2 and places a single number in either the CO_2 emissions or CO_2 removals column, as appropriate. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).*

Table 1.8.3 Initial national greenhouse gas inventories of anthropogenic emissions by sources and removals by sinks for all greenhouse gases not controlled by the Montreal Protocol: 1994 (Gg).

	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Total National Emissions and Removals	**1,866**	**0**	**0**	**1**	**0**	**0**	**3**	**0**
1 Energy Reference Approach(1)	**1,866**							
Sectoral Approach(1)	**0**		**0**	**0**	**0**	**0**	**3**	**0**
A Fuel Combustion	0		0	0	0	0	0	
B Fugitive Emissions from Fuels	0		0	0	0	3	0	
2 Industrial Processes	**0**		**0**	**0**	**0**	**0**	**0**	**0**
3 Solvent and Other Product Use	**0**			**0**			**0**	
4 Agriculture		**0**	**1**	**0**	**0**			
5 Land-Use Change & Forestry	**(2)**	**0**	**(2)**	**0**	**0**	**0**	**0**	**0**
6 Waste				**0**	**0**			
7 Other (please specify)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Memo Items:								
International Bunkers	**645**		**0**	**0**	**0**	**0**	**0**	**0**
Aviation	341		0	0	0	0	0	0
Marine	305		0	0	0	0	0	0
CO_2 Emissions from Biomass	**0**							

P *= Potential emissions based on Tier 1 Approach.* ***A*** *= Actual emissions based on Tier 2 Approach.*

(1) *For verification purposes, countries are asked to report the results of their calculations using the Reference Approach and explain any differences with the Sectoral Approach. Do not include the results of both the Reference Approach and the Sectoral Approach in national totals.*

(2) *The formula does not provide a total estimate of both CO_2 emissions and CO_2 removals. It estimates "net" emissions of CO_2 and places a single number in either the CO_2 emissions or CO_2 removals column, as appropriate. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).*

Note 1: *X - Data to be presented to the extent that the Party's capacities permit (Article 12.1(a)).*

Note 2: *Non-Annex I National Communications will include the information in this table, and a description of assumptions and methods used, and the values of emission coefficients, where these differ from IPCC assumptions, methods and values.*

Note 3: *Efforts should be made to report the estimated range of uncertainty, where appropriate.*

CHAPTER 2

NATIONAL INVENTORY OF GREENHOUSE GASES

2.1 INTRODUCTION

In accordance with Article 4.1(a) of the United Nations Framework Convention on Climate Change (UNFCCC), all parties to the Convention are required to update and report periodically on their national inventory of anthropogenic greenhouse gas emissions and the removal by sinks. A National Climate Change Committee (NCCC) (see Annex 1 for composition), was formed and first convened in March 1996. The NCCC undertook the preparation of this First National Greenhouse Gas Inventory for The Bahamas. The committee used the IPCC greenhouse gas inventory software, the spreadsheet workbook, and followed the revised 1996 IPCC Guidelines for national greenhouse gas inventories Revised 1996, IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 1996)).

Photography: courtesy of Philip Weech

Greenhouse gas (GHG) emissions and their removal by sinks have been calculated for The Bahamas for 1990 and 1994. Electricity generation and the transportation sector are the two most significant sources of greenhouse gas emissions in The Bahamas. There is no primary fuel production in the Bahamas and all fossil fuels are imported. International marine and air bunkering fuels, and the storage and transmission of fossil fuel, represents fuel exported through The Bahamas.

2.2 INVENTORY PROCESS

The National Climate Change Committee organized the First Greenhouse Gas Inventory Workshop in July 1998, at which time potential greenhouse gas sources were identified, and these sources organized into four broad categories. The workshop identified data sources and agreed on a procedure for the conduct of the national inventory.

Subsequent workshops organized by the NCCC provided for the review of data categories and analysis of fuel sources for imports into The Bahamas. The workshops also identified problems in the compilation, gathering and access to data held in the public domain. A key issue was one pertaining to the rules and procedures governing the access to data collected for statistical purposes in The Bahamas. Data can only be provided in an aggregate form according to the statistical guidelines. In most cases data held in statistical databases could not be made available for the inventory without violating existing rules and regulations. This issue was of particular concern in the industrial sector. Additionally, it was determined that the detailed data required to verify the top-down reference approach using the revised IPCC guidelines were not available in the form required for input into the IPCC tables. A statistical survey was required to collate and verify existing data.

Unfortunately, preparations by the relevant government agency for the 2000 Census of the Population of The Bahamas frustrated this process.

Further discussions provided a means for indirectly obtaining information from the Central Bank of The Bahamas and from the Customs Department database, needed to conduct an initial greenhouse gas inventory for The Bahamas. It was determined that public data contained in the Central Bank's Quarterly Statistical Digest (Central Bank, 1997, for example),and, and the Bahamas Customs database and reports, the local oil companies' reports, and data from other fuel sources, contained data that could be were used in the inventory process especially in the fuel analysis important to the Energy sector.

Photography: courtesy of Philip Weech

Data for other sectors was taken from the Central Bank of the Bahamas Quarterly Statistical Reports, as well as directly provided by the Department of Statistics, the Department of Agriculture, the Department of Fisheries, the Department of Lands and Surveys and the Water and Sewerage Corporation. The data in the Central Bank's Quarterly Statistical Reports on oil trading is supplied directly, to the Central Bank, by the local oil companies and is disaggregated into oil imported for domestic consumption, and that for the bunkering of foreign ships and aircraft. Oil that is imported for transshipment, or for refining and subsequent re-export, has been excluded from the trade account, since no change of ownership occurred according to the procedures used by the Central Bank of The Bahamas. In some cases, the data available were not immediately suitable for input into the IPCC spreadsheets.

Photography: courtesy of Philip Weech

In such cases, assumptions were made to allow the incorporation of these data. Box 2.2 lists some of the problems and constraints experienced in undertaking the inventory, and Table 2.2.1 indicates the Categories and sub categories reviewed in the national inventory process for The Bahamas.

Box 2.2 Problems and constraints to the greenhouse gas inventory process and proposals to improve the process.

The Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC, 1996) was used to produce the national inventory of greenhouse gases for the Bahamas. Some of the difficulties encountered in following the guidelines are summarized below.

The IPCC Reference or Tier 1 Approach had to be modified in order to accommodate the type, format and accuracy of the data collected by national authorities.

In some instances national regulations governing the use of statistical data also impacted this process.

- A "top-down" approach was applied using the aggregate statistical data compiled by the Central Bank of the Bahamas on fossil fuels, but no "bottom-up" comparison was attempted,as the essential statistical data were unavailable in the disaggregated format required for input into the IPCC spreadsheet.
- In many cases a new data collection exercise would have had to be conducted to obtain data in the format needed.
- The Department of Statistics was fully engaged in preparatory work for the 2000 Population Census of The Bahamas, and was unable to cooperate as fully as they would have liked with the exercise.
- In some instances the types of national data were simply not available: in the transport sector for example, data on fuel usage and numbers, types and sizes of vessels in the marine transport, commercial, and recreational fishing sub-sectors, were not available.

Given these constraints, the Central Bank's Aggregated Statistical Summary of fuel imports provided the highest quality verifiable data source available for immediate use in a format that allowed for the initial national inventory of greenhouse gases in a modified Tier 1 Approach. Central Bank's Statistical Survey of 1994, that focused on disaggregating the fuel used in international bunkering, allowed for some refinement of the inventory process. Verification of the data was undertaken in discussion with the fuel suppliers in The Bahamas, and through consultation with the Customs Department. Additionally, work by other government agencies, notably by the Ministry of Agriculture in the 1994 Agricultural Census, also provided reliable data for the agricultural sector.

In order to improve the reproducibility and accuracy of future national inventories, the following steps are proposed.

- Steps must be taken to allow for verification of data, using multiple sources, so as to permit the use of a "top-down" and "bottom-up" comparison.
- The compilation of statistical data, and the nature of the reporting process, need to be addressed.
- A detailed examination of the transport sector, focusing on fuel usage in private and public vehicles, in marine transport, in domestic aircrafts, and in agriculture, is required.
- A national system for data collection, storage, archiving and retrieval, also needs to be developed, and persons trained in its use.
- Land use, land use changes and forestry, will require special attention, as this initial national inventory relies heavily on data collected by a Land Resources Survey (Little et al., 1971-1976) completed some 25 years ago.
- A system for updating and reporting on changes in land use needs to be developed so as to provide reliable data for future national inventories.
- The issue of carbon sequestration in the shallow waters of the Bahamas requires scientific study in order to verify the initial assessment, and to determine strategies for enhancing the capacity of the system to sequester carbon.

Table 2.2.1 Organization of the greenhouse gas (GHG) inventory.

Category	Sub category
Energy activities	Fuel combustion
	Energy Industries
	Transport
	Fugitive emissions
	Memo items: international bunkers
Agriculture	Enteric fermentation
	Manure management
	Agricultural soils
Land use, land use changes and forestry	Conversion to other uses
	Clearing of forests
	Managed areas
Waste solid and liquid	Solid waste disposal on land
	Wastewater handling practices

The IPCC guidelines were followed as data sources permitted and default values, where provided, were used. The IPCC reference approach was used for the energy sector. A top downtop down approach was used as data was not available or not in the required format that would enable a bottom-up verification of emission in the energy sector.

The industrial profile of The Bahamas did not change over the 1990 to 1994 period and consisted of brewing and distilling, some chemical plant output and from the pharmaceutical industry, the production and export of solar evaporated salt, and the re-export of crude oil. Essential industrial output data needed to calculate emissions in the sector was not available. However it was determined, based on an examination of the industrial sector make-up, that the sector was considered too small or were not accessible through indirect examination making use of the statistics maintained by the Central Bank.

The Bahamas National Green House Gas Inventory was organized into four main categories and sub-categories, as indicated in Table 2.2.1 above, and as described in the Revised IPPC 1996 Guidelines. GHG emissions were mainly from imported liquid fossil fuels consisting of gasoline, jet (aviation) and other kerosene, gas and diesel oil, liquefied petroleum products (principally liquefied propane gas (LPG)), and lubricants. Table 2.3.1 summarizes the quantities of fuel imported for the five years 1990 to 1994. These data were verified through discussions with the local oil companies and by reference to the Bahamas Customs database.

Table 2.3.1 Fuel imports into The Bahamas in thousands of barrels of energy (BOE) for the five years 1990 to 1994.

Fuel type	1990	1991	1992	1993	1994	% Total
Gasoline	1287	1327	1347	1345	1303	30.5
Jet Kerosene	187	141	120	126	148	3.3
Gas/diesel oil	1759	1595	1382	1083	1301	32.9
Residual fuel oil (Bunker C)	879	787	974	1537	1442	25.9
LPG	156	201	217	164	160	4.1
Other oils	225	381	34	24	33	3.2

2.3 EMISSIONS OF GREENHOUSE GASES

2.3.1 Energy sector

Electrical power in The Bahamas is generated through the combustion of imported liquid fossil fuels. In addition, residual fuel oil, diesel and fuel oils account for the total amount. The data for energy production and consumption are based on the latest information, as contained in Central Bank reports on petroleum usage in The Bahamas. Discussions among informed parties determined the most viable and reliable information. Data for a particular type of fuel, or for a particular supplier, were obtained from at least two sources. The import of fossil fuels for use in power generation and in transport represents the total use of fuel in the energy sector in The Bahamas. The storage of fuel and international bunkering represents a smaller fraction of fuels in the sector and is reported separately. Data on carbon dioxide emissions from fossil fuels for 1990 and 1994, by type of fuel, are presented in table 2.3.2.

Some 85% of gas and diesel oil is used in power generation and, as a result, carbon dioxide emissions produced from the consumption of fossil fuels for public electricity production accounts for some 65% of the total CO2 emissions in the Bahamas. The total installed capacity of the power plants in the Bahamas for 1995 is estimated at 209 megawatts (MW), with an estimated maximum demand of 140.5 MW. Total annual units of power generated increased from 750.4 million kWh in 1990 to 949.2 million kWh in 1995. There were significant variations in fuel usage as a result of a decline in tourism in the early 1990's, the global fuel crisis, and a dramatic fall off in visitor arrivals by air.

Table 2.3.2 Carbon dioxide emissions from fossil fuel energy sources in The Bahamas for 1990 and 1994 (Gg CO2).

Fuel type	1990	1994	% Total
Gasoline	470.7	476.5	25.2
Jet Kerosene	55.0	43.6	2.6
Gas and diesel oil	802.4	593.5	37.1
Residual fuel oil (Bunker C)	424.8	696.9	29.8
LPG	39.7	40.8	2.1
Other oils	101.5	14.9	3.1
Total (Gg Co2)	1894.2	1866.2	

Table 2.3.3 Estimated emissions of other greenhouse gases in The Bahamas for the years 1990 and 1994 (Gg).

Year	Methane (CH_4)	Nitrous oxide (N_2O)	Carbon Monoxide (CO)	NMVOC's
1990	2	0	4	3
1994	1	1	4	3

2.3.2 Fugitive emissions

Some three (3) million long tons of fuel are stored each year for transshipment outside The Bahamas. Primary seals in floating roof tanks are employed at the oil storage and transshipment facility, which is located in Grand Bahama. This single facility represents the primary source of fugitive emissions in the Bahamas. It is estimated that three (3) Gg of non-methane volatile organic carbon (NMVOC) compounds were emitted annually over the period from 1990 to 1994 (Table 2.3.3).

2.3.3 Emissions from international bunkering

The Central Bank Quarterly Statistical Report aggregated the oil sold in international bunkering activities, based on oil reports from the Customs Department, and oil companies reports. The Central bank conducted statistical exercise in 1994 to disaggregate the data. The survey revealed that three types of fuels were involved in international bunkering activities in The Bahamas: gasoline for and boats, jet fuel for aircraft, and gas oil for larger marine transport vessels transiting the Bahamas. Carbon dioxide (CO2) emissions from the two categories of bunkering aviation and marine fuels accounted, respectively, for 54 and 46 % of the total (Table 2.3.4). The data reflects the significant variations in international air and marine transport of tourist into and from the Bahamas over the 1990 to 1994 period.

Table 2.3.4 Carbon dioxide emissions from international bunkering in The Bahamas (Gg CO^2).

	1990	1994	% Total
Aviation	492	341	54
Marine	404	305	46
Total all Bunkers	896	645	

2.3.4 Agriculture

The Bahamas depends almost entirely on imports of basic foodstuffs to feed Bahamians and tourists. It has a very small livestock population (see Table 2.3.5),; there is no cultivation of rice, and no prescribed burning of savannas or field burning of agricultural residues. There is some slash-and-burn agriculture practiced in the Family Islands but the total acreage involved is very small. There is an insignificant amount of fuel wood or charcoal used for cooking. Enteric ferm entation by livestock, manure management, and agricultural soils all produce emissions on a very small scale. Emissions from animal production and from animal waste management systems are therefore considered negligible. Nitrous oxide can be produced from agricultural soils through various activities such as application of synthetic fertilizer, animal waste, nitrogen-fixing crops, decay of crop residues, and through indirect sources such as the atmospheric deposition nitrous oxide as a result of nitrogen fixation in the atmosphere.

Data from the 1994 Census of Agriculture (Department of Agriculture and Department of Statistics, 1996) were used to estimate livestock numbers (Table 2.3.5). The IPCC reference approach for warm developing countries default values were employed, as the sector, in relative terms, is very small, and significant data gaps were evident. Agricultural soils were addressed under Land Use, Land Use Changes and Forestry. No reliable data were available on the total imports of fertilizers nor of the types of fertilizers used. Consequently, an estimate of 2.65 short tons or 5300 lb (2403 kg) was assumed and has been applied to the 1994 data. The area of agricultural lands is considered under land use.

Photography: courtesy of Philip Weech

No estimate is made for feral animal populations (dogs, cats, pigs, donkeys and horses) and domestic animals have been excluded. Estimates of carbon dioxide, methane and nitrous oxide emissions from the agricultural sector for 1990 and 1994 are insignificant, with a combined total of less than 1 Gg.

Table 2.3.5 Livestock numbers in The Bahamas based on the Agricultural Census of 1994.

Type of Animals	Numbers of animals
Cattle (non-dairy)	796
Sheep	6292
Goats	13580
Pigs	4777
Poultry	750,000

Source: Department of Agriculture and Department of Statistics (1996).

2.3.5 Liquid and solid waste

Liquid waste disposal is mainly by use of septic tanks as less than 20% of homes are linked to any public sewerage drainage and collection, treatment and disposal facilities. The large tourism sector, and a high standard of living, is responsible for the estimated 1 Gg of methane (CH_4) emissions.

Photography: courtesy of Philip Weech

The per capita protein consumption was estimated at 25.8 kg per annum, based on a survey conducted in 1990 (Ministry of Health and Ministry of Commerce, Agriculture and Industry, 2000)

Solid waste is disposed of into unlined public dumps across the Bahamas. The estimated per capita waste stream from all sources was estimated at 2.6 kg per day, based on the Bahamas Solid Waste Study of 1998. It is estimated that only 70% of this total is disposed of in a public facility.

2.3.6 Land use, land use change and forestry

Forests are critical components of the climate system. Their potential for sequestering greenhouse gases is enormous, and they act as an additional reservoir to trap carbon dioxide ($C0^2$) emissions. The entire Bahamas was, at one time, entirely covered with forests of tall tropical hardwood and slow-growing trees in the drier south-centralsouth central and southern Bahamas, and with forests of pine in the north and north-central Bahamas. Mangrove forests occupy many shallow lakes and large area of coastal flats between the dry land and the sea. Managed areas of forests are evident with management practices while far from ideal having impacted the entire Bahamas over the last fifty years. At one end of the continuum of managed lands are the Pine Forests of the Bahamas, these forests are found in the northern and central Bahamas and comprises some 227.8 kha. Slash and burn agricultural practices inhabit the central point in the continuum of managed forests involving the tropical slow growing hardwood coppice area across the entire expanse of the Bahamas. Mangrove areas were also exploited less intensively than the dry land areas but were a valuable source of wood in the early part of the century and were used to preserve meats. The types of forest in The Bahamas and their estimated areas are shown in table 2.3.6.

Large areas of the tropical hard wood forests were cut down by the early settlers to make room for farms and plantations, for timber for housing, for firewood and for their economic value as exports. As the farms and plantations failed, the settlers went to a rotating "slash and burn" agriculture. Today, because of the migration of people from the Family Islands to the main economic centres of New Providence and Grand Bahama, some areas of tropical hard woods are regenerating. In the pine islands, forests were cut for timber to build boats and houses, for fuel wood and particularly to clear land for cane cultivation. No commercial logging activity is currently being practiced on the pine islands and, consequently, these islands are also in a younger phase of re-growth.

Table 2.3.6 Forest cover in The Bahamas by type and area (kha).

Type	Area (kha)	Type
Pine forest	227.8	Tropical moist
Pine under-storey	227.8	Tropical moist
Tropical hardwood coppice	701.8	Tropical dry
Mangrove forest	690.4	

A variety of carbon and nitrogen trace gases are either emitted or absorbed in the biosphere. Changes in the biosphere, through land use changes and forestry activities will modify the natural balance of these trace gases both in emission and uptake. On the global scale, the human activity, which most affects the biosphere is deforestation, especially in the tropics. In this section, the calculation of emissions focused on four activities which acted either as sources or sinks namely: abandoning of managed lands, forest conversion (to other land uses), managed fields and clearing forests for "slash and burn" agriculture, or for citrus groves.

The approach used in the initial inventory of greenhouse gases was to attempt to quantify the sequestration potential of all forested areas of The Bahamas. No national definition of managed forested areas exist and without undertaking a detailed surveys to determine the areas under management over the 1990 –1994 period or by updating the 1970 Land resources survey it was not possible to estimate areas under active management across The Bahamas. Consequently, for the purposes of this inventory the entire landmass of The Bahamas, its mangroves, tropical hardwood forests and pine islands including the under-storey is accounted for as significant areas are under some sort of native vegetation and management regime. The related issues of data uncertainty, areal coverage, growth rates, tree types and percent dry mass of wood is very high using this process. 50,250 ac (20,344 ha) or 78.5 mi^2 (203.4 km^2) of land, according to the 1994 Agricultural Census, which is only about 1.5% of total land.

According to the 1994 Agricultural Census, the area of agricultural land was 50,250 ac. (20,344 ha) or 78.5 mi^2 (203.4 km^2). This represents only about 1.5% of the total land area of The Bahamas. The soils of The Bahamas are poor and derived from the mechanical breakdown of limestone. Wind blown sand of marine origin accumulates along active beaches forming dunes, and the natural decomposition of vegetation in depressions, and Karst features, along with dust from the Sahara blown by the trade winds, form the only organic soils found throughout the Bahamas. These are classified as Class 1 lands (lands that can be easily tilled) along with the deeper red and brown soils, and together account for 5.5% of total agricultural lands (Little et al., 1971-1976)

CHAPTER 3

INITIAL NATIONAL VULNERABILITY & ADAPTATION STATEMENT FOR THE BAHAMAS

3.1 INTRODUCTION

The Bahamas is a Party to the United Nations Framework Convention on Climate Change (UNFCCC) and, as such has obligations in relation to mitigation and adaptation to climate change and sea level rise. One of the commitments is to submit national communications in accordance with Decision 10 CP/2. At the UNFCCC Fourth Conference of the Parties (COP4), it was stressed that Parties to the Convention should recognize the need for the implementation of adaptation measures to climate change and sea level rise.

The Bahamas contribution to the GHG emissions is low by global standards. However, The Bahamas is extremely vulnerable to the effects of global climate change and sea level rise, as some eighty percent (80%) of the landmass of The Bahamas is within 5 ft (1.5 m) of mean sea level. This initial national assessment of vulnerability and adaptation (V&A) is only a first step, and it is limited in its scope due to a dearth of information. This document should therefore be seen as an evolving or living document that must be updated periodically, and as relevant information becomes available. This initial V&A was compiled by Mrs. E. Philips (Department of Fisheries) and Mr. J. Simms (Department of Meteorology), based on available information on climate change in The Bahamas, and using the Pacific Island Climate Change Assistance Programme (PICCAP) of the United Nations Institute for Training and Research (UNITAR) (PICCAP/CC: TRAIN) as a model. In large part this work relies on the expert judgment of professionals in various disciplines drawn from the public service in The Bahamas. The substantive part of this work was prepared as part of a regional training workshop organized by the National Communications Support Programme (NCSP), held in Port-of-Spain, Trinidad and Tobago in July 1999, and entitled “Thematic Workshop on Vulnerability and Adaptation Assessment”.

3.2 CLIMATE AND SEA LEVEL SCENARIOS

The initial assessment of the vulnerability of the Bahamas to climate change began with an evaluation of projected climate and sea level scenarios for the Caribbean region. No sector specific analysis was available that addressed the national perspective and the downscaling of the results of the Global Circulation Models was not considered adequate for national purposes. This is because many islands are too small and “disappear” on GCM maps and the degree of resolution of the models is only regional.

In order to evaluate the observed recent changes in the meteorological record, and the impacts that have already occurred, the Government of The Bahamas commissioned a study of climate change in The Bahamas by Global Change Strategies International (GCSI). The report, entitled “Effects of climate change: hydro-meteorological and land based effects in The Bahamas” (Martin and Bruce, 1999, 2000), analysed the hydro-meteorological data and discussed land-based and human health issues, and draws comparisons with nearby countries where information in available. The report had as one of its many objectives "to contribute to the assessment of the vulnerability and adaptation of The Bahamas to the future impacts of climate change."

Reliable climatic data for the past half-century are available for all major islands of The Bahamas. In New Providence rainfall data is available from 1870 and all other elements from 1905 to the present. Analyses of these data have shown that there was a slight increase in temperature, more particularly during the 1990's. It was also shown that during the passage of tropical cyclones, which have become more frequent during the past decade, there were noticeable increases in rainfall.

3.3 VULNERABLE SECTORS

3.3.1 Introduction

Areas identified as most likely to be directly and measurably affected by climate change and sea level rise based on the examination of the climate change scenarios from the regional and national analyses (as summarized in Box 3.2.1) include, but are not limited to the following: tourism, coral reef resources, water resources and agriculture. Indirect effects are expected in human health and well being, in human settlement and infrastructure, and in the socio-economic sector and the environment sector. In addition, some of the response measures are anticipated to result in increased greenhouse gas (GHG) emissions. An example is the expected extra demand for air-conditioning with the consequent increase in energy demand and consumption. Air conditioning would reduce stress but at the cost of increased emissions.

Photography: courtesy of Philip Weech

The entire Bahamas is considered a coastal zone likely to be impacted directly and indirectly by climate change processes. The Bahamas has a very extensive coastal zone due to the multiple island structure of the country. Because of the size of the islands, one is rarely more than ten miles from the coast and in most cases it is difficult to define where the coastal zone ends and another begins.

The Bahamas has extensive mangrove coverage on both the coast and in inland brackish water lakes. The mangrove coverage on islands such as Andros is extensive, providing valuable breeding and nursery grounds for many species of fish, reptiles, crustacean, mollusks, birds and other fauna and flora.

Box 3.2.1 Predicted global and regional changes, and observed national changes in temperatures, precipitation, sea level, and occurrence of extreme events.

Temperature

Global: Based on current and predicted emission levels of greenhouse gases, global climate models predict a global mean temperature rise of about 3º F in 50 years.

National: The results of analyses of changes in Bahamian weather data over the last 100 years indicates the following observed changes: since 1905, the mean daily maximum temperature for July has increased at a rate of 3.6 ºF per 100 years, and more recently at a rate of 4.8 ºF per 100 years, and extreme high temperatures are increasing more quickly, for example, in January at a rate of 6.8˚F per 100 years.

Precipitation

Global: Changes in precipitation patterns with increasingly heavy rain events where total rain increases, and with more intense droughts elsewhere, and more precipitation in the northern Bahamas and less in the south (Hadley Centre projection to 2050s).

National: Over the past 95 years the annual rainfall in New Providence has decreased at a rate of 4.2 inches per 100 years. However, since 1959 annual rainfall has been increasing a rate of 21.8 inches per 100 years. Since 1959, the rainfall in Long Island and Inagua has been decreasing at rates of 10.2 and 16.8 inches per 100 years, respectively.

Sea level changes

Global: Based on IPCC predictions, sea level is expected to rise at a rate of 0.06 in (1.5 mm) per year, a sea-level rise of about 8 in (20 cm) by 2060.

National: No analysis of Bahamian sea level changes exists, so an examination was made of the rise in sea level recorded at long-term sea level sites in neighboring countries. Results indicate that the sea level is rising at 6 to10 in (15.2 to 25.4 cm) per 100 years.

Extreme events

Global: Increased severity of the most intense tropical storms, and a possible change in geographic distribution.

National: The Bahamas usually has a very active hurricane season averaging three passing within 100 miles of the country. Over the past decade, there seems to have been a slight increase in the number. Also there seemed to have been an increase in the intensity of storms and hurricanes An analysis of Bahamian hydro-meteorological data over the last 100 years indicates an increase in the number of North Atlantic Basin tropical storms per year from seven to about ten since 1905.

Other

National: Overall wind speeds are decreasing, particularly in summer, with windy or calm summers occurring in the same year as windy or calm winters. Since 1945, spring and fall months have been getting sunnier.

Based on Martin and Bruce (2000).

The Bahamas is noted internationally for the quality of its beaches. The pink, white and brown sands and calm, clear and warm waters attract thousands of tourists and residents alike. Coastal development has had an impact on beach formation and erosion, however. Proper reviews of likely impacts are necessary to ensure minimal damage to the beaches.

The Bahamas has one of the most diverse and extensive coral reef systems of the region, with over 900 mi^2 (2300 km^2) of healthy coral reefs, supporting a diverse and economically viable fishing industry. Reefs provide effective barriers and coastal protection to low lying areas on most of the islands exposed to storm surge and ocean waves. These reefs are also important aesthetically for Bahamians as well as tourists. The physical characteristics of the Bahamas, many of which predispose it to the negative effects of climate change, were presented earlier (see 1.1.1, 1.1.2, 1.1.3 and 1.2.2). In particular the low elevation with more than 80% of the landmass within 5 ft (1.5 m) of mean sea level, the porous nature of the young limestone formations and the location of the Bahamas in the Atlantic hurricane belt, render the country extremely vulnerable. Socio-economic issues are also relevant but no comprehensive attempt to evaluate these has yet been made, due to a lack of tools and methods to conduct an assessment.

3.3.2 Tourism

The tourism sector of The Bahamian economy generates about 50% of total direct Gross Domestic Product (GDP) and employs directly and indirectly about 50% of the labour force. Because of its dominant position in the economy, tourism tends to influence other commercial and economic activities such as government revenue and expenditure; wages and prices in the labour market; construction, and to a lesser extent, money, credit and interest rates. The tourism sector is therefore the dominant sector within the Bahamian economy (see Section 1.4.2).

An increase in sea level rise would result in beach and coastal (shoreline) erosion. This could result in loss of beaches, which is one of the major reasons tourists flock to The Bahamas. Most of the hotels and tourist resorts are situated along the coastline, so that any significant coastal erosion caused by sea level changes or as a result of tropical cyclones, could be disastrous for these structures and for the tourism industry in general.

Disruptions to the industry from hurricanes are expected. However, damage from frequent hurricanes, or from more intense hurricanes, as a result of global processes, could make investments in the sector too expensive, and the cost of business would increase rendering the sector less competitive when compared to other destinations globally. The possible impact on human health, and the possible spread of disease vectors, due to increasing temperatures and humidity has not been quantified. This is largely due to the inability of global models to predict the changes on the scale of a small island state like the Bahamas. Changes in disease vectors, malaria, dengue and other tropical diseases within the region are anticipated to impact the regional tourism product. The movement of peoples within the region, both legally and illegally, is also expected to indirectly impact the local situation.

3.3.3 Water resources

The demand for water in The Bahamas is met primarily by the extraction of freshwater from shallow freshwater lenses (see Section 1.1.3). The extraction of freshwater on some islands as a result of the demands of local population and the demands of the tourism industry, is extremely high, especially on New Providence, such that the freshwater resources on that island are unable to meet the demand, and as a result fresh water is shipped from Andros to augment the local supply. Water is also processed from seawater by reverse osmosis to meet the demand for freshwater.

An increase in sea level rise along with indiscriminate extraction of freshwater from the well fields, will put this already threatened resource at even higher risk. As noted in 1.1.3, the fresh water lens rests on top of the seawater within the porous rocks. Rising sea levels will bring the fresh water lens closer to the surface of the land, which is expected to expose the freshwater resources to increased evapo-transpiration, with the added risk of salinization from the increased natural withdrawal.

Inundation of land containing freshwater resources by storm surges associated with hurricanes and with non-tropical events, will impact water quality and lead to the further damage and loss of freshwater resources and lands used for freshwater extraction purposes.

It is also anticipated that a slow, gradual, rise in sea level will result in an increase in the area of wetlands. This, in turn, is expected to lead to the gradual evolution of pine forests and coppice forest to perennial wetlands, with consequent changes in the fauna and flora. Wetlands are also expected to evolve fresh to brackish to saline and, in extreme cases, to hyper-saline marshes, especially in the drier extreme southeastern islands of the Bahamas. The structure and natural productivity of these areas will therefore change over time. At the extreme projection of a sea level rise of 5 ft (1.5 m), above present sea level, some 80 % of the land mass of the Bahamas will be reclaimed by the sea for most, if not all, the year.

The freshwater resources are also threatened by human activity such as contamination from sewerage, agricultural runoffs such as fertilizer and insecticides, and pollution from vehicles such as oil and fuel runoffs and disposal. The resources of the heavily populated islands of new Providence and Grand Bahama are especially at risk by these activities.

3.3.4 Coral reefs

The coral reefs of The Bahamas have been described as the third most extensive coral reef system in the world. The reefs support a variety of commercially important marine resources, as described in Section 1.4.5. Reefs are also important as physical barriers to storm surge and ocean waves. Problems associated with reefs include over-exploitation, pollution from run off and sewage, and non-sustainable practices associated with diving and tourist related industries.

Climate change is expected to introduce additional stresses associated with higher temperatures and erosion of the shoreline and the resultant increase in silting. The greater inundation of the reef and shoreline from extreme events, such as hurricanes and surges, are also anticipated to stress coral reefs.

Coral bleaching events have been noted across The Bahamas and in the Caribbean region, and are associated with elevated sea surface temperatures, though this may not be the only factor involved. Additional temperature rises are likely to further stress and weaken coral and damage the ability of the coral reef system to withstand the impact of hurricanes, which will lead to further beach erosion.

Algal blooms, sometimes called “red tides”, can cause serious food poisoning. The causative bio-toxins accumulate in the food chain, and persons consuming scale fish and shellfish containing accumulated bio-toxins, can experience serious illness. The relationship between elevated sea level temperatures and the occurrence of these algal blooms, and with the content of the bio-toxins, is largely unknown at present, but is a matter of concern to fisheries and health authorities alike. The principle causal agents are dinoflagellates, a group of organisms that are classified as algae, but are sometimes regarded as protozoa. They are typically unicellular, and may be photosynthetic or heterotrophic, or both. One of these bio-toxins, known as ciguatera, is certainly a cause of poisoning in the Caribbean. There is a need for more information on red tides and the occurrence of ciguatera and other toxins in The Bahamas. Increased instances of red tides would almost certainly lead to an increase in incidences of food poisoning.

3.3.5 Agriculture

Although the agricultural sector is not a major contributor to GDP in The Bahamas, some agricultural production, both of crops and livestock, is undertaken to a greater or lesser degree, on several islands (see Section 1.4.6). Many of the population on the less developed islands depend on subsistence agriculture for at least a part of their livelihood. Many of the short-term crops (corn, pigeon peas, sweet potatoes and vegetables) are seasonal, and any significant shifts in climatic conditions such as increased temperatures, more frequent or more intense droughts, and any changes in mean rainfall, could have adverse effects on production and food supply.

Inundation by storm surges and rises in mean sea level, will result in the loss of agricultural land due to saltwater intrusion and salinization. Recent experiences with Hurricane Floyd in 1999 demonstrate the vulnerability of the agricultural sector to such events. Plant breeding, including genetic engineering, may increase the salt tolerance of some crops, and systems of crop production may need to be modified to adjust to increased salinization of the soil, or to saline irrigation water. The National Research Council (1990) has produced a useful account of salt-tolerant plants that could be useful, but many of them are unfamiliar.

On the other hand, increased atmospheric CO^2 concentrations may positively enhance the growth and yield of certain crops. Increased CO^2 concentrations however, may favour certain weed species over crop species, so shifting the balance of competition and leading to changes in the weed flora. “New” pests and diseases of crops and animal may enter the country as a result of climate change, and quarantine authorities will need to be vigilant.

3.4 ASSESSMENT OF EXPECTED IMPACTS

3.4.1 Introduction

This section considers the impacts of recent tropical and non-tropical processes as they serve to highlight the vulnerability to climatic events, processes and the types of damage that tropical systems can cause. An analysis of the impact of Hurricane Floyd in September 1999 demonstrates the impact that tropical processes can have on the economy, and quantifies the damage.

The non-tropical processes are considered separately as they fall out of the traditional hurricane season and include events that impact the Bahamas but are described as extreme events in other regions. In many ways this serves to emphazise the fact that the global climate system is indeed global, with effects across national borders and over great distances from the actual event.

3.4.2 Hurricanes

Hurricanes are frequent occurrences in the weather systems affecting The Bahamas, as has been pointed out in Section 1.3.1. In the past, during the hurricane months, experienced inhabitants watched changing weather patterns and watched their barometers for falling barometric pressure as indicators of approaching storm systems. Often they had only a few hours to prepare and often damage to buildings, boats and crops was severe. In most years one or more hurricanes come close enough to the islands to cause concern and the posting of warnings.

The landfall of Hurricane Andrew in North Eleuthera, in September 1992, ended an almost thirty-year period during which hurricane damage in the Bahamas was relatively minor, compared with that in other Caribbean countries and along the eastern seaboard of the United States. Having been largely spared the ravages of such hurricanes as David, Gilbert and Hugo, the last major hurricane prior to Andrew was Betsy in 1965. Hurricane Floyd in September 1999 (see Section 1.2.2) caused severe damage, and during the same season, Hurricane Dennis caused minor damage on Abaco, and Hurricane Irene dumped some rain but, along with Hurricane Harvey, skirted the islands.

Photography: courtesy of Philip Weech

It is important to note that, whereas considerable damage was caused in some Family Islands, neither Andrew nor Floyd seriously affected New Providence. A 30-mile shift to the south in the path of hurricane Andrew, and a 30-mile shift to the west in the case of Floyd, would have brought these systems much closer to New Providence, where Nassau is located, and nearly 70% of the population. One can only speculate on the amount of damage that might have occurred.

The Prime Minister outlined the damage caused by hurricane Floyd in two addresses to Parliament on October 13, 1999 and again on February 23, 2000 (Ingraham 1999b, 2000a). In the latter address, the Prime Minister noted that the local insurance industry reported payments totaling $167.8 million in settlement of hurricane insurance claims, and that $69.6 million in claims remained (at that time) outstanding. These figures did not include settlements made by foreign insurance companies. The Inter-American Development Bank (IDB) estimated the damage caused by hurricane Floyd at $153 million, excluding damage to housing and personal property.

Photography: courtesy of Philip Weech

The Prime Minister also noted that there were a large number of properties, especially in the Family Islands, that did not have insurance coverage. Their losses were not therefore included in the above figures. The government and public utility corporations found it necessary to engage in extensive repairs to roads, cemeteries, docks, bridges, abutments, utility poles and wires, water distribution systems and electric generators. Government purchased several million dollars worth of building supplies for distribution in the islands for the most needy inhabitants who lost their homes to Floyd.

Based on data available, it is estimated that the number of storms (and hurricanes) is increasing at a rate of between 3 and 4.5 per one hundred years. There were fourteen named systems during the 1998 season, with nine becoming hurricanes and three of these becoming intense hurricanes. During the 1999 season there were twelve named tropical storm systems, with eight becoming hurricanes.

In addition to the high winds and rain associated with hurricanes, storm surges are also of great concern in The Bahamas, because major hotels, exclusive residential properties and Family Island settlements are located in close proximity to the sea. Low-lying areas, usually residential, are easily flooded. There is also concern with the management and storage of pesticides and fertilizers, other hazardous chemicals, and petroleum products during hurricanes. Spillage can contaminate soil and groundwater. The storage and use of these chemicals is largely unregulated.

3.4.3 Non-tropical processes

The meteorological definition for “sub-tropical,” is the region between the tropical and temperate regions, particularly an area between 35 and 40 degrees north and south of the equator. The term “extra-tropical” applies to tropical cyclones moving pole-ward from about 40˚ to 45˚N, where the weather system generally encounters relatively cold ocean waters (less than 26˚C). Finally, “non-tropical” events are those not specifically confined to the tropics, (i.e., gales, thunderstorms, tornadoes). Experience suggests that severe weather phenomena can occur at any time of year in the Bahamian archipelago. Such weather phenomena may endanger life, destroy property, and require expenditure of funds for repair. Box 3.4.1 provides a summary of the types of damage to be expected in The Bahamas resulting from climate change.

Box 3.4.1 Analysis and summary assessment of the types of damage likely to result from climate change processes.

Degradation of coral reefs

Some species of corals will respond well to sea level rise. However, stress due to temperature increase will have a devastating effect on most species, and coral bleaching events and the incidence of coral diseases will increase. Increased storm activity and physical damage to reefs during the passage of storms will result in significant loss of the resource.

Salt water intrusion and loss of freshwater resources

Freshwater lens are expected to shrink from losses, and water quality to deteriorate, as a result of salinity changes resulting from inundation and salinization. Sewerage systems will be apt to flood and contaminate both the land and sea. Water borne diseases are likely to occur.

Loss of agricultural lands

Salt-water intrusions and arising water table will render some agriculture lands unfit for agriculture. Occasional inundation with also render lands unsuitable for agriculture at least for a period of time.

Environmental and socio-economic changes

Increased demands on limited natural resources. Shifts in traditional agriculture and fisheries practices will be necessary.

Human health and well-being

Vector borne diseases are expected to increase. Prolonged periods of high temperatures and humidity will lead to stress, particularly among the very young and the very old.

Coastal/Beach Erosion

The Bahamas is extremely vulnerable to sea level rise as some 80% of the country is within 5 ft (1.5 m) of mean sea level, with a resulting loss of land from erosion of the coastline. Low lying areas that border Nassau Harbour and much of downtown Nassau are expected to flood more frequently.

Settlement and infrastructure

Damage to coastal roads bridges, jetties and piers, is expected to occur as a result of storms, hurricanes and surges. Telecommunications and power lines are likely to be damaged by winds and sea, with loss of services. Airports will be subject to flooding.

Analysis of meteorological and oceanographic data for the Bahamas indicates that the most serious threat of storm damage comes from tropical cyclones in which winds of destructive force are sustained for long periods of time. Nevertheless, storms of non-tropical origin, while of shorter duration and generally localized in nature, can also disrupt operations and endanger life and property. In addition to the above-mentioned events out-of-season tropical cyclones, though very rare in the Atlantic, can occur. Their region of formation is to the northeast of Puerto Rico and southeast of Bermuda, between December and May. These systems may move west to east, in contrast to the movement of systems developing during the hurricane season.

Some systems forming in this general vicinity during the off-season months include:

- A hurricane in March 1908 struck the Leeward Islands
- Hurricane Able, in May 1951, brushed the northern Bahamas and east coast of Florida.
- An unnamed tropical storm developed during December 1953.
- Hurricane Alice, in December 1954 to January 1955, struck the Leeward Islands.
- A subtropical storm formed in January 1978.
- Hurricane Lili, in December 1984, briefly threatened the Leeward Islands.
- A subtropical storm formed in April 1992.
- The Christmas Weekend or Santa Storm of December 1994.

The northern Bahamas experienced severe weather conditions on January 19,1977 when a low pressure system off Cape Hatteras deepened rapidly, causing gale force winds and large northeasterly swells to bombard the eastern shorelines of the islands over the next few days. There were unconfirmed reports of snow flurries on Grand Bahama and Abaco. This system caused a major freeze in South Florida and severely damaged the citrus crop.

In 1991, The Bahamas felt the affects of the “Halloween Storm" of October 30 to November 1. Although this did not produce much "weather", the sea swells (waves which break away from the wind systems that produce them) caused extensive coastal damage along the eastern coastline of islands in the northwest and central Bahamas. A rare combination of meteorological factors, including a weakening Hurricane Grace in the Atlantic, an unusually strong Canadian high-pressure ridge, and developing low pressure in the North Atlantic, combined to generate this system. It is worth noteworthy that these waves traveled approximately 1100 miles to affect The Bahamas.

3.5 MOVING TOWARDS ADAPTATION IN THE BAHAMAS

Conventional literature on the subject of adaptation, and in particular the recent outputs of the Intergovernmental Panel on Climate Change (IPCC), presents several strategies for adaptation to climate change. Adaptation to change occurs naturally whenever humans are faced with other choice but to change. At various times in Bahamian history the stages of adaptation have been exercised largely in an unplanned manner in response to change processes that have impacted the Bahamas. An example is the growing of sisal, a crop well-adapted to the drier islands of The Bahamas, in the early 1940s, in response to the need for ropes and twines and the impossibility if importing these commodities during World War II. The sisal was retted (soaked) in old salt-pans that were no longer used for salt production.

Climate change however presents new challenges due to the speed of the anticipated changes, and the magnitude of the investments need to effect adequate change. Additionally, in the case of some small islands the only option may be to retreat, a practice of abandonment that in the minds of most residents of small islands is difficult to visualize. One should perhaps distinguish between “retreat” which implies a withdrawal, in this instance to higher and drier ground, and abandonment of dwellings and other buildings, and “relocate” which implies transferring to another island (or another country). In small island states, such as The Bahamas, “retreat” may not be an option because there is no place to retreat to. In low-lying small island states, also like The Bahamas, relocation may be a necessary option from small islands with no high ground.

The adaptation process is summarized in Box 3.5.1.

Box 3.5.1 The options available in the adaptation process.

Bear losses

This is the “do nothing” strategy or response, against which all options may be compared. All too often, however, this is the “default strategy” because other options are not available or not know.

Share losses

This response involves sharing the losses with a wider community, either through informal arrangements (e.g. extended families and cooperatives) or through institutional ones, such as the insurance industry.

Modify or eliminate the threat

It is sometimes possible to exercise a measure of control over the environmental threat. In the case of climate change, the reduction of green house gas emissions is the major modification that is a possibility. This is also known as mitigation.

Reduce or prevent effects

This option or measure involves taking steps to prevent the effect. In agriculture, for example, it could involve using irrigation when the climate gets drier, or changing to drought-resistant crops.

Avoid the effects

This measure could involve the relocation of an economic activity, such as the development of inland resort facilities because of rising sea levels and increasingly frequent storms, which would threaten the viability of seaside operations.

The third type of adaptation strategy, modifying or eliminating the threat (by reducing emissions of GHG), is not discussed here, but is discussed in Chapter 5 “Policies and Measures”.

Some of the possible adaptation strategies or options for The Bahamas are summarized in Box 3.5.2. This is organized around the major sectors likely to be impacted by climate change. No attempt has been made in this initial assessment to cost, assess the technical feasibility, or consider practicality of any particular option or options. It is clear, however, that across the Bahamas no one option will alone achieve the desired results of reducing the vulnerability of the Bahamas to climate change. It is also clear that in the adaptation process hard choices will have to be made to abandon some settlements, or not replace them when damaged. Improvements to human settlements by zoning practices based on vulnerability risk assessments, restrictions on class or type of development, prohibition of all activities likely to exacerbate impacts, and the costs associated with replacement of buildings, and providing for increased security of settlements and infrastructures, are options that need to be considered. It is also clear that the costs associated with planned adaptation will be high, but the cost of not acting at all will be measured directly in loss of life, loss of competitiveness in the tourism sector, and often at the expense of the environment.

Box 3.5.2 Some adaptation options that may be applicable to The Bahamas.

Tourism

The Bahamas has in excess of 3.5 million visitors a year. More emphasis on the development of eco-tourism programmes, especially on the Family Islands, will provide a means of ensuring sustainable development while preserving the natural environment. Smaller, less dense and more dispersed facilities are suggested.

Improved Infrastructure

In light of recent increases in numbers, and greater intensity tropical storm systems, affecting The Bahamas, improved coastal infrastructure, and improved designs of sea walls, cause ways and bridges, is needed. Coastal zoning, setbacks, hazard mapping and enforcement are recommended. Building control enforcement is also strongly recommended. Insurance schemes to provide funds for “adaptative” rebuilding are needed.

Water Sector and Resources

A water sector policy is needed as the sector and its resources need further protection. Monitoring of competing uses of the resource, such as non-registered private wells, is needed. Efforts need to be directed at educating the public in water conservation. The use of reverse osmosis and other forms of desalination needs to be further expanded and actively considered for the more remote family islands and in New Providence. Sewerage schemes and their infrastructure will requires upgrading in the face of rising sea levels.

Redistribution of population

The Government of the Bahamas has almost completed the electrification process for most of the country. The far southern islands have experienced depopulation as a result of persons seeking economic opportunity elsewhere in The Bahamas. Recent electrification and general improvements of infrastructure in these islands will positively encourage the movement of population back to these islands, providing that economic activities are available.

3.6 GAPS AND RESEARCH AND INFORMATION NEEDS

3.6.1 Introduction

This Chapter represents an initial assessment of the Vulnerability and Adaptation (V&A) options to global climate change for The Bahamas. The report draws on data from known sources and no attempt, except for the commissioned study by Martin and Bruce (2000), has been made to examine the impacts of climate change to a service-based economy from outside its borders. This issue is important because one of the global effects of climate change will be seasonally higher mean temperatures across the higher latitudes. Tourism is the major economic base in The Bahamas and any changes in global weather patterns could potentially lead to reduced demand from the eastern United States and Canada, the main tourist market, for winter holidays in The Bahamas. Additionally, any significant change in the price, use and availability of energy in the transport sector, has the potential for raising costs and reducing competitiveness in the tourism sector.

Further, the possible introduction of exotic diseases and disease vectors, and their spread as a result of increases in mean temperature and humidity, are causes for concern. Malaria and dengue fever are two examples of diseases with potential for impacting both the Bahamian population and the tourism sector. Health-based impacts are likely to be manifested mainly in the poorer countries of the region, and the migration of persons from these countries to and through The Bahamas, has the potential to introduce diseases and vectors.

There is as yet little hard data on climate change and its potential impacts on biodiversity, human health and well-being, and on marine ecosystems that can be used to develop a socio-economic model for The Bahamas. Consequently an assessment of the economic impact of the negative or positive impacts of climate change has not yet been attempted.

V&A assessment general assumes that climate change will be steady and linear in nature, and catastrophic change has not been factored into the assessment. It also assumes that impacts, both positive and negative, will be measurable, and that the resources and knowledge of mitigation and adaptation will be within the national capacity. The cost of adaptation, and of acquiring the needed capacity, has not yet been quantified.

The issue of natural disaster management and response to the multiple stresses experienced as a consequence of hurricanes impacting The Bahamas also requires examination. Experiences of past extreme events and the impacts of El Nino and La Nina episodes, provide valuable lessons and a basis for costing impacts and adaptation responses to climate change.

3.6.2 Research and information needs

Arising from the initial V&A assessment for The Bahamas, it became clear that there were many gaps in existing data and information, and a lack of tools to assess the physical and economic impacts on the most vulnerable sectors of the economy. The following listing is grouping by categories, which are either economic sectors or subject area, and is not in any order of priority either between or within categories.

Agriculture

- Assess the vulnerability of the sector to soil salinization, to loss of agricultural lands due to year-round and seasonally high water tables, and to salt-water flooding, using Geographic Information Systems (GIS) and other information sources.
- Develop and evaluate agricultural production systems adapted to various levels of soil salinization, and to atmospheric CO2 enrichment and increased temperatures.
- Develop production systems to use low quality (saline) water for irrigation.
- Assess likely impact of increased temperatures on pest and disease incidence and on weeds, and monitor for changes in pests, diseases and weeds.

Fisheries

- Assess the impact of increased sea surface temperatures on the economically important fish species, and on sea-grass beds.
- Assess the impact, for various scenarios of shifts in the strength and direction of the gulf stream, on migratory deep-water fish and marine mammals.
- Assess the impact of increased water temperatures on the breeding behaviour and performance of economically important fishes.

Forestry

- Assess the effects of salinization of the soil, and rising water tables, on pine forests, and monitor the changes in the biodiversity of these forests.
- Assess the effects of salinization of the soil, and rising water tables on hardwood coppice forests, and monitor changes in the biodiversity of these forests.
- Assess the effects of salinization of the soil, of inundation and rising sea levels, on coastal and inland mangrove communities, and monitor changes in the biodiversity of these communities.
- Review the suitability of alien (exotic) saline-adapted species of timber trees for The Bahamas.

Geographic information systems

- From additional runs of the Sea Lake and Overland Surges from Hurricanes (SLOSH) model and Digital Elevation Models (DEM), develop digitized data sets to be maintained and managed by the Bahamas National Geographic Information System Centre (BNGISC).
- Produce digitized bathymetric and land contour maps for the entire Bahamas indicating all features of land use, to facilitate the more accurate modeling of storm waves and surges.
- Digitize changes in the movement of sand bodies and silting rates in shallow marine waters.

Health

- Establish a system of UV-B bio-meters to assess the likely impacts of UV radiation on human health.
- Conduct epidemiological monitoring of human diseases, especially dengue, yellow fever and malaria, and of insect vectors of human diseases, in The Bahamas.
- Assess the likely effects of heat and humidity stress on the human population.

Meteorology and oceanic observations

- Establish additional sea level monitoring stations at selected sites.
- Establish wave recorders at selected sites to monitor, inter alia, the impacts of non-tropical processes that generate strong ocean swells.
- Expand and upgrade the meteorological and hydrological monitoring system in The Bahamas, and provide access to data to key sectors.

Physical planning

- Using GIS data, develop a national of zoning and a series of maps covering the entire Bahamas, based on risk assessment, for various projected scenarios though to the year 2100.
- Develop draft legislation to enforce the system of zoning, and to enforce the use of risk assessment and impact analysis in project planning and environment impact assessment.

Public works

- Using GIS and physical planning data and maps, produce a catalogue of public facilities (docks, jetties, and public buildings, etc.) at risk of damage from storm surges, and inundation and inland flooding by heavy rainstorms.
- For the above, develop strategies to minimize vulnerability, and prioritize the work necessary.
- Develop and revise at regular intervals, the cost of the above.

Tourism, insurance and commercial

- For the tourism sector, carry out an economic impact assessment for various scenarios of climate change and sea level rise.
- For the tourism sector, prepare plans with costs, for infrastructure needs to protect properties against extreme events.
- For the insurance sector, conduct a study to of the insurance implications of climate change and sea level rise in The Bahamas.
- For the commercial sector, conduct a study of the commercial implication of climate change and sea level rise, with particular reference to the location of commercial properties, the storage of dangerous materials, local transportation and inter-island traffic, etc.

Water resources and supply

- Institute a systematic programme of water quality monitoring for fresh, saline and hyper-saline waters, so as to assess their vulnerability to contamination by sea level rise and anthropogenic pollution.
- Develop appropriate mitigation measures, especially for fresh (potable) water supplies.
- Develop long-term national water resources plans for the entire Bahamas.
- Identify water resources at risk from inundation, sea level rise and flooding from extreme events.

CHAPTER 4

SYSTEMATIC OBSERVATIONS AND CAPACITY BUILDING

4.1 SYSTEMATIC OBSERVATIONS AND RESEARCH

4.1.1 Introduction

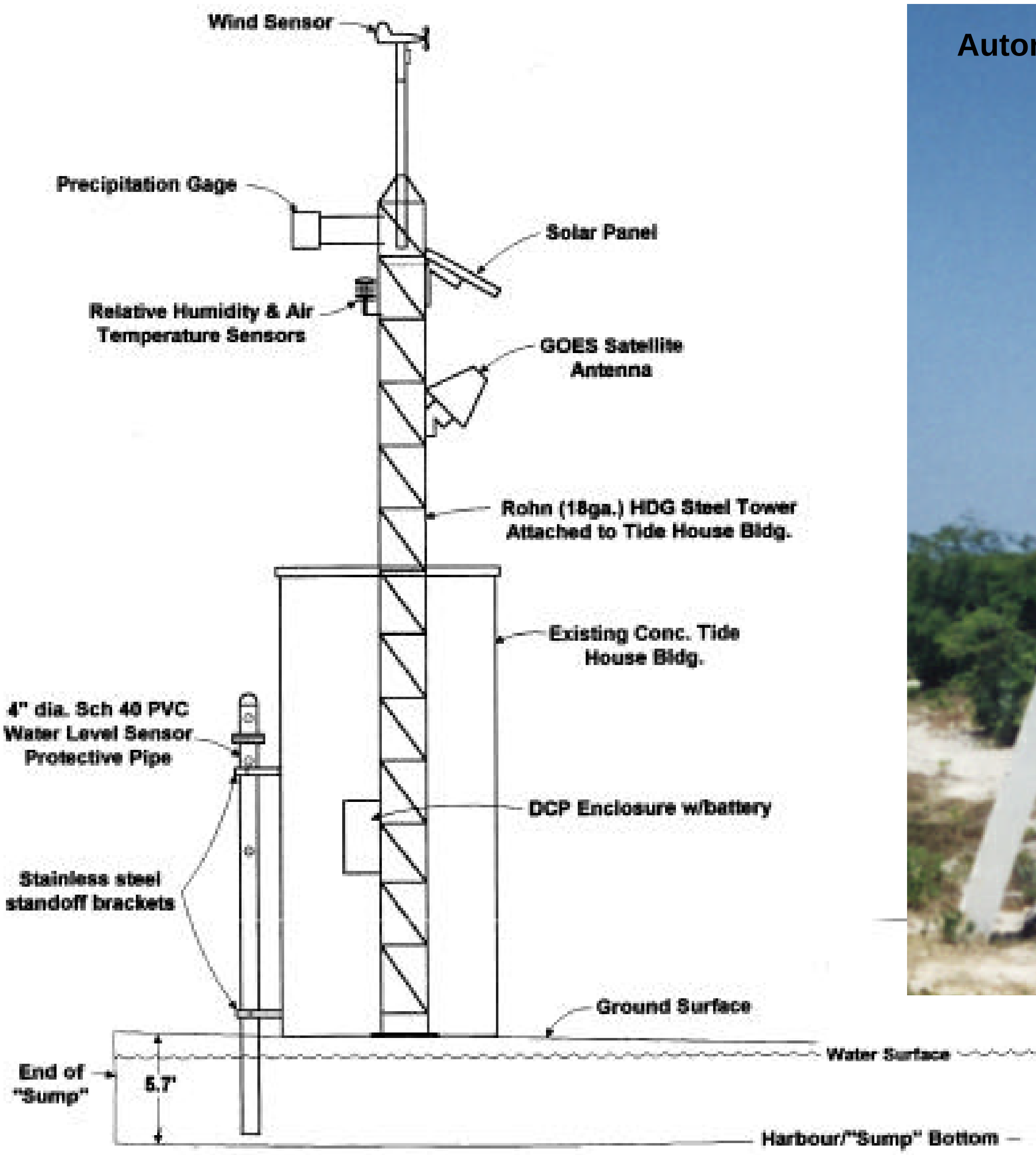
Weather observations in The Bahamas have been made since the arrival of Christopher Columbus in 1492, and have continued to the present day. Historically, these observations were reported by numerous private individuals, usually untrained, on both land and at sea, and at widely dispersed locations across the Bahamas. These records are often incomplete with numerous gaps. Additionally, the instruments used to collect data were of varying type, quality, and accuracy.

Of particular interest are the observations and reports on tropical cyclones, the dominant seasonal feature of Bahamian weather. Tropical cyclones that affected The Bahamas were named "hurricanes" by the Lucayan Indians. Shaklee (1997, 1998) examined the records of hurricanes in historical accounts and observed that, prior to 1871, the data was "sadly deficient." He considers this primarily due to the lack of permanent settlers to record the passage of hurricanes through the islands. Shaklee (1997) also points out that the records for the period 1492-1750 (258 years) suggest that only seventeen hurricanes passed through The Bahamas during that period. This compares with reports for the period 1750 to 1799 (49 years) of thirty-six possible hurricanes reported as having passed through The Bahamas (Shaklee, 1998).

4.1.2 Systematic observations

In 1935, a network of observing stations was organized by the Bahamas Telecommunications Department, in conjunction with the United States Weather Bureau. The Bureau provided the instrumentation and forms for recording the information, along with the necessary instructions. Annual tours were arranged to inspect and maintain the instruments. The information collected was disseminated in accordance with the international standards and practices of the times. The formation of the British Caribbean Meteorological Service in 1951 resulted in the formulation of a more systematic manner of making observations. The Caribbean Meteorological Service was reconstituted in 1962, and this prompted the Government of The Bahamas to establish its own Meteorological Office as an autonomous section of the Department of Civil Aviation. This Office was in existence from 1963 to 1972 (A.W. Rolle, personal communication).

The Bahamas Meteorological Service was created as a separate Department (the Department of Meteorology) in 1973, under the Ministry of Tourism. A cooperative upper air observing station with the United States has been maintained since 1978. On July 2 1982, the governments of the United States and the Commonwealth of The Bahamas concluded an agreement regarding cooperation in the operation and maintenance of a network of meteorological surface observation and reporting stations in the Bahamas. During this time, the number of observing stations increased to 14, all providing hydro-meteorological information. Upon examination, this coverage was considered to be insufficient to adequately monitor the climate of The Bahamas, as analysis suggested that at least 60 rainfall stations should be installed, throughout the archipelago, to provide adequate coverage.



Automated Weather Station and Tidal Gauge

Photography:
courtesy of G. Burnside
Department of Meteorology

Systematic hydrological observations date back to the early 1970s, and formed part of the comprehensive Land Resources Survey (Little et al. (1971-1976)). All of the major islands were monitored over a period of five years for the purposes of this survey.

Various marine and oceanographic observations have been made on an ad-hoc basis over the past century. Systematic observations however are more recent, the more notable being those of the Caribbean Marine Research Centre (CMRC), now known as the Perry Institute for Marine Sciences, at Lee Stocking Island in the Exuma Cays. These observations include records of the physical processes controlling water temperature, water level, and circulation. Some of the observations are in-situ, and are made in the shelf waters of Exuma Sound, the adjacent shallow waters of the Great Bahama Bank to the west, and in the connecting tidal channels.

Sea level recordings have been made by various entities over the past century, but no long-term records exist for any individual site across the Bahamas. A tidal gauge has been maintained and

Photography:
courtesy of G. Burnside

operated by the National Oceanographic and Atmospheric Administration (of the United States) as part of the GLOSS (Global Sea Level Observing System) network, at Settlement Point, Grand Bahama, since 1978. Under the Caribbean: Planning for Adaptation to Climate Change (CPACC) Project of the Organization of American States (OAS), the Department of Meteorology (of The Bahamas) was provided with three long-term sea level and hydro-meteorological monitoring stations, to augment and complement the existing national and regional efforts. The new sites are expected to provide comprehensive measurements of long-term sea level trends in The Bahamas. The monitoring efforts at Lee Stocking Island and Great Inagua (though the latter site was completely destroyed by Hurricane Floyd in 1999) are important regional measuring stations, while the site in Nassau Harbour is important because Nassau is the main population center, and has economic and historical significance as the main port of entry for much of the past 500 years.

There are no wave recorders in the Bahamas, even though tropical and non-tropical processes generate significant swells that have caused extensive damage in coastal areas in recent time. Ultra-violet radiation (UVB) that is harmful to health is being measured by an ultraviolet bio-meter installed at Nassau International Airport in 1999. For comparative purposes, there is a need to install at least two more such recorders, one in the central and the other in the southeast Bahamas.

4.1.3 Research activities

These range widely and encompass regional and international initiatives, and include not only meteorological but socio-economic elements.

4.1.3.1 Regional research

The most notable research activity on global climate change in which The Bahamas is participating, is the CPACC Project (see above). There is a parallel Feasibility Study on the Prediction and Amelioration of Socio-Economic Impacts of the El Nino Southern Oscillation (ENSO) in Latin America and the Caribbean. Twelve CARICOM states are involved in the CPACC Project funded by the Global Environmental Facility (GEF). The objective of the project is to build a regional and national capacity in climate change. The CPACC Project is further discussed under 4.2 (Capacity Building).

4.1.3.2 El Nino.

The El Nino episodes of 1995 and 1998 were, in part, responsible for the Feasibility Study referred to in 4.1.3.1 above. It was during these events that Bahamian coral reefs experienced significant bleaching. Coral reefs are regarded as excellent indicators of climate change, since they respond to changes in the temperature and turbidity of the water, and to solar radiation. The general objective of the Project is to design feasible regional early warning systems to ameliorate the impacts of the El Nino Southern Oscillation (ENSO). The Study will include some case studies on ENSO in the Caribbean.

4.1.3.3.Climate change investigations

In June 1999, the Government of The Bahamas, through the National Climate Change Committee (NCCC) of the BEST Commission, contracted with Global Change Strategies International (GCSI) of Canada, to undertake a study of climate change in The Bahamas. The study (Martin and Bruce, 1999, 2000) formed part of the effort of the Government of The Bahamas to develop a National Action Plan on Climate Change, and a First National Communication to the United Nations Framework Convention on Climate Change (UNFCCC). The study follows earlier GCSI contributions to a workshop, and the provision of consultancy services to The Bahamas. The scope and objectives of the study of climate change impacts in The Bahamas are summarized in Box 4.1.2.

4.1.3.4 Vulnerability

The degree of resolution of Global Circulation Models (GCM) is generally inadequate to depict the regional climates in areas consisting of small and narrow landmass, such as The Bahamas. Examination of these models nevertheless indicate that the Geophysical Fluid Dynamics Laboratory (GFDL) Model, the Canadian Climate Centre (CCC) Model, and the United Kingdom Meteorological Office (UKMO) Model all predict an increase in mean air temperature of about 2° degrees Centigrade in the Caribbean region. All the models simulated the future climate in an atmosphere with a doubled carbon dioxide concentration within 75 years. No signals could be had for rainfall from the simulation exercises. However, for research purposes it was decided that a 1° to 2° degree Centigrade temperature increase should be used, along with a 10 to 20% variation in rainfall.

Box 4.1.2 Scope and summary of the principal findings of the report "Effects of climate change: hydro-meteorological and land-based effects in The Bahamas".

Scope

The study examined human health, hydro-meteorological and land-based issues. The overriding question addressed was: what changes have occurred in the Bahamian climate to date, and what impacts have been identified? Using data provided by the Bahamian government, the study examined, analyzed and reported on, the following:

- Hydro-meteorological data for The Bahamas.
- Historical review of tropical storms, storm processes and storm surge inundations.
- The occurrences of drought periods and heavy rains, focusing on the increase in intensity of rainfall events.
- Changes in vegetation and sedimentary processes throughout The Bahamas.
- Mean air temperature changes.
- Changes in mean groundwater levels in freshwater lenses in The Bahamas.
- Possible health impacts, to date, as indicated by hospital admissions data and incidences of malaria, respiratory disease and heat stress, for example.

A comparison with nearby countries and with comparable regions, will be attempted if data are available. In general, the availability of appropriate databases will influence the level of detail produced in the final report. The study will not produce new databases nor undertake supplementary measurements.

Principal findings

The study contributed to a subsequent assessment of the vulnerability and adaptation of The Bahamas to the future impacts of climate change by:

- Identifying data gaps in the hydro-meteorological monitoring system, and proposing method(s) of filling these gaps.
- Proposing climate change scenarios that might be used to predict future change.
- Providing a relative assessment of the vulnerability of The Bahamas to the effects of climate change.
- Commenting on possible adaptation strategies for The Bahamas.

The study report will form a background paper on the hydro-meteorological and land-based effects of climate change in The Bahamas. It is intended to be the basis for a national workshop on vulnerability and adaptation, to be held at the completion of the study. To this end, the report will make specific reference to questions posed, and to discussion points that may be raised by workshop participants.

Source: Martin and Bruce (2000)

These models projected sea level rises of 1.6 in (4 cm), 12 in (30 cm) and 20 in (50 cm) over the next 25, 50 and 100 years respectively.

Observations in The Bahamas reveal that storm surge produces most of the flood damage and drowning associated with tropical storms that make landfall, or that closely approach a coastline. Recognizing this fact, and the vulnerability of the Bahamian archipelago to storm surges, the Government of the Commonwealth of the Bahamas, the World Meteorological Organization (WMO) and the United States Government, applied the Sea Lake and Overland Surges from Hurricanes (SLOSH) computer model developed by Jelesnianski (1967), to the Bahamas. On the basis of observations by forecasters of the Department of Meteorology of The Bahamas and of the National Hurricane Center in Miami, Florida, thirteen storm-track headings were selected as representative of storm behavior in this region. Rolle (1990) has produced an atlas that provides maps of SLOSH-modeled heights of storm surge and extent of flood inundation, for various combinations of hurricane strength and direction of storm motion. This project, an example of bilateral assistance, was done with the assistance of the Storm Surge Group of the National Hurricane Center, National Oceanic and Atmospheric Administration.

The model has so far been applied only to the northern and central Bahamas (i.e., to the islands of New Providence, Eleuthera, Cat Island, San Salvador, Rum Cay, Long Island, Exuma and the Cays, southern Abaco and the Berry Islands). “Ground-truthing” of the model came in 1992 with the passage of Hurricane Andrew over the island of Eleuthera. Consultants recommended that for further assessments the SLOSH model be run with a 20 cm sea level rise, and the use of Geographic Information Systems (GIS) data generated by this model. The work now needs to be expanded to include the remaining islands of the Bahamas, which are also frequently threatened by hurricanes. The findings should undoubtedly guide development in those areas vulnerable to severe flooding.

4.2 CAPACITY BUILDING

4.2.1 Introduction

The intergovernmental negotiation process that led ultimately to the Earth Summit in 1992, served as a mechanism for highlighting global concerns for the environment, including climate change, and to achieve heightened awareness of these issues in The Bahamas and throughout the Caribbean region. The process in the Bahamas, of coordinating the national effort to prepare a national report for UNCED (Ministry of Foreign Affairs, 1992), led to the formation of a National Inter-Ministerial Committee on Science and Technology (NIMCOST). This Committee had the approval of the Cabinet of The Bahamas and was charged with coordinating the national effort to prepare the country report to UNCED under the aegis of the Ministry of Foreign Affairs. The UNCED country report represented the first national statement on climate change and served, within the public service, as an initial assessment of the potential impacts of climate change on The Bahamas. Awareness within the public sector was also heightened, and the stage was set for efforts to develop the technical capacity, and the advocacy needed to develop a national strategy responsive to the global problem of climate change.

The members of the Caribbean Community (CARICOM) are primarily low-lying coastal states and islands with fragile coastal ecosystems. Tourism and agriculture are the principal sources of employment and of foreign exchange earnings. Coastal areas, holding the vast majority of the population and economic activity, are vital to the prosperity and well being of these countries. They are also the most productive areas, supporting a wealth of living marine resources and high biological diversity. In recent years these resources have come under increasing stress. This problem may well be compounded by the anticipated global warming, which will result in rises in sea level, increases in sea surface temperatures, and changes in wind and ocean currents. The vulnerability of coastal resources, of human settlements, and of infrastructure to sea level rise, underscores the urgent need for an integrated framework to address these issues. The scarcity of reliable data and lack of suitable information systems and coordinated institutional structures to manage coastal resources, aggravate the difficulties.

National governments in the Caribbean came to the realization that the coastal environments in the region were under stress because of increasing human activities, tourism-related infrastructure, environmentally inadequate disposal of liquid and solid waste, decaying drainage infrastructure, uncontrolled development schemes, severe weather events, mismanagement of coastal ecosystems, and increased sedimentation due to poor watershed management. Further, there was the realization that the potential impacts of sea-level rise in the small island developing states of the Caribbean, included but were not limited to, salt water intrusion, increased coastal erosion, permanent flooding or inundation, and increased vulnerability to the impacts of tropical storms.

4.2.2 CPACC capacity building

The active participation of The Bahamas in the 1994 Global Conference on Sustainable Development of Small Island Developing States, held in Barbados (United Nations, 1994), resulted in the CARICOM countries approaching the OAS for technical assistance to assess the potential impacts of climate change in the Caribbean region. Thus originated the CPACC Project. The OAS and Global Environment Facility (GEF) Project Development Faculty supported the preparation of a project proposal. It became effective in April 1997, when the Board of Directors of the World Bank, one of the Global Environment Facility (GEF) implementing agencies, approved a US$6.5 million grant, and designated the OAS as the executing agency. A Regional Project Implementing Unit (RPIU) has been established at the Barbados campus of the University of the West Indies. CPACC constitutes an enabling activity of the United Nations Framework Convention on Climate Change.

The overall purpose of the CPACC project is to support Caribbean countries in preparing to cope with the adverse effects of global climate change, particularly sea-level rise, on coastal areas through vulnerability assessment, adaptation planning, and capacity building. The project follows a regional approach, being executed through the cooperative efforts of all twelve participating countries, the University of the West Indies Centre for Environment and Development (UWICED), and several regional institutions, through a combination of national projects, pilot and demonstration activities, and regional training and technology transfer workshops. This approach seeks to strengthen regional cooperation and institutions and provides cost-effective means for adaptation planning, data collection, and sharing of information, skills, and project benefits.

Box 4.2.1: Regional components of the Caribbean Planning for Adaptation to Climate Change (CPACC) Project.

- **Component 1: Design and establishment of a sea level and climate-monitoring network.** All countries. **Spare parts for the sensor, were purchased and shipped to Barbados to start stockpiling replacement parts at CIMH. The second** continuously operating GPS station was installed in Jamaica. The Institute of Marine Affairs (IMA) of Trinidad and Tobago has launched a web site to present data from the monitoring stations (http://www.ima-cpacc.gov.tt/index.htm).

- **Component 2: Establish database and information systems.** All countries. A series of workshops sponsored by the United Nations SIDSNet programme were mounted by CPACC and successfully completed.

- **Component 3: Inventory of coastal resources and uses.** All countries. The metadata protocol for coastal resources inventories was prepared and participating countries were trained in completing the data forms.

- **Component 4: Formulation of a policy framework for integrated coastal zone and marine (ICZM) management.** All countries. A first evaluation of how climate change adaptation is being incorporated into the existing policies of selected countries has been completed.

- **Component 5 (Pilot Component): Coral reef monitoring for climate change.** The Bahamas, Belize and Jamaica. The coral reef monitoring activities have begun in all participating countries.

- **Component 6 (Pilot Component): Coastal vulnerability and risk assessment.** Barbados, Grenada. and Guyana. Phase I has been successfully completed, producing national screening assessment implementation plans and data requirements.

- **Components 7 and 8: Economic valuation of coastal and marine resources** (Dominica, St Lucia and Trinidad and Tobago) and formulation of economic and regulatory proposals (Antigua and Barbuda and St. Kitts and Nevis). A draft methodology for Component 7 has been agreed, and country visits were conducted to the two countries participating in Component 8. A work plan for sharing experiences between the two components has been developed.

- **Component 9: Greenhouse gases (GHG) inventory and agriculture and water resource vulnerability assessment.** St. Vincent and the Grenadines. The national communication for St. Vincent and the Grenadines has been completed and is awaiting endorsement by the government.

The project's specific objectives are to strengthen regional capability for monitoring and analyzing climate and sea-level dynamics and trends, and to seek to determine potential impacts of climate change. Other objectives include identifying socioeconomic, environmental and geographic areas particularly vulnerable to the adverse effects of climate change, to develop an integrated management and planning framework for cost-effective responses and adaptation to the impacts of climate change on coastal and marine areas, to enhance regional and national capabilities for preparing for the advent of climate change through institutional strengthening and human resource development, to identify and assess policy options and instruments that will initiate and guide the implementation of long-term programmes of adaptation to climate change in vulnerable coastal areas. The nine components of the CPACC Project are specifically designed to address Caribbean issues and are summarized in Box 4.2.1.

4.2.3 Climate change awareness

The CPACC project has provided a means for training and awareness building and further support for the national effort at public awareness and advocacy on climate change issues in The Bahamas. Focused training in a regional context is facilitated by the project in the execution of its various regional and pilot components.

The lack of a national evaluation of the observed climate change signals in The Bahamas constrained the national awareness, training and public education efforts. The available scientific reports largely prepared by the IPCC served as the basis of national discussions within the public sector but the scientific material often lacked the required specificity required for public dissemination. Consequently, mainly public officers were targeted in the initial efforts. Persons trained at the national level for execution of the pilot component on coral reef monitoring involved both non-governmental organizations and private sector participation in the establishment, selection and monitoring of the selected sites across The Bahamas. Public awareness was heightened as a result of the national consultation that preceded the implementation of the CPACC project at a national consultation held on the 1996.

Under Component 1 (see Box 4.2.1), Department of Meteorology staff were responsible for the installation, and are now responsible for the repair and upkeep, of three sea level monitoring devices across The Bahamas. This necessitated consultations with the private sector and the research community to build support and cooperation. A national workshop under Component 2 (establishment of a database and information system), supported by the United Nations SIDSNet Programme, and executed by CPACC, was successfully completed.

Public addresses by senior government officials have focused on the impacts of climate change and government's efforts to build capacity, to report on the national involvement in the UNFCCC process, advise on the status of national efforts under the CPACC project and its various components and progress in executing the "Enabling Project". Additionally, experiences with tropical cyclones, public debates and the increased national and international media attention to climate change has also led to, and been used to increase, awareness on the subject.

4.3 CONCLUSIONS

The existing systematic observations, and the historical records of weather in the Bahamas, are sufficiently detailed to meet the reporting needs of the country. Deficiencies however exist, and there is a need to further examine the historical records in order to fill data gaps in the long-term weather records for some islands. There is also a need to develop new systems to monitor the anticipated changes in Bahamian weather, to provide a basis for fine-tuning regional climate models, and to build capacity in areas where it does not presently exist.

A research agenda, covering most of the major sectors, and embracing many disciplines, is presented at 3. 6.2.

CHAPTER 5

POLICIES AND MEASURES

5.1 INTRODUCTION

> "The small island states are extremely vulnerable to global climate change and global sea-level rise. A range of adaptation strategies is theoretically possible. On some small low-lying island states and atolls, however, retreat away from the coasts is not an option. In some extreme cases, migration and resettlement outside of national boundaries might have to be considered."
>
> *Watson et al. (1998)*

As a small island developing state with a services-based economy, dependent on imported fossil fuels, and lacking the scientific capacity to develop the technologies in the energy, transport and technological sectors needed to address issues of mitigation and adaptation to climate change, The Bahamas, and indeed, many other small island states, are caught between the proverbial "rock and a hard place". This assessment is reflected in the above quote from the IPCC in its assessment of the regional impacts of climate change and the vulnerability of small island states.

The Bahamas recognizes that efforts to mitigate the impacts of climate change, as expressed in climatic variability, rising sea levels, and an increase in the intensity and frequency of tropical processes, requires approaches that are multidisciplinary and cross-sectoral. These efforts must take account of the archipelagic nature of The Bahamas, its natural vulnerability, and its location within the tropical convergence zone. National sustainable development efforts and practices, capacity development, and the use of appropriate policies and measures, can serve to reduce the impact, but will not prevent climate change. International assistance, adequate financial resources and the availability of scientific and technological solutions, can reduce vulnerability and provide the means for developing adaptation strategies. However, efforts within any one country, will be defeated if the global trend of increasing GHG emissions is not reduced.

5.2 POLICIES AND MEASURES

The Bahamas has taken the first steps in adapting to global climate change through both regional efforts and at the national level. At the regional level, the Organization of American States Caribbean Planning for Adaptation to Climate Change Project (OAS: CPACC) is the initiative that grew out of the Small Islands Developing States (SIDS) Conference in 1994. The Bahamas involvement in this regional initiative focuses on capacity building and efforts directed at incorporating climate change in national planning.

At the national level, recent experiences with several major hurricanes and tropical and non-tropical processes have heightened awareness of the nation's vulnerability, and the public's awareness of the potential impacts of climate change. In this regard, there is a need to develop strategies to implement policies and measures to reduce The Bahamas' vulnerability to the impacts of climate change.

Box 5.2.1 Capacity building needs in the area of climate change.

Component	Capacity building needs
Strengthen coordination and support mechanisms at the national and regional levels in climate change by:	
Developing further international negotiating skills	At the national level establish a negotiating unit.
Developing regional systems based on existing region alclimate change initiatives.	At the regional level establish a climate change centre.
Regional climate scenarios for vulnerability and adaptation (V and A) assessment.	Creation of skills needed to assess V and A options at the sector levels in water resources, socio-economic including tourism, energy and
Education training and awareness	transport sector policy considerations
Public advocacy	Production of national assessments of V and A
Research and systematic observation	Develop regional climate models scaled for Bahamian level examination of sector level impacts.
Policy formulation and implementation	Skills to translate climate change sector recommendations into policy implementation.
Green house gases inventory	SIDS-friendly national database creation and monitoring systems to track national policy objectives. Sector based studies to determine policy options.

Government policy, at the national level, is being defined through the work of the BEST Commission. This is partially in response to the country's commitments to its international obligations and, more importantly, because government realizes the need to preserve the country's natural heritage and to provide for the sustainable use of resources for future generations of Bahamians.

Capacity development efforts have focused largely on project-based activities in response to the regional CPACC project and to the "Enabling Activity". Global Environment Facility (GEF) is funding both projects, the former in the amount of US$6.5 million, and the latter in the amount of US$187,000. The "enabling activity" is intended, inter alia, to produce The Bahamas' First National Communication to the UNFCCC. The transition from a project-based approach to a process-based approach, with the objective of providing for sustainable development, has started.

There is however much work still needed in capacity building and Box 5.2.1 is a summary list of areas where capacity building is required, in the area of climate change, that have been partially realized from the "enabling activity" project.

The policy and measures proposed, and currently being employed in The Bahamas, fall into two broad categories:

- Actions taken to provide for sustainable development and the sustainable use of natural resources; and
- An examination of possible measures, that are climate change specific, that can respond to changing conditions, and that would be beneficial to a small island developing state even if climate change does not occur in the manner, or on the time scales, predicted by scientists.

The former type of action is fairly well developed as a result of ongoing national efforts in the area of biodiversity and the movement in the tourism sector to develop eco-tourism as a major economic activity. The latter is in the early consideration phase, but is expected to develop as a better understanding and appreciation of the vulnerability of The Bahamas, and the need for adaptation options on an island-by-island basis for national planning, is realized.

5.3. SUSTAINABLE DEVELOPMENT

Some of the more often used definitions of sustainable development in the modern context include:

> "…meets the needs and aspirations of the present generation without compromising the ability of future generations to meet their own needs."
>
> "…a process, which enables all people to realize their potential and to improve their quality of life in ways which protect and enhance the Earth's life support systems."
>
> "………improves the quality of human life while living within the carrying capacity of supporting ecosystems."

Sustainable development, as a concept of national development, has only become fashionable in recent times. The practice of providing for the sustainable use of natural resources however, is not foreign to Bahamians. Living close to sea level, at the mercy of nature and dependent on its abundant resources for survival, led our immediate ancestors, and the Amerindians that preceded them, to make use of the natural resources for basic survival. The stockpiling of "hurricane ham", as it was locally called, and dried conch (*Strombus gigas*), as food reserves at the start of the hurricane season, was a traditional survival tool. Scattered across hundreds of islands of the archipelago over the past centuries, the inhabitants also learned to depend on each other in times of need.

Two critical elements of sustainable development are already enshrined in national legislation, and in actions taken in the absence of a firm scientific basis, thus employing nationally "the precautionary principle", a key feature of the UNFCCC. These elements involved the creation of a national marine park in 1958 (the Exuma Land and Sea Park) along with the creation of the Bahamas

National Trust. The trust is a non-governmental organization, established by Act of Parliament. Since that time, eleven other national parks have been established, but the system is as yet far from completely representative of the ecosystems of The Bahamas. These The Bahamas commitment to environmental conservation and preservation.

Recent developments, and further refinement of the government's national policy on sustainable development, have yet to be fully defined in a single national policy document. Elements of policy, as it relates to a national biodiversity strategy and action plan, exist in response to the reporting requirements under the Convention on Biological Diversity. More recently, the Governor-General, senior officials and public servants, have enunciated elements of government policy direction in various speeches and presentations. For example, at the beginning of the each new session of parliament, the Governor-General delivers the "Speech from the Throne", written by the government to outline its achievements over the previous parliamentary session, and to detail its legislative programme for the coming session. Further, the Prime Minister has made a number of statements relating to environmental issues, including sustainable development, in a series of national addresses made on matters on which members of the public have expressed concern (Ingraham, 2000a, b).

Additionally, in a speech to the Third US Coral Reef Task Force Meeting held in St. Croix in the US Virgin Islands in November 1999, the Ambassador for the Environment noted that natural resources and environmental protection are inextricable linked in The Bahamas (Deveaux, 1999). The content of a large portion of these speeches and public addresses are not within the purview of this report, but new elements of a national sustainable development policy can be identified and cover theelements presented in Box 5.3.1 on the following page.

Photography: courtesy Philip Weech

Box 5.3.1 Elements of a national policy towards sustainable development.

Box 5.3.1(a)

MEASURES TO PRESERVE THE MARINE ENVIRONMENT.

“The Bahamas has long recognized the need of conservation and preservation”

“Natural resources and environmental protection are inextricable linked in The Bahamas and that the Government recognizes that future social and economic development of the country depends on responsible economic exploitation of natural and manmade resources.”

“The Bahamas has taken significant steps to protect its marine environment. The country is the first to prohibit fishing for the Nassau grouper (spp name) the spawning aggregation and will expand the prohibition to other aggregations. A management plan for the queen conch (Strombus gigas) fishery is being developed based on a recently concluded three-year study. A national creek and wetlands restoration programme has been launched to ensure that the creek and wetlands make the critically vital contribution to replenishing the oceans and reefs”

Speech given at the Third US Coral Reef Task Force Meeting in St. Croix, USVirgin Islands in November 1999 by Ambassador for the Environment, Dr. Earl Deveaux (Deveaux 1999)

During the past decade there has been a growing interest in marine fishery reserves as an alternative management approach for protecting the marine environment. Government accepts that marine parks hold significant potential for protecting diverse and integrated ecosystems, keystone species, research and monitoring sites, for the protection of spawning stocks, and for providing a basis for recruitment of species to wider areas. Further, government accepts that the marine environment provides the most significant potential for improving the well-being of the Bahamian people, including tourism development and fisheries, as well be the development of pharmaceuticals from marine resources. As a consequence, government has agreed as national policy objectives:

- That as much as 20% of the shallow water habitats of Bahamian marine resources will be included as no-take zones. In 1999, Government created the first of five "no-take" fishing zones throughout the country to serve as buffers to over fishing in The Bahamas.
- Government, in advanced discussions with the Bahamas National Trust, plans to develop a Marine Park at Clifton Bay, New Providence. This park will include a no-take replenishment zone, but would not interfere with traditional use of the area by boaters, snorkellers, and line-fishermen.
- Government has agreed to establish a network of marine protected areas throughout the country based on research conducted by The Bahamas National Trust.
- Government proposes to establish other parks in the country including:
- several Cays near Andros and New Providence would be purchased and included in the parks system,
- A marine park at Walker’s Cay, Abaco,
- The expansion of the Exuma Land and Sea Park, and
- Several community parks on New Providence and Grand Bahama.

MEASURES TO REDUCE THE VULNERABILITY OF HUMAN SETTLEMENTS AND INFRASTRUCTURE.

Proposal to introduce a new Town Planning Act to:

- Provide for the preparation and adoption of a land-use plan for New Providence,
- Facilitate public participation in planning and land-use matters,
- Formalize the types of projects requiring Environmental Impact Studies,
- Extend the boundary of the Historic Nassau District, and
- Designate Historic Districts in the Family Islands.

The Act will also include stronger provisions for prosecutions and increased fines for those guilty of illegal land-use and unauthorized building activities. Town Planning Regulations under the Act will set standards for land use, building heights, setbacks, density and parking among other things for New Providence and the Family Islands.

Box 5.3.1(b)

MEASURES TO PRESERVE THE PHYSICAL LANDSCAPE.
Government recently enacted the "Conservation and Protection of the Physical Landscape of The Bahamas Act (1997)" and regulations that created a list of protected trees and provided for improved regulation of the cutting or excavation of hills for fill, and for the indiscriminate land clearing of virgin vegetation for development

MEASURES TO BUILD CAPACITY
"a significant response by the Government towards meeting the stated goal and objective to protect and conserve the environment was the establishment of the BEST Commission in 1994 and the appointment of an Ambassador for the Environment in 1995."
Prime Minister Hubert A. Ingraham

The BEST Commission serves as:

- The primary Government agency for creating framework strategies for sustainable development,
- The implementing agency for the environmental impact assessment process, (a requirement for all major development proposals)
- The coordination of international assistance for developing model policies on conservation and preservation, and
- The development of data banks of information on the environment.

The Bahamas has received significant assistance from international organizations as follows:

In Climate Change
UNEP for the Caribbean Planning for Adaptation to Climate Change (CPACC) project, designed to improve the data available on the likely impacts of Climate Change. The project was also substantially supported by the Organization of American States (OAS) and will contribute information critically important to the protection of The Bahamas coastlines. The Bahamas is also involved in coral reef monitoring, another component of CPACC activities.

In Environmental Impact Assessment (EIA)
The BEST Commission received technical advice under an OAS consultancy on the development of a legislative basis for Environmental Impact Assessment (EIA) studies.

In Biodiversity
The Bahamas National Biodiversity Strategy combines two of three major projects funded by the United Nations over the past four years through a grant from the Global Environmental Facility. The Biodiversity Strategy recognizes that The Bahamas comprises several distinct ecological regions and recommends integrated bioregional planning and management through the development of partnerships among central and local government and the people of each region. The Bahamas was selected to participate in several international programmes including a National Biodiversity Data Management project.

5.4 MEASURES TO RESPOND TO CLIMATE CHANGE

5.4.1 Introduction

The options available to the Bahamas in the formulation of policy and measures to respond to climate change are very limited. These limits are not unique to The Bahamas but mirror concerns raised by many small island developing states. It is clear however that the future for small island states will be made more uncertain because of:

- Small size and economies,
- The natural resource base, while possessing a high biodiversity, is often poor in fossil fuel resources,
- The lack of indigenous capacity, science and technology, and dependence on imports of virtually all goods and services,
- High dependence on technology importation in the key sectors of the economy, such as transport, water production, etc.,
- Susceptibility to free market forces with the risk of marginalization due to small size, and
- Lack of any real adaptation options, other than abandonment, retreat, or accommodation to climate change.

What is certain is that The Bahamas will suffer frequent disruptions in its main economic activities as a result of climate change, climatic variability and the projected increase in the numbers, frequency and intensity of tropical and non-tropical processes. Multiple stresses will become the order of the day, as the impact of natural disasters will be felt throughout the economy and the society as health, human settlement and well-being are impacted. In essence, the vulnerability of the Bahamas to the adverse effects of global climate change processes will increase.

The initial assessment of the vulnerability of The Bahamas to climate change and the future of the Bahamas in the global marketplace presents a rather bleak future. It is anticipated that:

- Fuel imports and GHG emissions will continue to increase as population grows and the demand for basic services as a result of, and in response to, climate change.
- There will be increased dependence on imported technologies for water production (by reverse osmosis and desalination), which are energy intensive.
- There will be increased flows of foreign reserves to pay for the fossil fuels and the technology needed to provide the essential services of water and power.
- Growth in the demand for electricity in order to cope with heat stress will continue.
- Health impacts from heat related stresses will increase, and there will be the possibility of negative effects from tropical diseases, such as dengue, and the threat of other tropical diseases spawned or encouraged by poverty and a low standard of health in neighboring states.
- More frequent disruptions and damage to infrastructure and human settlements from hurricanes and storm surges will occur.
- Costs of providing insurance and costs for rebuilding damaged property and facilities will increase.
- Land degradation (including salinization), loss of coastal zones, and increase in the area subjected to frequent flooding, will occur. In addition there will be a loss of freshwater resources, increase in the areas subject to inundation by storm surges, and greater climatic variability.

5.4.2 Policies and measures for reductions of GHG emissions

The Bahamas does not represent a significant source of GHG emissions and, as such any effort to reduce or mitigate GHG emissions will have only a minor impact globally. However, in the context of The Bahamas's competitiveness in its service-based economy and in the tourism sector, and the need to reduce the drain of foreign reserves used to import fossil fuels for the energy and transportation sectors, policies and measures can have a meaningful impact. Additionally, the possible health benefits of reducing emissions that impact human health and well-being are beneficial side effects of actions being taken to reduce emissions.

5.4.2.1 Energy and local transport

An increasing population, and the archipelagic nature of the Bahamas, will make it increasingly difficult to meet the energy needs of the country. The importation of fuel for electricity generation and for local transportation, are expected to increase over time, driving up emissions if measures are not taken to reverse or slow this trend. Currently, the bunker "C" and other heavy fuel oils used for power generation in The Bahamas are responsible for large quantities of greenhouse gas emissions. The available policy options considered at this initial stage focus on the primary source of GHG emissions identified in the inventory analysis in Chapter 2. The possible options include, but are not limited to, the measures summarized in Box 5.4.1. These options represent an initial assessment and no attempt has been made to prioritize or to cost measures presented.

Box 5.4.2.1 Possible options for reductions in greenhouse gas emissions in the energy generation and local transport sectors.

Box 5.4.2.1(a)

Sector: Power consumption and use

Possible measures

Increasing power plant efficiency

Comments

An option is not to generate electricity locally at all but to explore the feasibility of importing electricity from Florida via submarine cables. Combining this approach with the use of electric vehicles would greatly reduce greenhouse gas emissions in the country.

BEC should explore the viability of using solar energy to meet its internal electricity consumption needs. The Big Pond Administration Complex, for example, can be transformed into a state-of-the-art "green" compound with solar heating and solar electricity generation, "Petlier Effect" cooling systems, "smart" lighting systems, etc.

The implementation of tariffs for commercial users needs to be explored. Large consumers should be encouraged to improve their power factor by the offer of discounted rates.

Possible measures

Change type(s) of lighting

Comments

Reduce or eliminate the duty on energy friendly consumer products, such as fluorescent lightning and low wattage cooling systems, so that the demand for energy is reduced.

Possible measures

Use of cleaner fuel(s) that are less carbon intensive.

Comments

The Bahamas Electricity Corporation generates electricity from the burning of heavy fuel oil and diesel fuel. By moving to a cleaner fuel, such as compressed natural gas (CNG), the Corporation could greatly reduce its greenhouse gas emissions.

Possible measures

Investigate the use of alternate technologies for power generation

Comments

Ocean thermal energy conversion (OTEC), wind farms, solar cells, ocean turbines, etc. need to be considered.

Box 5.4.2.1(b)

Sector: Power generation

Possible measures
Demand-side power management

Comments
Bahamas has endorsed the Caribbean Renewable Energy Programme.

Possible measures
Encourage use of insulation to lower cooling needs and solar tinting of windows to reduce heat build up

Possible measures
Reduce consumers demand for power, or encourage off peak consumption

Comments
Use of solar heating and power generation

Possible measures
Target growth in solar systems for heating solar hot water systems, and

Comments
Most homes in the country use electric water heaters. However The Bahamas is blessed with an average of over seven hours of sunshine per day, year round. This energy can be used to generate power for street lighting as well as for water heating purposes in both homes and businesses.

Possible measures
Power generation in rural areas
National “Energy Star” system to reduce standby power requirements of electrical systems.

Box 5.4.2.1(c)

Sector: Local transport

Possible measures
Investigate use of cleaner fuels e.g. compressed natural gas (CNG)

Comments
Gasoline powered vehicles currently in use could be replaced with electric vehicles. The larger diesel powered vehicles could be replaced with vehicles that operate on CNG, and that use ultra-capacitors or flywheel technology

Possible measures
Encourage phase out of low mpg vehicles

Comments
Target older less efficient vehicles; encourage car-pooling.

Possible measures
Encourage early adoption of hybrid vehicles

Comments
Electric automobiles (EVs) and hybrid vehicles (HVs): hybrid and electric vehicles currently cost between US$ 25,000-$40.000 and current custom duty on these vehicles is in excess of 70% of the vehicle’s cost. To encourage the use of these vehicles in the Bahamas, this duty should be eliminated.

Possible measures
Improvements to mass transit to discourage the use of private passenger vehicles.

Government has a responsibility to its citizens to ensure sustainable development and the sustainable use of its resources while preserving the economic base and international competitiveness. In the energy sector, the strategic use of punitive measures, usually in the form of taxation (in The Bahamas in the form of custom duties) can help to achieve this objective. By making environmentally friendly products exempt from customs duty, and by increasing the duty on environmentally hostile products, government can encourage the introduction and adoption of sustainable products and practices. In the energy sector several options are available namely:

- **National Energy Standards Commission**. Government can encourage sustainable development by enacting legislation to ensure that standards in the energy sector are implemented and enforced. Standardization helps to eliminate the waste of energy, improve efficiency and reduce costs. The funding and expertise required to start this standardization process, should be sought from the developed world.

- **The Power Generation Sector.** There are a number of steps that The Bahamas can take to assist in minimizing the increasing demand for energy in the country and reduce the negative effects associated with generating electricity in the Bahamas. The use of alternate fuels, improved sector efficiency, the use of “renewable” energy and the review of other power generation options represent possible approaches.

- **National Energy Policy.** The use of fossil fuels is a major drain on the foreign exchange reserves of the Bahamas. The formulation of a National Energy Policy, with the objectives of reducing the loss of foreign exchange earnings, reducing GHG emissions, improving efficiency, the adoption of renewable technologies and the reducing energy costs, should be considered.

5.4.2.2 International transport

The Bahamas as the third largest international ship register also requires review. An improvement in GHG reduction in the international bunkering and shipping sectors would have global benefits. Programmes to effect measures that will at least contribute to addressing climate change and its adverse impacts, including the abatement of increase in greenhouse gas emissions and enhancement of removals by sinks, should be considered.

Photography: courtesy Philip Weech

5.4.3 Carbon sequestration

The word "sequestration" has many meanings, including those of separation, putting away in a place of concealment or confinement. "Carbon sequestration" has come to mean the act of putting away carbon in "places of confinement", in the form of plant tissues by photosynthesis, or by chemical processes such as conversion to carbonates. The term "carbon sinks" is often used to refer to these "places of confinement". The processes are also referred to as "carbon fixation."

5.4.3.1 Marine sequestration

Both globally and in The Bahamas, carbon sequestration occurs naturally through several well-documented processes. In The Bahamas only two of these processes have the possibility of enhancement by the actions of man. Firstly, there are the natural marine processes that have functioned from distant geological time and involve both chemical and biochemical reactions. Secondly, there is the fixing CO2 by photosynthesis, primarily of forests. The scientific basis for quantifying the benefits of the latter is fairly well documented, but that for quantifying marine processes is less well documented.

As pointed out in Chapter 1, The Bahamas is an archipelago of some 700 islands, covering 100,000 square miles (260,000 km^2) of ocean. Extensive shallow water banks dominate these waters. The land area of The Bahamas totals approximately 5,382 square miles (13,778 km^2). Of this area, mangroves forests account for an estimated 690 km^2. The national inventory identified sources and sinks of GHGs, utilizing the IPCC 1996 guidelines. This exercise, by design, did not consider carbon sinks that have moderated climate over geological time frames and in the context of a small island states make them unique features of the biosphere.

The growth and expansion of coral reefs, the natural precipitation of carbon dioxide to produce oolitic sands, the growth of calcareous algae producing lime and aragonite mud and sand, and other biological and chemical processes have, in geological time kept pace with sea level rise. The oolitic sands and aragonite are almost pure calcium carbonate. Data are not readily available on the magnitude of these processes. There is uncertainty as to the rates and importance on a global scale, but it is clear that these processes play, and will continue to play, an important role in adaptation strategies in the context of a small island state. An attempt was made however to quantify one element of these processes where scientific data exist. The growth of calcareous algae, and the production of carbonate sands and muds, has been considered, along with an estimate of the total carbon sink potential in the Bahamas. The uncertainty of this estimate is high, and all carbon sources are assumed to be atmospheric. The results have been extrapolated across the shallow banks of The Bahamas. Geologists have described these as a “vast carbonate bucket” that has operated over geological time undisturbed by the accelerated rates of CO_2 emissions attributed to the activities of mankind. Rates of sediment production have kept pace with changes in sea level, and the geological evidence indicates that the “bucket”, operating undisturbed, has seen sediment levels constantly rising and overflowing into the deep-water canyons and oceans surrounding the Bahamas. Far more sediment is produced in the “bucket” or within the area of the banks (estimated at 100 times) than along the coastal margins or coral reef zones.

These extensive shallow marine areas sequester carbon dioxide through chemical, mechanical and biological processes. The marine flora, comprising communities of turtle grass and other calcareous green algae have in geological time resulted in the upward growth of the Bahamian platforms. Studies have demonstrated that the shallow marine flora of calcareous algae in the Bight of Abaco have contributed to a two-meter thick sediment carpet of calcareous muddy sands, accumulating at a rate of some 120mm per 1000 years. Calcareous green algae have produced some 1.5 to 3 times the mass of carbonate sands and muds in a year according to studies (Neumann and Land, 1975). An estimated 370 to 739 kg CO_2 per year is or sequestered over a 2,770 km^2 area of the shallow marine banks around Abaco. This equates to a carbon sequestration of some 121,968 to 243,930 Gigagrams (Gg) CO_2 over the shallow water banks of The Bahamas. Not considered are the other chemical, mechanical and biological processes that are at work.

Unfortunately, the scientific basis to enhance the functions of the marine processes is not well understood, and the uncertainty of the potential benefits globally is high. It is clear however that efforts to protect coral reefs, while at the same time reducing GHG emissions, will have the added benefit of reducing stresses on the marine systems and on the process that work to sequester carbon in marine systems.

5.4.3.2 Forestry

The pine forests of The Bahamas have been studied and their environmental benefits documented in work that formed part of the Bahamas Land Resources Survey (Little et al. date). Chapter 2 includes, as part of the national GHG inventory of The Bahamas, an estimate of the carbon removal by the forests of the Bahamas. Protection of Bahamian forests by activities that reduces stresses from fires, and legislation providing for the setting aside of forests as conservation, managed and preservation areas, have the potential for enhancing the service that forests provide as sinks for carbon dioxide.

The need to develop a modern management regime for all forests in The Bahamas has been documented and a Forestry Act developed by the Department of Lands and Surveys, the agency responsible for the management of forests in The Bahamas. Box 4.5.1 below presents some of more important features of the proposed Forestry Act. The broader definition of forest includes pine, coppice (or hardwood), and mangrove areas. These have all been considered in the draft Act, as well as the need to provide means for fire management in forested areas both government owned and on private land holdings. Additionally, government policy to set aside 20 % of coastal and marine areas including pine forests, mangroves and coppice forests, and the establishment of a National Creeks and Wetlands Restoration Initiative, will serve to enhance the carbon sequestering functions of forests in The Bahamas.

Box 5.4.1 The intent and major provisions of the proposed Forestry Act.

Intent

The object is to provide a legal framework for the long-term management of forests in The Bahamas, through the establishment of a governmental forestry agency, and a permanent forest estate subject to scientific management and the licensing of timber-cutting activities.

Categories of forest

Provision is made for three categories of forest on Crown lands: forest reserves, protected forests and conservation forests.

- Forests reserves are areas of Crown land designated for permanent inclusion in the forest estate. They make up the majority of the land to be designated under the legislation. In order to protect the integrity forest reserve they may only be declared, modified or abolished by Act of Parliament.
- Protected forests are, similarly, areas of Crown land managed under the same regime as forest reserves but which may at some later time be subject to other land uses (e.g., agriculture, tourism, industrial or residential). Protected forests may be declared or their boundaries modified by Ministerial Order.
- Conservation forests are areas set aside for the conservation of bird, animal and plant communities. Designation as a conservation forest would not prohibit all activities but would prohibit certain activities at certain times. Conservation forests may only be declared, modified or abolished by Act of Parliament.

Institutions

The Chief Forest Officer, subject to the directions of the Minister responsible for forestry, has overall responsibility for:

- The administration of the legislation, and for the management and development of forests.
- The taking of forest inventories, conducting research, and collecting information on forest resources.
- The preparation and submission to the Minister of a national forest plan every ten years, which will serve as a basis for the national forestry activities during that period.
- A forest management plan for each area designated under the legislation, describing the area and the objectives of the management plan.

Licensing
Legislation would authorize the issue of leases, licenses and permits authorizing types of activity within forest reserves, protected forests and conservation forests. The Chief Forest Officer would assist owners of private forest lands in planting, cutting, forest management and valuation, charging them a reasonable sum for these services. In addition, private forest owners who intend to utilize their forests commercially would be required to submit a forest management plan for scrutiny by the Chief Forest Officer. The legislation would enable authorized officers to inspect and seize goods and to prosecute offenders. It would be an offence for a person to cut trees, clear land, set fire or hunt in any forest reserve, protected forest or conservation forest without a lease, license or permit issued under the legislation. Repeat offenders would be subject to double penalties and any person taking or destroying trees or other forest products would be required to pay compensation in addition to any fine imposed.

The Bahamas has also drafted new legislation intended to provide for modern management of the water sector through a new Water and Sewerage Corporation Act. The proposed Act will work co-operatively with the Forestry Act and the National Creeks and Wetlands Restoration Initiative to protect ecosystems that provide services in forestry, wetlands and water resources conservation. Regulations restricting activities such as dredging (and the resulting destruction of freshwater lenses), the creation of marinas in areas of freshwater lens, all impact negatively on forests, wetlands and water resources are proposed.

5.4.4 Financial implications

There is a need to provide adequate financial resources directed at public awareness, education, training and development, that is critical to the successful implementation of any policy and measures in the energy, forest, water, transport sectors.

Several of the measures proposed will initially impact negatively on government sources of revenue from the energy sector, or on the tax revenue from these sectors through concessions in customs duty, for example on vehicle conversions. Additionally, many of the technologies proposed for consideration have yet to prove their environmental benefits. High capital cost, research and development needs, and the economies of scale all need to be studied and tested in the context of a small island developing state.

External financial resources will be required in order to undertake the required cost:benefit analyses, and the pre-feasibility and socio-economic impact analyses. Conservative estimates indicate that, if the proposed enhancement of sinks by the adoption of modern forestry and water resource management practices were implemented nationally, some US$5 to 10 million would be required initially, and some US$2 to 3 million annually a five to ten year period. No estimates have yet been made to cost the conversions required in the energy and transport sectors.

CHAPTER 6

RECOMMENDATIONS

This final chapter presents recommendations for future actions that are considered necessary for The Bahamas to adequately meet the challenges of climate changes and sea level rise. A list of research and information needs has already been given at Section 3.6, and Box. 2.1 in Chapter 2 lists a number of the constraints encountered in the inventory process. The recommendations that follow inevitably overlap: capacity building, for example, is not an end in itself but must relate to particular disciplines and topics.

6.1 CAPACITY BUILDING

Building of national capacity in all the areas and disciplines relevant to climate change is essential if The Bahamas is to adequately manage the challenge of climate change. Box 5.2.1 in Chapter 5 partially addresses this topic. Training at the tertiary level in a number of relevant disciplines will be necessary and the disciplines needed include, meteorology, oceanography, hydrology, fisheries, marine and terrestrial ecology, database management, natural resource economics, and policy formulation. Recommendations include:

- A national system for the management of environmental and climate change databases and information systems be established, including strengthening of the Bahamas National Geographic Information System Centre (BNGISC).
- The undertaking of an inventory and economic valuation of coastal resources, including risk assessments of all coastal zones, including settlements.
- Formulation of policy and legislation for integrated coastal zone and marine (ICZM) management.
- Training in methodologies for the preparation of greenhouse gases (GHG) inventories.
- Training in the conduct of vulnerability and adaptation assessment.
- The coordination of international assistance in the area of management of climate change.

6.2 DATA COLLECTION AND MONITORING

As pointed out in Box 2.1, much of the available data were not in the format required for input into the IPCC Spreadsheet. Recommendations include:

- Formulation of guidelines, in consultation with government's data collection agencies, to ensure the compatibility of data with the reporting requirements of all international organizations, including the UNFCCC.
- That, where necessary, additional data requirements be incorporated into survey and data collection instruments on a periodic basis, to meet reporting deadlines set by international organizations.
- That a national repository and system for the collection, storage, archiving and retrieval, of census and survey data, be established.
- That a system be established for the monitoring on changes in land use, in order to provide reliable data for future national inventories.

6.3 METEOROLOGY AND OCEANIC OBSERVATIONS

It has been pointed out that additional recording stations are considered necessary in The Bahamas to adequately monitor climate change. Recommendations include:

- Establishment of additional sea level monitoring stations at selected sites.
- Establishment of wave recorders at selected sites.
- Establishment of a system of UV-B bio-meters to assess the likely impacts of UV radiation on human health.
- Expansion and upgrading of the meteorological and hydrological monitoring system in The Bahamas to provide fuller coverage.
- Application of the Sea Lake and Overland Surges from Hurricanes (SLOSH) computer model to all islands of The Bahamas, to provide maps for various scenarios.

6.4 SCIENTIFIC RESEARCH, MONITORING AND DATA COLLECTION

Scientific research and reviews of literature, establishment of baselines, and monitoring, is required for several areas. The following identifies eight areas, but the list is not necessarily comprehensive. Recommendations include:

6.4.1 Coral reefs

- Monitoring of coral reef monitoring for the impacts of climate change (this is underway under the CPACC Project) but needs to be expanded.
- Expansion of marine fishery reserves as an approach for protecting the marine environment, and as a means of conserving fish stocks.
- Studies of the role of coral reefs and calcareous algae in sequestering carbon dioxide.
- Studies of the role of carbonate deposition in sequestering carbon dioxide.

6.4.2 Fisheries

- Assessment of the impact of increasing sea surface temperatures on important fish species.
- Assessment of the impact of changes in flow and direction of the Gulf Stream, on migratory species of fish and marine mammals.

6.4.3 Forests

- Assessment of the effects of salinization of the soil, and rising water tables, the growth and biodiversity of pine and coppice forests.
- Assess the effects of salinization of the soil, of inundation and rising sea levels, on coastal and inland mangrove communities, and monitor changes in the biodiversity of these communities.

6.4.4 Agriculture

- Assessment the vulnerability of the sector to soil salinization, loss of agricultural lands to inundation, and to periodic salt-water flooding.
- Development and economic evaluation of agricultural production systems adapted to soil salinization, to atmospheric CO_2 enrichment and increased temperatures.

6.4.5 Geographic information systems

- Utilization of the BNGISC as the repository for all digitized data sets for spatial data in The Bahamas, including bathymetric and land contour data, to facilitate the modeling of storm waves and surges and movement of sand bodies in shallow marine waters.

6.4.6 Health

- Epidemiological monitoring of human diseases that may increase in frequency in The Bahamas as a result of climate change.
- Assessment of the likely effects of heat and humidity stress on the human population.

6.4.7 Public works

- Identification, based on GIS data and maps, those public facilities (docks, piers, coastal roads, and buildings) at risk of damage from storm surges, inundation and inland flooding, and develop strategies to minimize vulnerability.

6.4.8 Water resources and supply

- A systematic programme of water quality monitoring for fresh, saline and hyper-saline waters, in order to assess their vulnerability to sea level rise.
- Development of long-term national water resources plans for the entire Bahamas.
- Identification of water resources at risk from inundation, sea level rise and flooding from extreme events.

6.5 ECONOMICS

Economic evaluations and impact assessments, cost: benefit studies, sensitivity analysis, and economic modeling of options, will be of great importance in guiding decision making.

Recommendations include:

- An economic impact assessment of the tourism sector for various scenarios of climate change and sea level rise in The Bahamas.

  An economic impact assessment of the property insurance implications of climate change and sea level rise in The Bahamas.
- An economic impact assessment of the implications for the commercial sector of climate change and sea level rise in The Bahamas.
- An economic analysis of the options for generation of electrical power including, but not limited to, solar cells, ocean thermal energy conversion, wind farms and ocean turbines. .
- An economic analysis of the cost implications of switching to “cleaner” fossil fuels for generation of electricity. See also Box 5.4.1.
- An economic analysis of the options for alternative power sources for motor vehicles, including those used for public transport and the revenue implications.

6.6 LEGISLATION

Legislation is critical to the management of climate change and all its implications.

Recommendations include:

- Enactment of the proposed Forestry Act to provide for effective management of the national forest, the conservation of natural resources, and the possible enhancement of the forests carbon sequestering function.
- Enactment of the revised Water and Sewerage Corporation Act, which would provide protection for freshwater resources, and for forests and wetlands.
- Enactment of a new Town Planning Act to, inter alia, provide for the adoption of a land-use plan for New Providence, facilitate public participation in land-use matters, and formalize the types of projects requiring environmental impact studies.
- Enact legislation, comparable to the above, to control development in the Family Islands.

6.7 CLIMATE CHANGE AWARENESS

Public awareness of the reality and consequences of climate change, and particularly, given the vulnerability of The Bahamas, is essential. The CPACC and “Enabling Project” have raised the awareness of the many in the public service and in the public (business) sector. Awareness is needed among the public at large.

Recommendations include:

- The holding of town meetings and other public fora throughout The Bahamas to educate the public as to the vulnerability, time scale, and options for adaptation.
- To use the print, radio and television media to increase public awareness, and ensure public input into the decision making process.

6.8 COLLABORATION

The Bahamas is presently participating in the CPACC Project, and in the Feasibility Study on the Prediction and Amelioration of Socio-Economic Impacts of the El Nino Southern Oscillation (ENSO) in Latin America and the Caribbean. There is also the GEF-funded “Enabling Project”. It is recommended that such regional collaboration continue.

DEFINITIONS AND ABBREVIATIONS

CARICOM: Caribbean Community. CARICOM is essentially two organizations in one. The Community deals with functional matters of regional cooperation while the Common Market is the economic branch. The members are Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, Montserrat, St Lucia, St Kitts and Nevis, St Vincent and the Grenadines, Suriname, Trinidad and Tobago The Bahamas is not a member of the Common Market. Haiti is expected to become a member in July 2001. Anguilla, the British Virgin Islands, and Turks and Caicos, are associate members.

Commonage land: Land held in common by the inhabitants of the Family Islands who were born there. These lands were originally granted to commoners of the islands for services rendered the Crown. Until recently, such lands were used exclusively for farming but are now used for residential purposes.

CPACC: Caribbean Planning for Adaptation to Climate Change.

El Nino: A warm current that periodically flows along the western coast of South America, usually forming around December or January. It results in temporary reversals of airflows and surface ocean currents in the equatorial Pacific ocean, abnormal warming of surface waters of the coast of Peru, leading to disturbances of global weather patterns.

GHGs: Greenhouse gases: those gases capable of absorbing terrestrial radiation and therefore responsible for the greenhouse effect. The main greenhouse gases are water vapour, carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O) and the wholly anthropogenic chlorofluorocarbons (CFCs).

Family Islands: The major populated islands other than New Providence and Grand Bahama. These are Abaco, Acklins, the Berry Islands, the Bimini Islands, Cat Island, Crooked Island, Eleuthera, the Exuma Islands and Cays, Great Inagua, Long Island, Mayaguana, Rum Cay and San Salvador

Ghyben-Hertzberg Lenses: Freshwater lenses in oceanic islands that are made up of three layers: an upper layer of drinkable (potable) water, a transition layer, in which salinity increases downward, and a saline layer in which salinity increases rapidly downwards. Water is ideally abstracted only from the upper layer, but over-pumping can to the intrusion of saline water. Freshwater moves outwards from the centre of the lenses towards the ocean and this flow carries away salt water that might otherwise enter and spoil the lens.

IPCC: Intergovernmental Panel on Climate Change.

New Providence/Nassau/Paradise Island: Nassau is often used synonymously with New Providence. Nassau is the capital city of The Bahamas, and New Providence is the island on which Nassau is located. Paradise Island, formally Hog Island, is located a few hundred yards north of New Providence and is separate from, but linked by two bridges to, New Providence. Paradise Island is a major tourist area. The sea between New Providence and Paradise Island forms Nassau Harbour.

OAS: Organization of American States. Comprises thirty-four member states in the Americas and the Caribbean.

Saffir-Simpson Scale: Based on wind speeds, the scale is designed to show the level of damage that can be expected from hurricanes. There are five categories which range from category 1 (wind speed 74 to 95 mph, damage minimal) to category 5 (winds in excess of 156 mph and damage catastrophic.

SIDS: Small Island Developing State(s).

Units of measurement: Units of length used in this communication are inches (in), feet (ft) and miles (mi), along with the metric equivalents of metre (m) and kilometer (km).
Units of area used are square miles (mi^2) and square kilometers (km^2).
Wind speeds are in knots (kt), which are nautical miles per hour.
Conversion factors used are: 1 in = 25.4 mm; 1 ft = 0.348 m; 1 mi = 1.61 km; 1 mi^2 = 2.59 km^2.
Temperatures are given in degrees Fahrenheit (^oF) and in degrees Centigrade (^oC).

ANNEX 1

NATIONAL CLIMATE CHANGE COMMITTEE

In order to coordinate The Bahamas' national response to the issue of climate change at the local, national, regional and international levels, and to provide a mechanism for responding to its obligations under Articles 4 and 12 of the UNFCCC, the National Climate Change Committee (NCCC) was established as a sub-committee of The Bahamas Environment, Science and Technology (BEST) Commission, Office of the Prime Minister.

The Ambassador for the Environment serves as an ex-officio member of the NCCC. Other members of the committee are appointed by the BEST Commission, and comprise senior public servants, public and private sector policy advisors, and representatives of non-governmental organizations. The NCCC Chairman is on the Board of Directors of the BEST Commission, to ensure coordination of the committee's work with national governmental policies.

The first meeting of the NCCC was convened on March 6, 1996. The committee has met frequently since its inception and organized a national workshop in 1998 to increase public awareness of climate change. Committee membership has remained consistent during the four years of operation. The following is a list of Committee Members:

- Mr. Philip S. Weech, Senior Hydrologist, Water and Sewerage Corporation (Chairperson).
- Mr. Arthur W. Rolle, Deputy Director, Department of Meteorology (Deputy Chairperson).
- Mr. David L. Cates, Deputy Permanent Secretary, Ministry of Foreign Affairs (Secretary).
- Mr. Michael Braynen, Director of Fisheries, Ministry of Agriculture and Fisheries (1997-present).
- H.E. Earl Deveaux, M.P., Ambassador for the Environment and Chairperson of the BEST Commission (2000-2001).
- Dr. John Hammerton, BEST Commission (1998-2000).
- Mr. Patrick Hanna, Bahamas Electricity Corporation.
- Mr. Colin Higgs, Director of Fisheries, Ministry of Agriculture and Fisheries (1996-1997).
- H. E. Lynn Holowesko, Ambassador for the Environment, and Chairperson of the BEST Commission (1996-1999).
- Mr. Lambert Knowles, Bahamas Association of Professional Engineers and George V. Cox and Associates.
- Mr. Reginald Lobosky, President, Bahamas Chamber of Commerce (1995-1997).
- Mr. Neil McKinney, President, Bahamas Chamber of Commerce (1997-1999).
- Mr. Dwight King, Ministry of Public Works.
- Ms. Melanie Roach, Director, Department of Public Works.
- Mr. Bismark Coakley, President, Bahamas Chamber of Commerce (1999-present).

At the first meeting Mr. Philip Weech was elected Chairperson, Mr. Arthur Rolle was elected Vice-chairperson, and Mr. David Cates was elected Secretary. These office holders have not changed since the inception of the NCCC. Mr. Michael Braynen succeeded Mr. Colin Higgs as Director of Fisheries; Mr. Neil McKinney succeeded Mr. Reginald Lobosky as President of The Bahamas Chamber of Commerce; and Ambassador Deveaux succeeded Ambassador Holowesko as Ambassador for the Environment in January 2000, and in February 2001, the BEST Commission portfolio was transferred to the Ministry of Agriculture and Fisheries. The Minister is the Hon. James F. Knowles, M.P. The Permanent Secretary, Mr. Colin Higgs, is the Ambassador for the Environment.

National Climate Change Committee
photograph: courtesy Bahamas Information Services

Standing, left to right:
Mr. Arthur Rolle (Deputy Chairman NCCC), Mr. Patrick Hanna (AGM B.E.C.), Mrs. Nakira Gaskin-Wilchcombe (BEST), Dr. John Hammerton (FNC Editor), Mr. Michael Braynen (Director of Fisheries), Mr. Lambert Knowles (Engineer).

Seated, left to right:
Mr. Donald Cooper (US BET),Mr. James P. Bruce (Consultant GCSI), Mr. Philip S. Weech (Chairman NCC), Ambassador T. Neroni Slade (Chairman AOSIS), Dr. Davidson Hepburn (Consultant NCCC).

ANNEX 2

ACKNOWLEDGEMENTS

The National Climate Change Committee (NCCC) gratefully acknowledges the work of committee members in compiling this report, all of whom served on a voluntary basis. These persons have substantive posts in either the public service or the private sector, and preparation of this report was, therefore, outside the scope of their regular work. Their determination is indicative of the importance accorded to environmental issues in The Bahamas.

The Committee would be remiss if it did not acknowledge the work of the late Mrs. Catherine Benjamin. Although ill for a number of years, and at times confined to home, Mrs. Benjamin worked untiringly in the BEST Commission as its first coordinator. Holding the rank of Deputy Permanent Secretary, she was, in the early years of the Commission, also responsible for the relief efforts following the passage of hurricane Andrew. Mrs. Benjamin did not serve on the NCCC, but she was largely responsible for setting up the BEST Commission and its subsidiary committees.

The Committee thanks Senator, formally Ambassador, Lynn Holowesko, for her support and encouragement while Chairperson of the BEST Commission from 1994 to 2000. Senator Holowesko has a lifelong interest in environmental issues, and was twice President of The Bahamas National Trust, from 1976 to 1982 and from 1984 to 1991.

Ambassador Earl Deveaux, M.P., Chairman of the BEST Commission from January 2000 to February 2001, and a former Minister of Agriculture and Fisheries, was also very supportive of the Committee's work since his appointment.

The Hon. James F. Knowles, M.P., assumed responsibility for the BEST Commission effective February 2001, and has been, and continues to be, understanding and supportive of the work of the NCCC.

Ms. Teresa Butler, Permanent Secretary in the Office of the Prime Minister, is thanked for her constant understanding and guidance during the work of the NCCC. The staff of the BEST Commission, especially Ms. Lorca Bowe and Ms. Maria Heild, is acknowledged, especially in arranging committee meetings and circulating documents.

Thanks go to Mrs. Eleanor Philips (Department of Fisheries) and Mr. Jeff Simmons (Department of Meteorology) for undertaking the initial vulnerability and adaptation assessment, reported in Chapter 3.

Many other persons contributed to the preparation of this document, some unknowingly.

Special thanks go to:

Mr. Errol Bethel (Parliamentary Registrar) for information on the electoral process,
Mr. Timothy Bethel (Bahamas National Trust) for information on the National Parks System,
Mrs. Barbara Burrows (Acting Permanent Secretary in the Cabinet Office) for information on
hurricane damage, and facilitating the work of the NCCC,
Dr. Richard Cant (Acting General Manager, Family Island Water Environment, Water and Sewerage Corporation) for providing information and support,
Mr. Clarence Cleare (Ministry of Local Government) for information on the local government system.
Mr. David Cates (Deputy Permanent Secretary in the Ministry of Foreign Affairs, and Secretary to the NCCC) for diligently compiling the first draft of this First Communication.
Dr. John L. Hammerton (now retired but formerly a member of staff of the BEST Commission and one-time member of the NCCC) for undertaking the revision and editing of this First Communication.
Mr. Oris Russell (retired Permanent Secretary) for information on the Bahamian flora.
Mr. Carl Smith (Director of Agriculture) for information on the Bahamian flora.
Ms Patrice Williams and Ms Grace Turner (Department of Archives) for information on the history of The Bahamas.
Comptroller of Bahamas Customs, for data on imports.
Governor of the Central Bank of The Bahamas, for data on oil imports.
Director of Meteorology and staff, for provision of meteorological data and general support.
Director and staff of the Department of Statistics, for census data and data on imports,
Esso Standard Oil SA Ltd for information on oil imports.
General Manager and staff of the Bahamas Electricity Corporation for information on generating capacity and demand.
General Manager and staff of the Water and Sewerage Corporation, for facilitating the work of the NCCC in many ways.
Ministry of Foreign Affairs, for general support and for facilitating the work of the NCCC.
Shell Bahamas Ltd for information on oil imports.
Texaco Bahamas Ltd for information on oil imports.
Preparation of the Report has truly been a team effort and a capacity building activity.

ANNEX 3

LIST OF SCIENTIFIC NAMES OF MARINE AND TERRESTRIAL ANIMALS AND PLANTS REFERRED TO IN THE TEXT

Birds

- **Bahama parrot** Amazona leucocephala bahamensis
- **Bobwhite** Colinus virginianus
- **Chukar** Margarops fuscatus
- **Cuban grass-quit** Tiaris olivacea
- **Kirtland's** Warbler Dendroica kirtlandii
- **Northern mockingbird** Mimus polyglottos
- **Ring-necked pheasant** Phasianus colchicus
- **West Indian flamingo** Phoenicopterus ruber
- **Whistling duck** Dendrocygna aborea
- **White crown** pigeon Columba leucocephala

Terrestrial mammals

- **Bahama hutia** Geocapromys ingrahamii
- **Raccoon** Procyon lotor

Mark Catesby: Bahama hutia

Iguanas

Iguana Cyclura spp.
(including C. baelopha, C. carinata, C. cychlura, C. rileyi)

Scale fish of commercial importance

Amberjack Seriola dumerili
Bonefish Albula vulpes
Blue marlin Makaira nigricans
Dolphin Coryphaena hippurus
Jacks Caranx spp.
Lane snapper Lutjanus syngaris
Nassau grouper Epinephelus striatus
Sail fish Istiophorus platypterus
Swordfish Xiphias gladius
Tuna Thunnus thynnus
Wahoo Acanthocybium solanderi
White marlin Tetrapturus albidus

Other marine species of commercial importance

Spiny lobster Panuluris argus
Queen conch Strombus gigas

Turtles

Cat Island freshwater turtle Trachemys terrapenInagua
Green turtle Chelonia midas
Hawksbill turtle Eretmochelys imbricata), and
Inagua freshwater turtle Trachemys stejnegeri
Leatherback turtle Dermochelys coriacea
Loggerhead turtle Caretta caretta

Dolphins

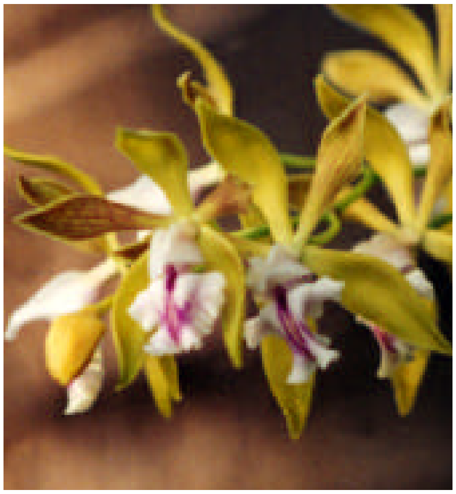
Bottlenose dolphin Tursiops truncatus
Atlantic spotted dolphin Stenella longirostris
Spinner dolphin Stenella plagiodon

Whales (migratory)

Beaked shortfin whale Globicephala macrohynchus
Humpback whale Megaptera novaeangliae
Minke whale Balaenoptera acutorostrata
Sperm whale Pyseter caodon

Sharks

Hammerhead shark Sphyrna mokarran
Tiger shark Galeocerdo cuvieri
Nurse shark Ginglymostoma cirratum
Mako shark Isurus oxyrinchus
Lemon shark Negaprion brevirostris



Photography: courtesy of Philip Weech

Native and naturalized plants

Black mangrove Avicennia germinans
Brazilian pepper tree Schinus terebinthifolius
Button wood Conocarpus erectus
Caribbean pine Pinus caribea
Casuarina Casuarina equisetifolia
Horseflesh Lysiloma sabicu
Lignum vitae Guaicum sanctum
Mahogany Swietenia mahagoni
Paper bark tree Melaleuca quinquenervia
Poison wood Metopium toxiferum
Red mangrove Rhizophora mangle
Turtle grass Thalassia sp.
White mangrove Laguncularia racemosa
Wild fig Ficus spp.
Wild tamarind Lysiloma latisiliquum

Introduced crop species

Avocado Persea americana
Beans Phaseolus spp.
Breadfruit Artocarpus communis
Cassava Manihot esculenta
Corn Zea mais

Mark Catesby: Flamingo with coral

Guava Psidium guajava
Gooseberry Phyllanthus acidus
Guinep Melicocca bijuga
Hog plums Spondias mombin
Hot pepper Capsicum spp.
Mamey Mammea americana
Mango Mangifera indica
Melon Cucumis melo
Pigeon pea Cajanus cajan
Pineapple Ananas comosus
Sapodilla Manilkara zapota
Scarlet plum Spondias purpurea
Soursop **Annona** muricata
Sweet potato Ipomoea batatas
Sugar apple Annona squamosa
Water melon Citrullus vulgaris

The West Indian Monk Seal *(Monachus tropicalis)* is now extinct, while the American crocodile *(Crocodylus acutus)*, Scarlet Ibis *(Guara rubra*) and West Indian Manatee *(Trichechus manatus)* are no longer recorded in The Bahamas. Freshwater fish of the genus Gambusia have been introduced and are found in ponds and potholes on most islands.

Reference: BEST (1995).

REFERENCES

Albury, P. 1978. *The story of The Bahamas.* London, Macmillan.

BEST. 1995. *Bahamas Biodiversity Country Study Report.* Bahamas Environment, Science and Technology Commission, Office of the Prime Minister. Nassau, Bahamas.

BEST. 1998. *National biodiversity strategy and action plan.* Bahamas Environment, Science and Technology Commission, Office of the Prime Minister. Nassau, Bahamas.

Bohlke, J.E. and C. Chaplin. 1993. *Fishes of The Bahamas and adjacent tropical waters* (2nd ed.). Austin: University of Texas Press.

Britton, N. L. and C.F. Millspaugh. 1920. *The Bahamas flora.* New York: published by the authors.

Brown, L. and J.F. Downhower. 1993. *The eyes of Andros.* Bahamas Naturalist: 7, (1), 5-10.

Brudenell-Bruce, P.G.C. 1975. *The birds of New Providence and the Bahama islands.* London: Collins.

Bryant, D., L. Burke, J.W. McManus and M. Spalding. 1998. *Reefs at risk: A map-based indicator of threats to the world's coral reefs.* Washington, DC: World Resources Institute.

Campbell, D. 1978. *The ephemeral islands.* London: Macmillan.

Cant, R.V. 1996. *Water supply and sewerage in a small island environment: The Bahamian experience.* Small Islands Marine Science and Sustainable Development Coastal and Estuarine Studies, 51, 329.

Cant, R. 1997. *Developing water supply strategies for The Bahamas.* Bahamas Journal of Science: 4, (2), 5-7.

Cant, R.V. and P.S Weech. 1986. *A review of the factors affecting the development of Ghyben-Hertzberg lenses in The Bahamas.* Journal of Hydrology: 84: 333-343.

Cant, R.V., P.S. Weech, and E.E. Hall. 1989. *Saltwater intrusion in The Bahamas: a case study of the Great Lucayan waterway, Grand Bahama, The Commonwealth of The Bahamas.* Nassau, Bahamas: unpublished report. 9 pages.

Carter, T.R. 1994. IPCC *Technical guidelines for assessing climate change impacts and adaptations.* Working Group II of the Intergovernmental Panel on Climate Change (IPCC). 59 pages.

Carew, J.L. 1997 *Rapid sea-level changes at the close of the last interglacial (substage 5e). Recorded in Bahamian Island Geology: Comment and Reply.* Geology: 25, 527.
Cates, D.L. 1998. *Alligators, Seals and Iguanas. In: The Bahamas Handbook and Businessman's Annual.* Nassau, Bahamas: Dupuch Publications. Pages 111-121.

Cates, D.L. 1997. *Mark Catesby and The Natural History of Carolina, Florida and the Bahama Islands.* Journal of The Bahamas Historical Society: 18, 2-10.

Catesby, M. undated. *Natural history of Carolina, Florida and the Bahama Islands.* Two volumes. London: Published by the Author, 1729-1747.

Central Bank. 2000a. *Central Bank of The Bahamas 1999 Annual Report.* Nassau, Bahamas: Central Bank of The Bahamas.

Central Bank. 1997. *Quarterly Statistical Digest. 6, (2).* Nassau, Bahamas: Central Bank of The Bahamas.

Cleare, C.B. 2000. *Local government profile.* Ministry of Local Government, Nassau, Bahamas: unpublished paper.

Coenen, C. 1995. *Observations on the Bahamian rock iguanas of the Exumas.* Bahamas Journal of Science: 2, (2), 8-14.

Correll. D. and H. Correll. 1982. *Flora of The Bahamas archipelago.* Germany: Gantner Verlag K-G.

Department of Agriculture and Department of Statistics. 1996. *Second census of agriculture 1994. Final Results.* Nassau, Bahamas: Department of Agriculture and Department of Statistics.

Department of Meteorology. 1977. *Rainfall of New Providence.* Nassau, Bahamas: Department of Meteorology. 57 pages.

Department of Statistics. 1998. *The Bahamas in Figures 1997.* Nassau, Bahamas: Department of Statistics.

Deveaux, E. 1999. *Sustainable use of The Bahamas' marine environment.* Address to the 3rd US Coral Reef Task Force Meeting, St. Croix, USVI, November 2-3. Unpublished.

Dupuch Publications. 2000b. *Bahamas handbook and businessman's annual 2000.* Nassau, Bahamas: Dupuch Publications.

Eneas, G. 1998. *Agriculture in The Bahamas. Its historical development 1492-1992.* Nassau, Bahamas: Media Publishing.

Fairbridge, R.W., R.N. Young, C.G.A. Harrison and M.M. Ball. 1961. *Geology of The Bahamas.* In: *The Encyclopedia of World Regional Geology Part I: Western Hemisphere.* Stoudesburg, Pennsylvania: Dowden Hutchinson and Ross: 109-114.

Foos, A. 1994. *Water Budget for Cockburn Town, San Salvador.* Bahamas Journal of Science: 2, (1), 31-35.

Gamble, D.W., M.E. Brown, D. Parnell, D. Brommer and P.G. Dixon. 2000. *Lessons learned from Hurricane Floyd damage on San Salvador.* Bahamas Journal of Science: 8, (1), 24-31.

Hearty, P.J. 1998. *Enigmatic boulders of Eleuthera: geological evidence tells of catastrophic waves in The Bahama.* In: *The Bahamas Handbook and Businessman's Annual 1998.* Nassau, Bahamas: Dupuch Publications. Pages 122-132.

Hearty, P.J. and P. Kindler. 1995. *Sea-Level highstand chronology from stable carbonate platforms (Bermuda and The Bahamas).* Journal of Coastal Research: 11, (3), 675.

Higgs, L. 1978. *Bush medicine in The Bahamas.* Nassau, Bahamas: published by the author.

Ingraham, H.1999a. *Environmental enhancement.* Broadcast address by the Prime Minister of The Bahamas, May 2. Nassau, Bahamas.

Ingraham, H. 1999b. *Reconstruction effort following hurricane Floyd.* Communication to Parliament by the Prime Minister of The Bahamas. October 13. Nassau, Bahamas.

Ingraham, H. 2000a. *Hurricane Floyd recovery efforts and hurricane Floyd tree replacement and beautification programme.* Communication to Parliament by the Prime Minister. February 23. Nassau, Bahamas.

Ingraham, H. 2000b. *Contribution on a resolution to return to Nassoak Limited 208.41 acres of land acquired by the Government in 1989 for development of a freight terminal at Clifton, New Providence.* Communication to Parliament by the Prime Minister. May 17. Nassau, Bahamas.

IPCC. 1996. *Revised IPCC guidelines for national greenhouse gas inventories.* Intergovernmental Panel on Climate Change.

Jelesnianski, C.P. 1967. *Numerical computation storm surges with bottom stress*. Monthly Weather Review, 95, 740-756.

Kindler, P. and P. Hearty. 1996. *Carbonate petrography as an indicator of climate and sea-level changes: new data from Bahamian quaternary units*. Sedimentology: 42, 381.

Little, B.G, et. al. 1971- 1976. *Land Resources of the Commonwealth of The Bahamas. Volume 1 Abaco; Volume 2 Eleuthera; Volume 3 Cat Island; Volume 4 Andros; Volume 5 Grand Bahama; Volume 6 Great Exuma, Little Exuma and Long Island; Volume 7 Crooked Island and Acklins; Volume 8 Mayaguana and Inagua.* Nassau, Bahamas.

Martin, H. and J.P. Bruce. 1999. *Effects of climate change: hydrometeorological and land-based effects in The Bahamas. Ottawa, Canada:* Global Change Strategies International, Inc.

Martin, H. and J.P. Bruce. 2000. *Effects of climate change: hydrometeorological and land-Based effects in The Bahamas: Final report. Ottawa, Canada*: Global Change Strategies International, Inc.

Ministry of Foreign Affairs. 1992. *Report of The Commonwealth of The Bahamas to the United Nations Conference on Environment and Development. Nassau, Bahamas:* Ministry of Foreign Affairs.

Ministry of Health and Ministry of Commerce, Agriculture and Industry. 2000. *National Food and Nutrition Policy and Agenda for Action. Nassau, Bahamas:* Ministry of Health and Ministry of Commerce, Agriculture and Industry. Unpublished Draft.

National Research Council. 1990. *Saline agriculture. Salt-tolerant plants for developing countries. Washington, DC: National Academy Press.*

Neumann, A.C. and P.J. Hearty. 1996. *Rapid sea-level changes at the close of the last inter-glacial (substage 5e) recorded in Bahamian island geology.* Geology: 24, (9), 775.

Neumann, AC. and Land, L.S. 1975. *Lime mud deposition and calcareous algae in the bight of Abaco, Bahamas. A budget*. Journal of Sedimentary Petrology, 45, (4), 763-786.

N**eumann, C.J., G.W. Cry, E. L. Caso and B.R. Jarvinen** 1981. *Tropical cyclones of the North Atlantic Ocean, 1871-1980.* National Climatic Center, Ashwville NC, in cooperation with the National Hurricane Center and National Hurricane Research Laboratory, Coral Gables, Fla.

Patterson, J. 19977. *Native Trees of The Bahamas.* Nassau, Bahamas: published by the author.

Rappaport, E.N. and F.C. Sheets. 1993. *Hurricane Andrew. Bahamas Journal of Science: 1, (1), 2-9.*

Rolle, A. W. 1990. *A storm surge atlas for the northern and central Bahamas New Providence and vicinity.* Nassau: the National Weather Service of The Bahamas. 21 pages plus Appendix.

Russell, C. 1998. *The future of forestry in The Bahamas.* Bahamas Journal of Science: 5, (3), 2-11.

Russell, C. 2000. *Bahamas country report: forestry outlook study for the Caribbean. Nassau, Bahama*s: Department of Lands and Survey. Mimeographed.

Sealey, N.E. 1994a. *Bahamian Landscapes. Nassau, Bahamas:* Media Publishing.

Sealey, N.E. 1994b. *Rainfall distribution in New Providence for 1993*. Bahamas Journal of Science: 1, (3), 33-35.

Sealey, N.E. 1995. *Rainfall distribution in New Providence for 1994*. Bahamas Journal of Science: 2, (2), 32-34.

Sealey, N. E. 1996. *Rainfall distribution in New Providence for 1995.* Bahamas Journal of Science: 4, (1), 35-36.

Sealey, N. E. 1997. *Distribution of rainfall in New Providence for 1996.* Bahamas Journal of Science: 5, (1), 36.

Sealey, N. E. 1998. *Distribution of rainfall in New Providence for 1997.* Bahamas Journal of Science: 5, (2), 34-36.

Sealey, N. E., P. Balfe and N. Wardle. 1999. *Rainfall distribution on New Providence for 1997-1998.* Bahamas Journal of Science: 6, (2), 55-57.

Shaklee, R.V. 1997. *Historical hurricane impacts on The Bahamas: Part I:* 1500-1749.Bahamas Journal of Science: 5, (1), 7-9.

Shaklee, R.V. 1998. *Historical hurricane impacts on The Bahamas: Part II:* 1750-1799. Bahamas Journal of Science: 5, (2), 16-20.

Shaklee, R.V. 1998. *Historic weather at Nassau.* Bahamas Journal of Science: 6, (1), 23-30.

Shaklee, R.V. 2000. *Historical hurricane impacts on The Bahamas: 1800-1850.* Bahamas Journal of Science, 8, (1), 16-24.

Shattuck, G. (ed.). 1905. *The Bahama Islands.* Baltimore, Maryland: Baltimore Geographical Society.

Smith, D., L. Miller and J. Miller. 1994. *The Butterflies of the West Indies and South Florida*. Oxford and New York: Oxford University Press.

Suplee, C. 1999. *El Nino la Nina nature's vicious cycle.* National Geographic 195, (3), 72-95.

United Nations. 1994. Earth Summit. *Programme of action for small island developing states. Global conference on the sustainable development of small island developing states*, *Bridgetown, Barbados, April 26 to May 6 1994.* New York. United Nations.

United Nations. 1992. Agenda 21: *programme of action for sustainable development. Rio Declaration on Environment and Development. Statement of Forest Principles.* United Nations Conference on Environment and Development, Rio de Janeiro, Brazil, June 3-14., 1992. New York. United Nations.

UNFCC. 1999. *Compendium of decision tools to evaluate strategies for adaptation to climate change*. Bonn: UNFCC Secretariat.

Watson, R.T., M.C. Zinyowera and R.H. Moss (Eds). 1998. *The Regional Impacts of Climate Change. An assessment of vulnerability. A special report of IPCC working group II.* Published for the Intergovernmental Panel on Climate Change. Cambridge University Press, United Kingdom.

Weech, P.S. 1999. *Situational analysis of water resources: country report for The Bahamas*. Nassau: Report for the Water Sector in The Bahamas. Unpublished: 15 pages.

White, A. 1998. *A birder's guide to the Bahama islands and Turks and Caico*s. American Birding Association.

Williams, P.M. 1999. *Chronological highlights in the history of The Bahamas 600 to 1900*. Nassau, Bahamas: published by the author and The Bahamas Historical Society.

Woods, C.A, (ed.). 1989. *Biogeography of the West Indies past, present and future*. Gainesville, Florida: Sandhill Crane Press, Inc.