The Second National Communication Report Of

The Commonwealth Of The Bahamas

Under The United Nations Framework Convention On

Climate Change

(UNFCCC)

SEPTEMBER 2014

In numerous statements, speeches, and public pronouncements since becoming a signatory to the United Nations Framework Convention on Climate Change (UNFCCC), The Bahamas has repeated the simple truth that's a small island developing state, our lives, livelihood, and way of life are all threatened by our vulnerability to climate change. The consequences of extreme weather and more frequent tropical processes are evident across the entire archipelago. None of our islands has been spared flooding, a more variable climate, coastal erosion, and the invasion of the alien lionfish (linked to Hurricane Andrew that devastated The Bahamas in 1992).

The Bahamas, surrounded by shallow seas, is indeed a unique ecosystem with more than 80% of its land within one meter of mean sea level. Geologically, the evidence found in our many blue holes and in stalactites and stalagmites chronicles the historic and dynamic rise and fall in mean sea levels. In fact, conditions that we now experience, including one-foot rise in the mean sea level since the beginning of this century, is unprecedented in human history.

The Bahamas has responded to the adverse impacts of climate change and extreme events. We have been constrained to relocate a Family Island community from the shoreline. Further to that, we have built new and strengthened existing coastal defenses; made our tbuilding codes more robust to mitigate against increase wind loadings; and adapted to a loss of freshwater by employing reverse osmosis facilities throughout our islands to provide access to potable water.

All of our achievements have derived from the use of national resources. Adaptation, of course, has come at an additional cost to the economy. For example, reverse osmosis technologies have increased dependence on technologies not available nationally while increasing our carbon emissions.

The Second National Communication of The Bahamas sets out our efforts to meet obligations to the UNFCCC. This report fulfills our commitment under Article 12 of the Convention; however, we have taken considerable action to reduce Climate Change. These actions include:

- Formalising a National Energy Policy that sets a target to achieve a minimum of 30% renewables in the country's energy mix by 2033;
- Joining the Carbon War Room "Ten Island Challenge" to deploy 20 MW of utility scale PV installations;
- Amending legislation to promote the use of alternative sources of energy and grid-tie connected systems;
- Adjusting our tax regime to encourage the deployment of energy efficient appliances, solar water heaters and photovoltaic systems;
- Phasing out the importation of incandescent light bulbs and increased the adoption of CFL and LED lights;
- Increasing fiscal incentives to foster the rapid deployment of fuel efficient and hybrid vehicles;
- Expanding the Marine Protected Area network to 10% of nearshore and marine environment; and
- Improving the fuel efficiency of our national airline.

Notwithstanding present strides and realities, with forty years of Public Service and a genuine love for our environment, I am not satisfied that I have witnessed an urgent enough global response to climate change. We must keep the global rise in temperature below 1.5C for our very survival...literally! I look forward to our collective and individual actions to ensure that no Small Island Developing State (SIDS) is left behind in accordance with Sustainable Development Goals (SDGs) and the SAMOA Pathway for SIDS.

Rt. Hon. Perry Gladstone Christie, M.P.
Prime Minister
The Commonwealth of The Bahamas

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

SEPTEMBER 2014

The Bahamas Second National Communication to the UNFCCC dated September 2014 is presented in accordance with the UNFCCC Guidelines for the preparation of national communications from Parties not included in annex 1 to the Convention as contained in decision 17/CP.8. The time lines for various sections of the report are based on those guidelines and projections for example used in BahamasSimClim use time scales to the year 2050 for illustrative purposes. All other data and information is presented in the time periods specified in the guidelines. "

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EXECUTIVE SUMMARY

NATIONAL CIRCUMSTANCES

The Commonwealth of The Bahamas is an archipelago of 700 islands and more than 200 cays, islets and rocks in the western Atlantic Ocean (lat. 21° and 27° N and long. 72° and 79° W) covering over 100,000 square miles (mi^2) or 260,000 square kilometres (km^2) of ocean between. Thirty islands and cays are permanently inhabited.

The total land area is 5,382 mi^2 (13,943 km^2) stretching from the northwest tip of Grand Bahama Island to the southeast coast of Inagua Island (approx. 550 miles (mi) / 880 kilometres (km)). The Bahamas Platform extends from the coast of Florida to the island of Hispaniola (840 miles (1,335 km)). Table 1 summarizes key information relating to the national circumstances of The Bahamas.

Daily maximum temperatures may reach 96°F (36°C) and night time temperatures may fall as low as 41°F (5°C) during winter in northern islands. Mean daily temperatures generally lie between 60°F and 90°F (17°C and 32°C). In the summer temperatures usually fall to 78°F (25°C) or less at night and seldom rise above 90°F (32°C) during the day (Fig. 1).

Average Monthly Maximum and Minimum Termperatures for New Providence

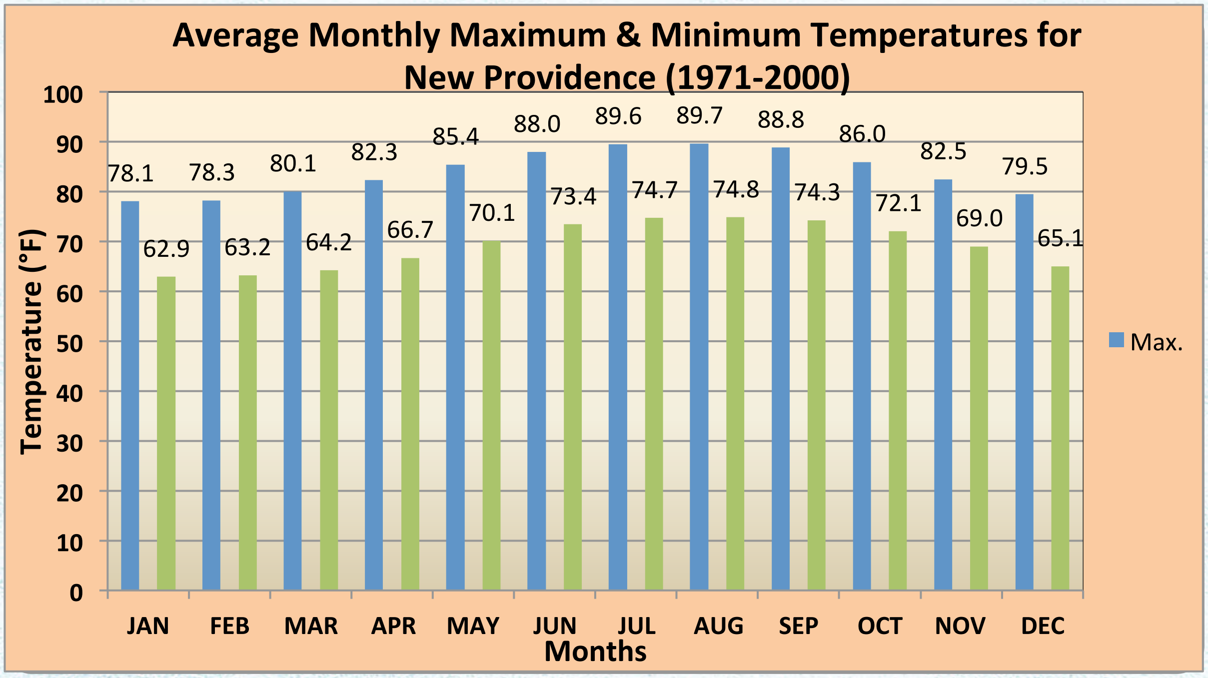

Fig. 1: Average monthly maximum and minimum termperatures for New Providence (1971 – 2000)

Rainy months are May to October. In New Providence, rainfall averages 2 inches (5.1 cm) a month from November to April and 6 inches (15 cm) a month from May to October. The northern islands of The Bahamas receive 20% or more rainfall than New Providence. On the other hand, the southern islands receive half of the total rainfall in New Providence.

Summary of National Circumstances

CRITERIA	2010
Population (2010 Census)	351,461
Relevant area Total (km^2)	13,943
Land area (km^2)	10,070
GDP at current market price	US$ 8.552 billion (2010 estimate)
GDP per capita at current market price (2010)	USD24,279
Share of industry in GDP (%)	14.7
Share of services in GDP (%)	84.1 (2001)
Share of agriculture in GDP (%)	1.2
Urban population as % of total population	83.9 (2009)
Total labour force (2009)	184,000
Percentage of workforce unemployed (%)	7.6
Population in absolute poverty (% 2004)	9.3
Life Expectancy at birth (years)	73 (2007)

Table 1: Summary of state of the nation. *Source: Central Bank of The Bahamas*

Tropical Storms and Hurricanes

The Atlantic Hurricane Season (June 1 to November 30) produces several hurricanes each year to necessitate warnings and alerts in The Bahamas. Since 2000, six major hurricanes have made landfall in The Bahamas or significantly impacted the islands. Tropical storms and hurricanes[1] most frequently occur in the months of September, October, August and November. Abaco and Grand Bahama had the greatest number of hurricanes with a frequency of 40 in every 4 years during 1944 and 2010 period. The island of Abaco is considered “Hurricane Capital of the Caribbean” based on the number of hurricanes between 1851 and 2010.

[1] Based on storms and hurricanes whose centre passed within 100 mi (160 km) of The Bahamas from 1871 to 1999 (129 seasons).

HISTORY, GOVERNMENT AND POPULATION

The Bahamas gained independence from England on July 10, 1973, and is now considered a small island state within the Commonwealth of Nations (formerly the British Empire).

Head of State (Queen of England) is represented by the Governor-General and the Government comprises the Executive with the Prime Minister, the Attorney-General and at least seven other members. The other Cabinet Ministers and Ministers of State are responsible for running their Government ministries. The Legislature is a two-chamber system based on the Westminster model, with a House of Assembly and a Senate. There are currently 25 constituencies in Nassau and 16 in the Family Islands totalling 41 House seats. Local Government is made up of 23 Local Government districts.

The population of The Bahamas was 351,461 in 2010. 246,329 (70%) live on the Island of New Providence while Grand Bahama has a population of 51,368 (14.6%). Data from the past three censuses indicate that the national population had an average growth rate of 2.2% per year over 30 years (1980 – 2010) and 1.9% between 1990 and 2010. In 2010 the highest percentage of the population in The Bahamas was less than 40 years old. A significant proportion of the population was20 years or less making The Bahamas a large young population.

There were 306 deaths in The Bahamas during 2013. The ten leading causes of death in The Bahamas during the 2006-2009 period include hypertension (688), ischemic heart disease (605), HIV (566), cerebrovascular disease (517), diabetes (399) and assault (homicide). (Bahamas 2013 http://www.paho.org/saludenlasamericas/).

ECONOMY

Tourism is the mainstay of the Bahamian economy and the financial services sector is the second largest contributor to the gross domestic product (GDP). The GDP in Current Prices for 2012 had a positive growth of 3.5%, while GDP in Constant Prices grew at 1.83%. The hotel and restaurant expenditure in 2012 was $983.11 million. Tourism employs directly or indirectly approximately 50% of the Bahamian population. Dependence on the tourism sector makes The Bahamas vulnerable to changes in the global economy. For example the global economic crisis of 2008-2009 resulted in thousands of lay-offs from hotels, resorts and guest service businesses throughout The Bahamas. The national per capita income for the year 2008 was $ 24,279 (2008 estimate). Banking and financial services include numerous offshore banks, which make gains through foreign exchange. Game and sport fish include amberjack, bonefish, dolphin, blue marlin (the national fish), white marlin, sailfish, swordfish, tuna, and wahoo. The total fisheries catch for the year 2007 was valued at B$80.3 million dollars. Coral reefs protect the island coastlines against erosion and storm action and studies by Burke and Maidens (2004) indicate that about 30% of the 4,000 mi^2 (10,300 km^2) of coral reef is under threat from overfishing and coastal impacts.

Agriculture is often focused on a small number of native and introduced fruit species. Approximately 90% of food consumed is imported, and includes all sugar, virtually all dairy products and most carbohydrate foods. Waste management is often carried out through an area designated (officially or unofficially) as a dumpsite. The Environmental Health Services Act of 1987 provides regulations, penalties and provisions for remediation of pollution emission into the environment. The primary source of energy for electricity generation, transportation and domestic use is the combustion of imported fossil fuels. Gasoline and diesel oil are used for transportation while liquefied petroleum gas (LPG) is used for cooking. Brewing, distillation and furniture production represent the growing industries in New Providence while chemical and pharmaceutical manufacture is currently present in Grand Bahama. Mining of rock and limestone sand are restricted by the regulations established in the Conservation and Protection of the Physical Landscape of The Bahamas Act of 1997.

The Ministry of Health holds responsibilities in human physical and mental health and manages two major hospitals and numerous public clinics. Vector–borne diseases represent a health and an economic threat to The Bahamas through incidences of dengue, malaria, and yellow fever. The Bahamas had 365 (1998), 155 (2003) and 3,500 (2011) confirmed cases of dengue fever.

The Bahamas' ship registry is among the three largest ship registry centres in the world. More than 1,600 ships were registered in The Bahamas in 1995.

ENVIRONMENT

The establishment of The Bahamas Environment, Science and Technology (BEST) Commission in 1994 and the Conservation and Protection of the Physical Landscape Act of 1997 made way for increased conservation action and use of scientific data in management decisions relating to the environment. The BEST Commission has been mandated to: advise Government on the environmental implications of development proposals; coordinate policies and programs for environmental protection and responses to the international environmental conventions to which The Bahamas is a party; foster development of science and technology; develop a national conservation strategy and action plan; propose legislation to support the national conservation strategy and plan; prepare an inventory of natural resources; and develop a national system of parks, protected areas and reserves, to provide for in situ conservation of inventoried resources.

The biodiversity of The Bahamas has been described by the BEST Commission in The Bahamas Country Study Report (1995) and other issues pertaining to the prevention of biodiversity loss are contained in the National Biodiversity Strategy and Action Plan (NBSAP). The Government has committed to protecting 20% of all near shore marine resources by the year 2020 through the Caribbean Challenge. In addition to national efforts to wisely manage its environment, the Government of The Bahamas has endorsed and/or ratified 35 International Legal Instruments on the Environment.

The Bahamas has a long history of land use, land use changes and forestry dating back to the 1700s. The country possesses substantial natural forest resources comprising of pine forests, coppice hardwoods and mangrove forests. Approximately 80% of forest resources are found on state lands (Crown land) and the remaining 20% on private lands. Under the Forestry Act 2010, a Forestry Unit, headed by a Director of Forestry, was established within the Ministry of the Environment administer, manage and develop forests**.**

NATIONAL GREENHOUSE GAS INVENTORY

Greenhouse Gas (GHG) emissions and their removal have been calculated for the year 2000 in accordance with the UNFCCC guidelines on the preparation of national communications from non-Annex I Parties. Accessing and retrieving data collected for statistical purposes was challenging because of the rules of the sector. Moreover, a statistical survey was required to collate and verify existing data.

The Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC) was used to produce the national inventory of greenhouse gases.

GHG emissions were mainly from imported liquid fossil fuels consisting of gasoline, jet, gas and diesel oil and liquefied petroleum products such as liquefied propane gas (LPF) and lubricants. Figure 2 provides a trend for petroleum imports.

Trend of Petroleum Imports from 1990-2000

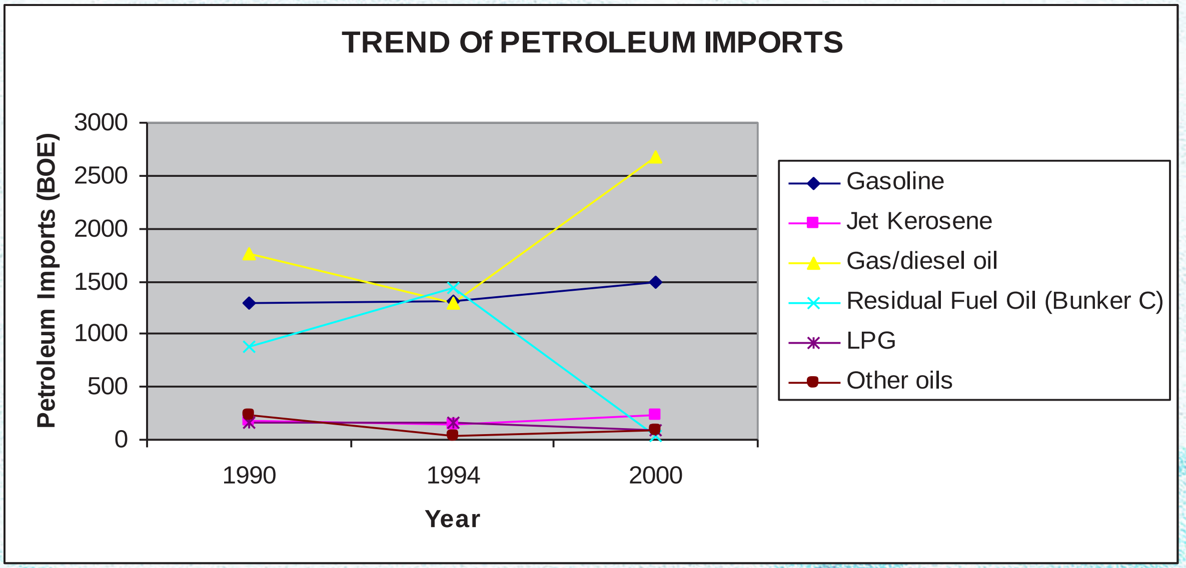

Figure 2: Trend of Petroleum Imports Reported between 1990-2000

The inventory found that electricity generation and the transportation sector are the two most significant sources of greenhouse gas emissions. Fuels exported through The Bahamas are international marine and air bunkering fuels and fossil fuel from storage and transmission. Therefore, bunker fuel totals are not included in the national total.

SUMMARY OF GHG EMISSIONS

A tabular summary of emissions by gas is presented in Table 2 below. From the table, the most significant GHG for The Bahamas is CO_2 emissions.

Summary of Gas Emissions in 2000

Emissions by Gas	**Gg**	**GWP**	**CO_2 Eq.**	**Tonnes CO_2**
CO_2 Emissions				
Energy	660.4448	1	660.4448	660,444.81
LUCF onsite burning of forests	4.35	1	4.3500	4,350.00
Methane Emissions	**Gg Gas**			
Livestock	0.233737	21	4.9085	4,908.49
Solid Waste	0.06940	21	1.4574	1,457.39
Comm/Industrial Wastewater	0.002675	21	0.0562	56.17
Wastewater and Sludge	0.054368	21	1.1417	1,141.73
LUCF on site burning of forests	0.500000	21	10.5000	10,500.00
N2O Emissions	**Gg Gas**			
Animal Waste Mgmt Systems	0.00115	310	0.3573	357.25
Grazing Animals	0.00387	310	1.2008	1,200.81
Agricultural Soils	0.00539	310	1.6705	1,670.46
Leaching	0.03414	310	10.5837	10,583.68
Human Sewage	0.01969	310	6.1054	6,105.39
LUCF	0.00013	310	0.0415	41.54
NO Emissions	**Gg Gas**			
LUCF onsite burning of forests	0.12000			
NMVOC Emissions	**Gg Gas**			
Fugitive Emissions	2.312			
Road Surfacing	0.17349			

Table 2: Summary of Emissions in 2000

Emissions from the Energy sector totaled some 660.48 Gg of CO_2 Equivalent. In 1994, some 85% of all diesel/ gas oil was used in power generation. In 2000, this figure dropped to 52%. This represents a rapidly increasing contribution of the transport sector to the GHG emissions, as well as, a movement away from the more expensive gas/oil for electricity generation. The CO_2 emissions produced from the consumption of fossil fuels for public electricity production totaled some 37.1% of the total CO_2 emissions. Fugitive Emissions were derived from the 3,287 metric tons of fuel stored on an annual basis and transshipped outside The Bahamas. A single facility *(South Riding Point Holding Ltd.)* represents the primary source of fugitive emissions in The Bahamas estimated at 2.3 Gg of non-methane volatile organic compounds (NMVOC). CO_2 emissions from International bunkers indicate that CO_2 emissions from the aviation and marine bunkers accounted for 881.86 Gg CO_2 and 791.15 Gg of CO_2 respectively.

Emissions from Waste contributed 11.1 Gg of CH_4 emissions while solid waste contributed more than 171,270,000 tonnes of municipal solid waste annually. New Providence Island contributed 77% to this total; Grand Bahama 17% and 6% was contributed by the other Family Islands.

The Industrial processes sector is small. It does not contribute significantly to the national emissions with 0.0562 Gg CO_2 equivalent emissions from commercial and industrial wastewater. The LUCF sector records net emissions of 1513.67 Gg of CO_2 and trace gases of 0.12 Gg of CO_2. The sector has recorded removals in the amount of 4159.61 Gg of CO_2.

Emissions from the Agriculture Sector showed 0.23 Gg of CH_4 emissions from Enteric Fermentation. Emissions of N_2O from Domestic Livestock were less than 1/100 of a Gg per year. Direct Emissions of N_2O from Agricultural Fields excluding cultivation of Histosols was estimated at 0.01 Gg per year. Emissions of Nitrous Oxide (N_20) from grazing animals pasture range and paddock was less than 1/100 of a Gg per year. Indirect emissions of Nitrous oxide (N_2O) from atmospheric deposition of NH_3 and NO_x were less than 0.01 Gg. Indirect N_2O emission from leaching was 0.03 Gg.

CLIMATE CHANGE MITIGATION

The Government of The Bahamas is committed to the following National Energy Vision: "The Bahamas will become a world leader in the development and implementation of sustainable energy opportunities, by aggressively re-engineering our legislative, regulatory, and institutional frameworks; retooling our human resources; and implementing a diverse range of well researched and regulated, environmentally sensitive and sustainable energy programmes and initiatives, built upon our geographical (both proximity and diversity), climatic (sun, wind, and sea) and traditional economic strengths (tourism and banking)."[2] Given this commitment the focus of the policies and measures is to target a lower dependence on imported oil, including a reduction in energy demand due to energy efficiency measures of 30% relative to a business-as-usual scenario by 2030 and an increase in share of renewable energies in electricity generation of at least 15% by 2020 and 30% by 2030.

A scenario analysis was conducted using the Long-range Energy Alternatives Planning system (LEAP)[3] for the energy sector to quantify energy demand and supply, greenhouse gas emissions and costs across four specific measures in the energy sector over the time period of

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[2] NEPC report p.4 http://www.best.bs/Webdocs/NEPC_2ndReport_FINAL.pdf (exact text).
[3] LEAP, developed by the Stockholm Environment Institute, www.sei-international.org; software distributed through the COMMEND website: www.energycommunity.org.

2010 to 2030. The non-energy sector and transportation measures and the costs associated with each measure were considered outside the scope of this assessment.

The analysis included a historical energy demand and supply in The Bahamas from 2000 to 2009. It also encompassed one baseline scenario of how a particular energy system might evolve over a time period of 2010 to 2030 in the absence of additional policies or measures. The baseline scenario includes demand projections for electricity and petroleum products within five sectors: households, commerce, industry, hotels and transport.

Energy consumption in The Bahamas is dominated by the household, commerce and transport sectors. Measures have been included in the mitigation scenario to target reductions in demand in the household, commerce, industry and hotel sectors (See Figure 3). All data points from 2000-2009 are historical values. Projections begin in 2010.

Energy and Electricity Demands by Sector

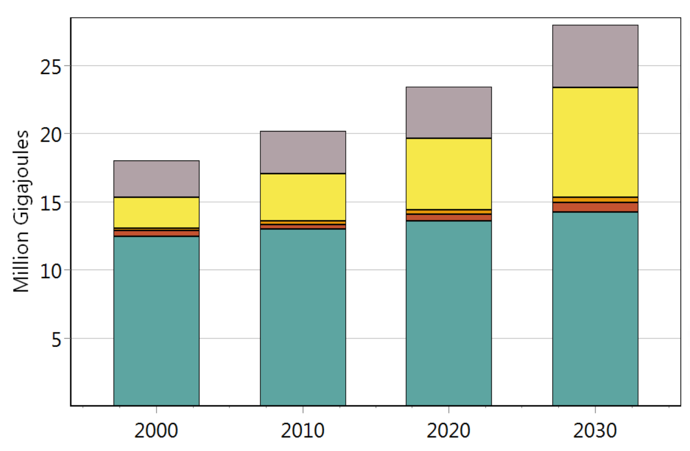


Figure 3: Total energy demand by sector, baseline scenario [Million Gigajoules]

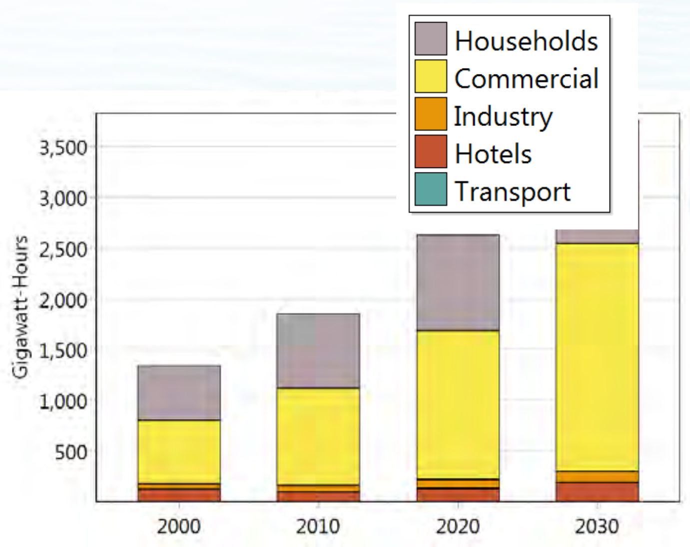


Figure 4: Total electricity demand by sector, baseline scenario [Gigawatt-hours]

The household sector is dominated by electricity consumption (See Figure 4), and that is assumed to increase as electric devices replace the use of kerosene and propane. Total energy consumption was projected forward to the year 2030 using total population projections of a growth rate of about 0.94% per year from 2010 to 2030 and historical trends of per capita consumption by fuel based on an assumption of 0.89% annual growth. In the commercial sector, GDP is expected to grow at a rate of 1.3% per year and energy consumption per unit of GDP is expected to increase at a 3.0% annual rate. As with the commercial sector, industrial sector GDP was assumed to grow 2.7% every year and electricity consumption per unit of GDP was assumed to be constant due to a lack of consistent trend in historical data. The hotel sector was assumed to consume electricity at a rate of 3.6% every year. The electricity consumption per unit of GDP was assumed to be constant due to a lack of consistent historical trends. The transport sector consumes a combination of various petroleum products. Total consumption was projected forward based on trends in transportation GDP, which was assumed to grow at 3.3% per year. Historical fuel consumption is assumed to decrease at 2.8% per year.

Electric Capacity Expansion - Baseline Scenario

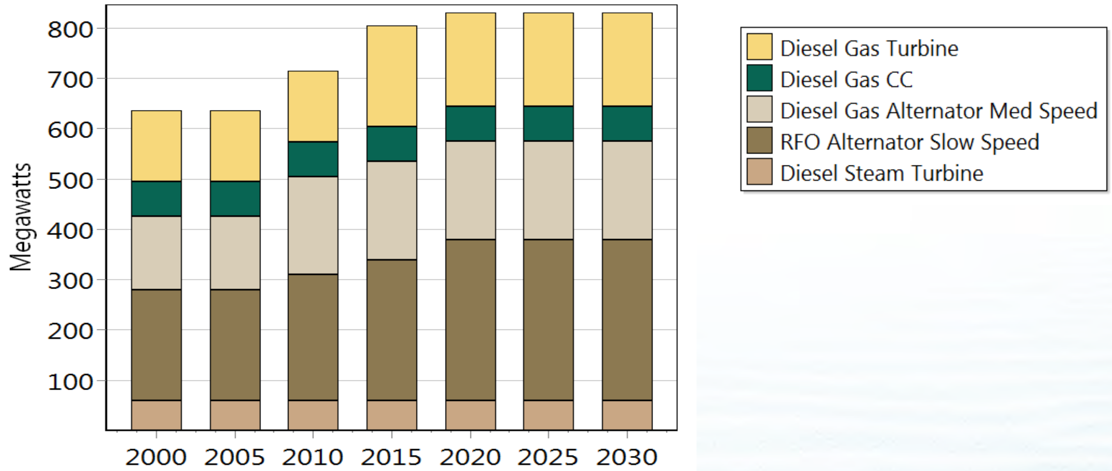


Figure 5: Capacity expansion, baseline scenario [MW]

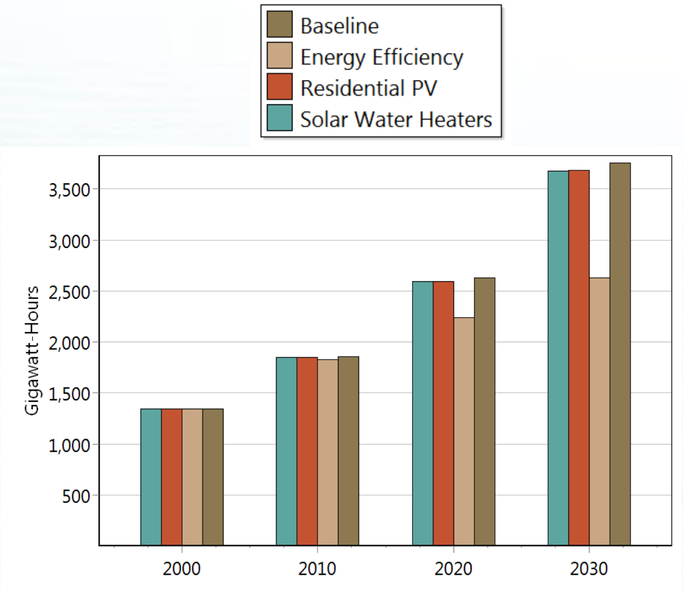
Electricity generation capacity includes all future power plants built according to utility expansion and retirement plans and include mainly diesel and residual fuel oil gas turbines and alternators. [4] Figure 5 shows the plans for the installations of new power plants in MW.

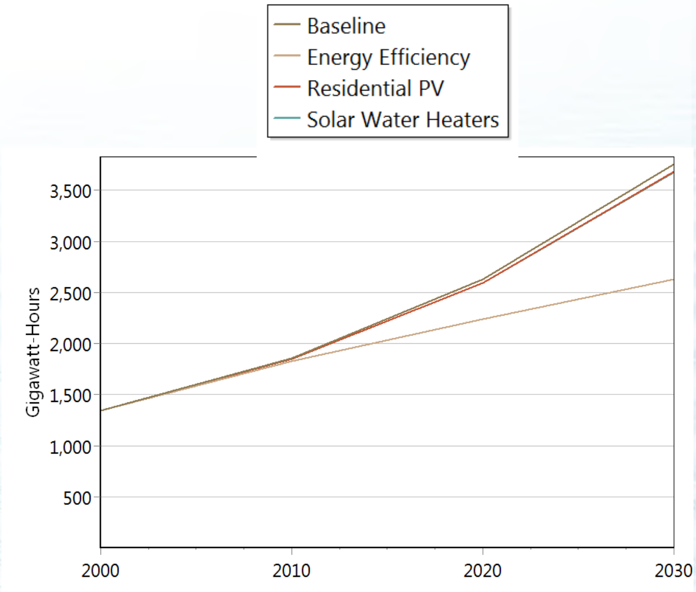
A mitigation scenario follows the same basic approach as the baseline, and includes the same historical data up to the year 2009. It consists of four components: (1) *Rooftop Solar Thermal Hot Water Heaters Replacing Electric Hot Water Heaters In Residential Homes* (assuming that 100% of the hot water demand could be met by solar thermal by 2030); (2) *Distributed PV Generation In Residential Homes* (assuming that 100% of household photovoltaic (PV) potential could be achieved by 2030); (3) *Energy Efficiency Measures (*assuming that all other energy efficiency measures would amount to a 30% reduction in electricity demand compared to the baseline by 2030); and (4) *New Renewable Generation Mix* (assuming that renewable power plants would be introduced to allow for 15% renewable generation by 2020 and 30% renewable generation by 2030). The first three scenarios are demand-side measures and the fourth is a supply-side measure.

[4] CC = combined cycle power plant; RFO = residual fuel oil.

A combination of these measures (and many others) is assumed to collectively be able to reduce electricity consumption in 2030 by 30% compared to the baseline scenario. This measure has the greatest electricity reduction potential of the demand-side policies when compared with the baseline scenario, as can be seen in Figures 6 and 7 below.

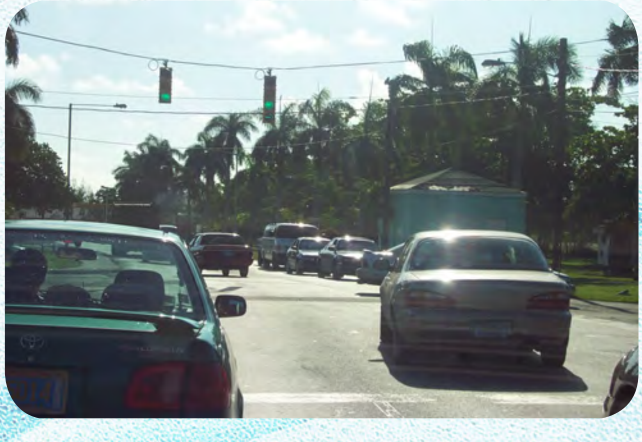
Electricity Consumption For Three Demand-side Policies As Compared With The Baseline Scenario





Figures 6 and 7: Total electricity consumption for three demand-side policies as compared with the baseline scenario [Gigawatt-hours][5]

Of the five technologies (Table 3 below) biomass shows the most promise to provide near-term electricity production potential in The Bahamas. The 15 Megawatt waste to energy power plant is being considered both for electricity generation purposes and also for waste management purposes. The ocean thermal electric conversion (OTEC) systems considered are expected to be a viable technology option for The Bahamas by 2030.



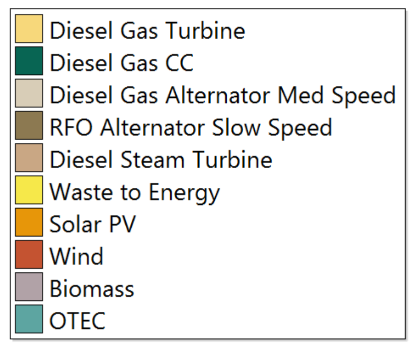
[5] The Residential PV measure and the Solar Water Heater measure have very similar reductions, and therefore the line for solar water heaters cannot be seen in Figure 8.

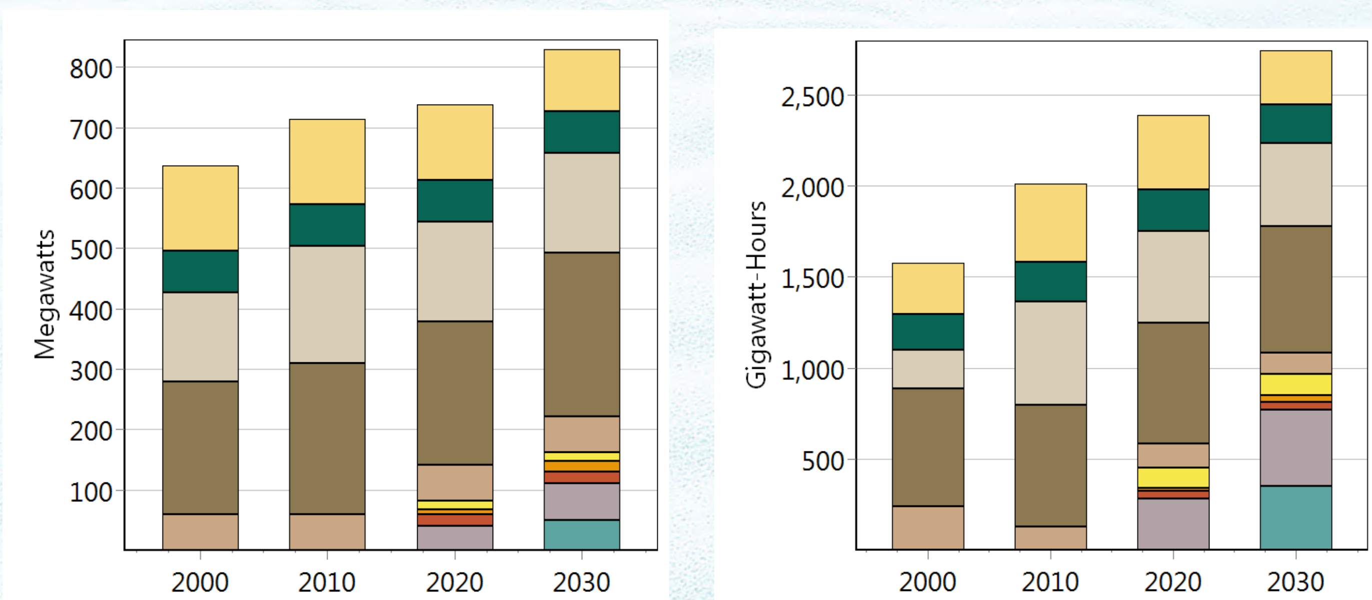
Renewable Electricity Generating Capacity and Generation In 2030, Mitigation Scenario

Technology	Capacity [MW]	Generation [GWh]
Biomass	60	1510
Waste to Energy	15	400
Solar PV	17	130
Wind	20	150
OTEC	50	1250

Table 3: Renewable electricity generating capacity and generation in 2030, mitigation

Capacity expansion and electricity output by technology, mitigation scenario





Figures 8 and 9: Capacity expansion [MW] and electricity output [GWh] by technology, mitigation scenario

Figures 8 and 9 show the addition of renewable energy to the national electric grid capacity in an overall electricity generation. Biomass, OTEC and waste to energy are base load plants, and can generate more electricity than wind and solar energy per unit of capacity.

RESULTS

Solar hot water heaters and residential PV policies are able to reduce household electricity demand by 6% and 5%, respectively in 2030. The energy efficiency scenario reduces electricity demand across all sectors by 30% in 2030. Total electricity demand reductions in the mitigation scenario amount to over 1200 Gigawatt-hours, approximately 34% of the baseline electricity consumption in 2030. Table 4 below included overall GHG savings from each policy measure included in the mitigation scenario. The energy efficiency and renewable grid electricity measures provide the majority of the savings. These measures mainly displace residual fuel oil and diesel fuel from electricity generation.

Electricity Demand and GHG Emission Savings in 2030 Based on Explored Policies and Comprehensive Mitigation Scenario

Policy/Measure	Electricity Demand Savings [GWh]	GHG Emission Savings [kT CO_2e]
Solar Hot Water Heaters	75	69
Residential PV	69	64
Energy Efficiency	1125	1032
Renewable Generation	0	843
Mitigation	**1269**	**1988**

Table 4: Electricity demand and GHG emission savings in 2030 based on individual policies explored and the comprehensive mitigation scenario

Figure 10 shows the dynamic reductions in electricity demand over time based on the three demand-side mitigation policies included in the mitigation scenario. The dotted white bar represents the avoided demand.

Avoided Electricity Demand in Mitigation Scenario Compared with Baseline Scenario

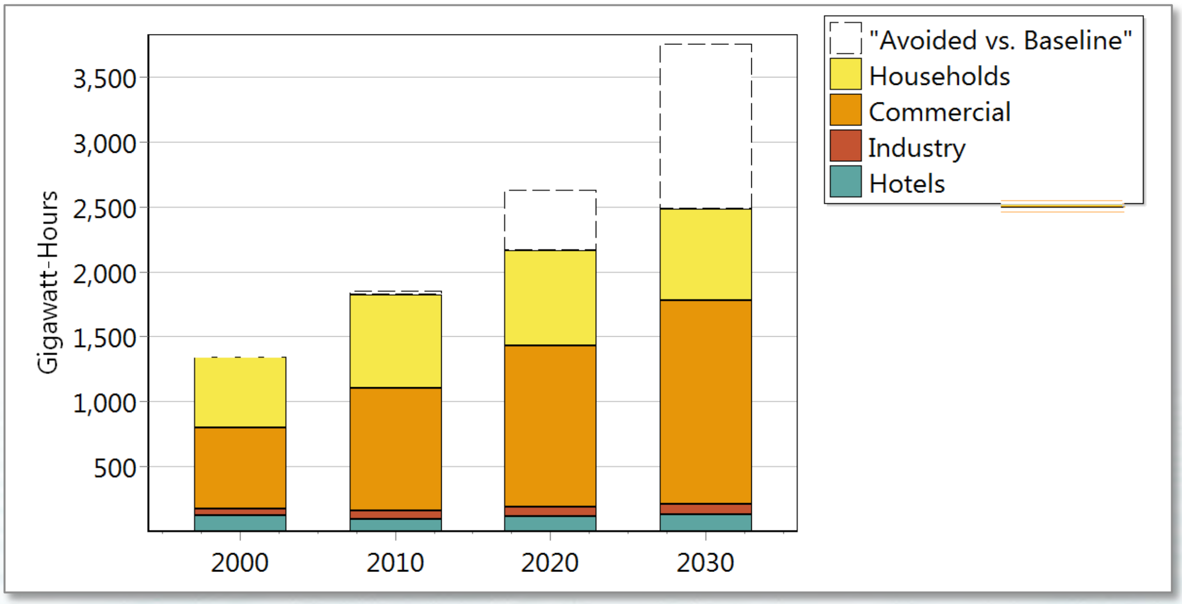


Figure 10: Avoided electricity demand in mitigation scenario as compared with the baseline scenario [Gigawatt-hours]

The electricity demands avoided due to solar PV, solar water heaters and energy efficiency in turn decrease the overall electricity generation required by power plants. Figure 11 shows a comprehensive picture of the electricity supply mix and the avoided electricity generation leading up to 2030.

Avoided Electricity Generation by Technology in the Mitigation Scenario as Compared with Baseline Scenario

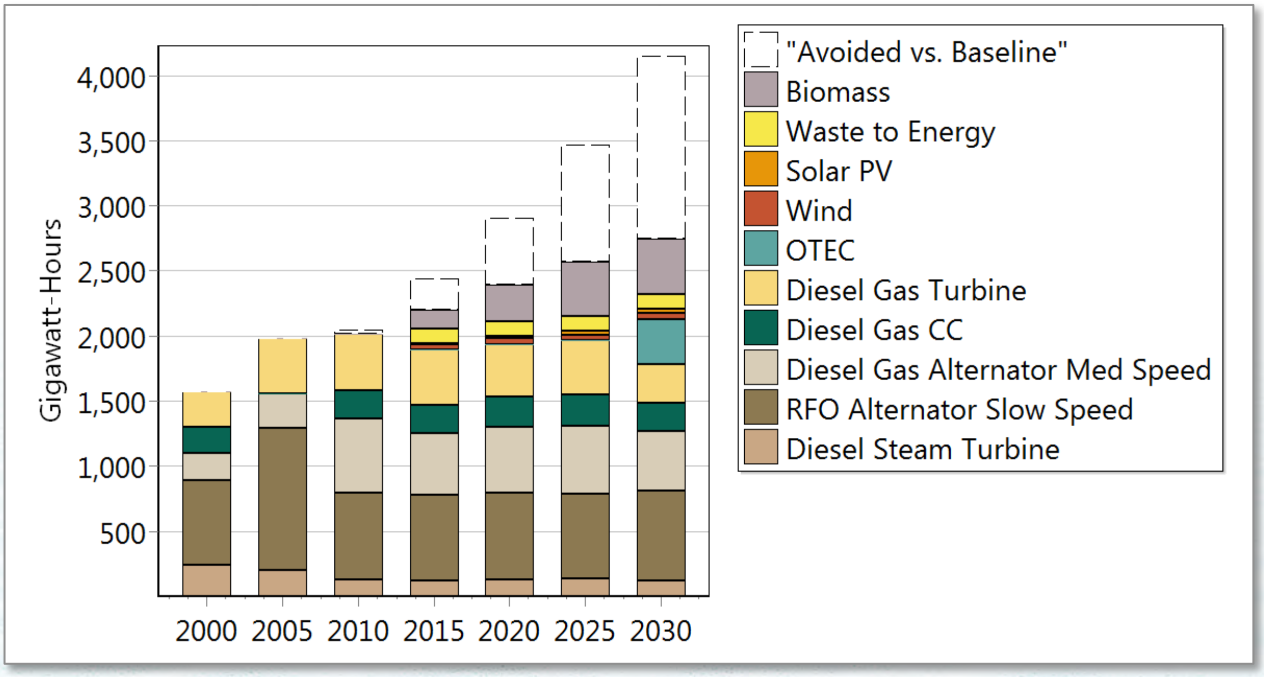


Figure 11: Avoided electricity generation by technology in the mitigation scenario as compared with the baseline scenario [Gigawatt-hours]

Based on the renewable energy potential assumed for the mitigation scenario, The Bahamas could feasibly produce over 30% of their electricity from renewable generation sources by 2030 as shown in Table 5 below.

Renewable Electricity Generation by Technology in Mitigation Scenario

	2010	2015	2020	2025	2030
Biomass	0	140	280	420	420
Waste to Energy	0	112	112	112	112
Solar PV	0	4	15	26	37
Wind	0	44	44	44	44
OTEC	0	0	0	0	350
Total Generation Required	2,014	2,195	2,338	2,568	2,743
% Renewable Generation	**0%**	**13.6%**	**19.3%**	**23.4%**	**35.1%**

Table 5. Renewable electricity generation by technology in the mitigation scenario [GWh]

The Bahamas also has a GHG emission sink from the land use change and forestry sector. If these savings were to be included in an analysis like LEAP, based on the estimates in GHG inventory calculations, net emissions would be negative, as seen in Figure 12.

Avoided Emissions by Sector for the Mitigation Scenario Compared with Baseline scenario

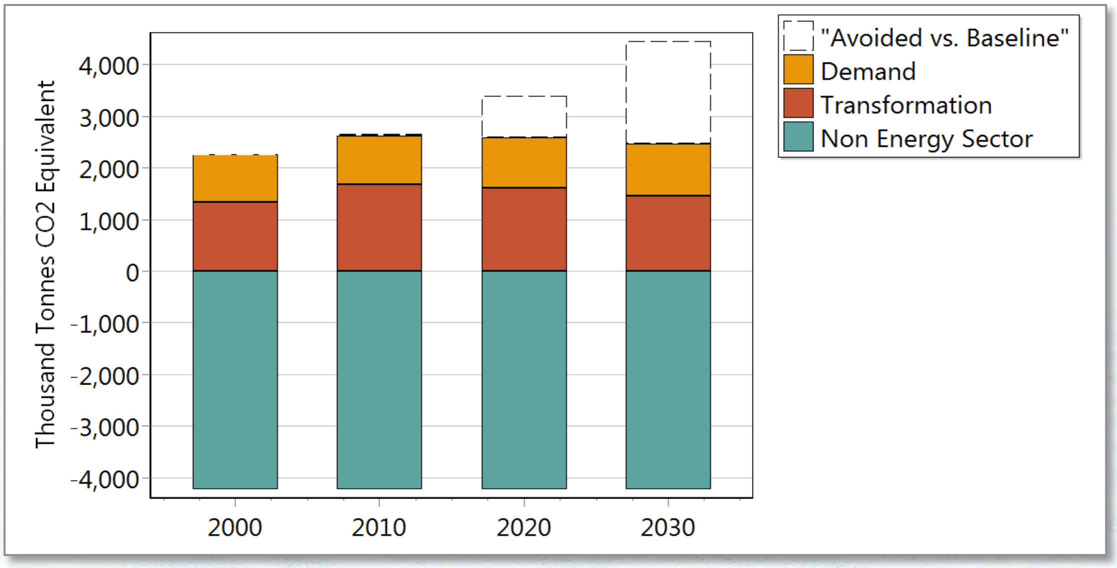


Figure 12: Avoided emissions by sector for the mitigation scenario as compared with the baseline scenario including land use change and forestry [Thousand Tonnes CO_2 equivalent][6]

Barriers to Energy Efficiency include lack of awareness, insufficient knowledge and skills among users, planners, designers and service providers about energy efficient alternatives and opportunities of energy efficiency; high up-front investments; limited availability to highly efficient technologies; landlord-tenant problems regarding the installation of energy efficient measures. Barriers to Renewable Energy Deployment include limiting access to capital; reduced incentives for The Bahamas Electricity Corporation (BEC) to buy electricity from Independent Power Producers; non-transparent technical and commercial grid connection rules; uncompetitive technologies under present conditions, petroleum product shipping, delivery and distribution frequencies and practices. [7]

[6] This assumes no change in GHG emissions or savings from the non-energy sector from the 2000 GHG inventory. Transformation includes emissions from electricity production and transmission and distribution.
[7] Policy report 13/44 (exact text).

CLIMATE CHANGE IMPACTS, VULNERABILITY AND ADAPTATION

The vulnerability and adaptation assessment (V&A) report presented here is in line with the guidelines provided by the UNFCCC guidelines for the preparation of national communications adopted at the eighth session of the Conference of the Parties to the UNFCCC. The information generated for the vulnerability and adaptation assessment (V&A) followed two principal approaches: (i) a consultative process involving key stakeholders and/or sectors and (ii) a modeling approach using climate change and sea-level rise projections for different time horizons in the future.

Approaches and Frameworks for Assessment of Vulnerability and Adaptation

The stakeholder consultations found that while climate change and sea-level rise are recognised as serious threats to relevant sectors of the economy most sectors do not necessarily incorporate climate change issues in their operations. This may be attributed to the lack of information on adverse impacts of climate change except for the most identifiable impacts resulting from hurricanes.

Workshop on climate change vulnerability and adaptation assessment to: (i) brief the stakeholders (thematic working group on V&A/participants) on the V&A assessment in preparation for the second national communication under the new UNFCCC guidelines[8]; (ii) introduce a range of frameworks, approaches, methods, tools, and data sources for conducting V&A; and provide a forum for participants to share knowledge, experience, and difficulties in preparing the V&A and examine ways of overcoming these constraints/gaps.

Learning-by-doing focused on building the capacity of The Bahamas' experts. These experts will conduct V&A and identify, evaluate and prioritise key vulnerabilities, adaptive strategies, policies and measures for implementation. This will improve the adaptive capacity of The Bahamas, its resources and people. The training workshop provided instruction in the use and application of BahamasSimCLIM[9] for examining impacts and adaptations to climate variability and change in The Bahamas.

Modeling of future Climate Change and Sea Level Rise for The Bahamas involved the creation and/or generation of climate change and sea-level rise scenarios, appropriate global circulation models, (from the IPCC Special Report on Emission Scenarios (SRES)) greenhouse gas, other emission scenarios and the interpretation of results. This component also allowed for input of country-specific or site-specific data to The BahamasSimCLIM system.

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[8] The UNFCCC guidelines for the preparation of national communications from Parties not included in annex I to the Convention is contained in decision 17/CP.8 http://unfccc.int/resource/docs/cop8/07a02.pdf#page=2

[9] BahamasSimCLIM is a tool for generating climate change and sea-level rise projections using the various SRES emission scenarios. The tool has an open structure which allows it to be populated with the country-specific data and is linked to the several biophysical models for conducting integrated assessments. BahamasSimCLIM uses ensemble of 21 GCM patterns for generating climate change and sea-level rise projections for The Bahamas. More information on this tool and its applications can be obtained from http://www.climsystems.com/.

Evidence of Climate Change in The Bahamas

Historical record

Recent analysis of the temperature record shows that the average annual temperatures have been steadily increasing over the last 30 years (1971-2000) and this trend is likely to continue in the foreseeable future (McSweeney, et al. 2009). The mean annual temperature has increased by about 0.5^{o}C since 1960, at an average of 0.11^{o}C per decade (McSweeney, et al. 2009). As for rainfall, observational record shows that the mean rainfall has not changed significantly since 1960.

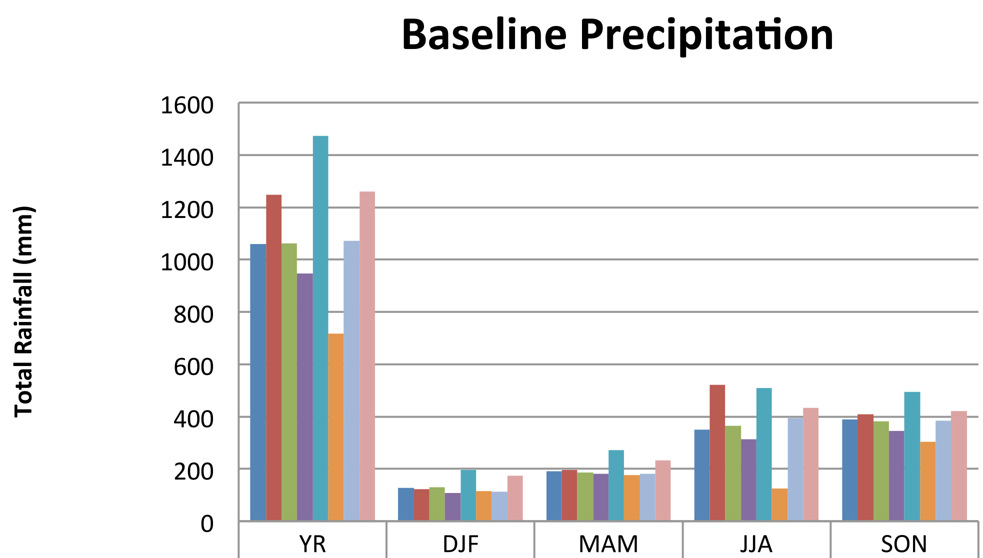
Climate Change and Sea-Level Rise Projections

Projections of future changes in climate are from a baseline, the average over the period 1961-1990. The SimClim software (Warrick 2009) which uses the results of the GCMs in the IPCC intermodal comparison database was used to generate the calculations. Where possible, ensemble results were used.

Precipitation

The baseline precipitation for The Bahamas and seven of the Family Islands is given in the table below (yearly total, as well as seasonal sums, all in millimetres).

Annual Seasonal Rainfall in The Bahamas



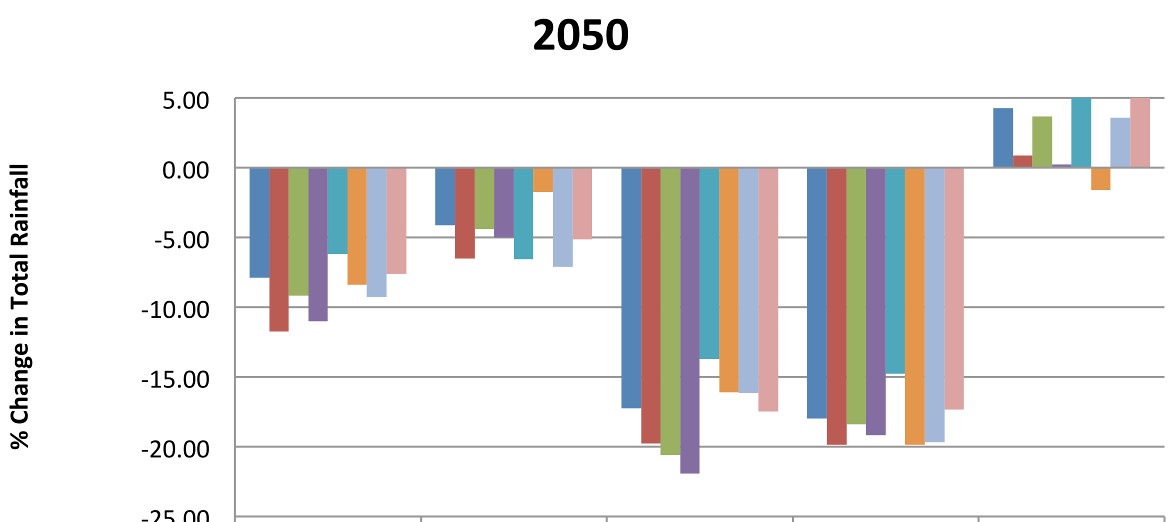
	YR	DJF	MAM	JJA	SON
Bahamas	1059	128	192	351	388
New Providence	1248	123	196	521	408
Eleuthera	1063	129	187	364	383
Exuma	948	109	180	313	346
Grand Bahamas	1472	196	272	510	494
Inagua	717	114	176	124	303
Andros	1072	113	180	394	385
Abaco	1260	174	232	433	421

Table 6: Annual seasonal rainfall in The Bahamas

The "wettest" island (Grand Bahama) gets twice the amount of rainfall (1472 mm) of that of the "driest" island (Inagua, 717 mm) annually. During, the June/July/August season, it is four times more (510 mm vs. 124 mm). Thus more rain falls in the northwest (Grand Bahama, Eleuthera, and Abaco), Central (Andros, New Providence) and less in the southeast (Exuma, Inagua). Decreases in summer rainfall in all islands are expected with significant decreases in Exuma, Eleuthera and New Providence. During the winter, Inagua will remain "driest" while all other islands to the northwest will experience an increase in rainfall by 2050.

Using the median result of a 21-GCM ensemble and the A1FI emission scenario, with high climate sensitivity rainfall changes (%) likely to be expected by 2050 will mean a decrease in rainfall by as much as 10% for annual precipitation, and 20% in some seasons for most islands (Table 6).

21-GCM Ensemble for The Bahamas (2050)



	YR	DJF	MAM	JJA	SON
Bahamas	-7.88	-4.12	-17.26	-17.99	4.25
New Providence	-11.76	-6.50	-19.79	-19.85	0.86
Eleuthera	-9.17	-4.38	-20.60	-18.41	3.67
Exuma	-11.00	-5.02	-21.92	-19.18	0.21
Grand Bahamas	-6.20	-6.58	-13.71	-14.79	6.92
Inagua	-8.38	-1.74	-16.12	-19.85	-1.62
Andros	-9.28	-7.09	-16.15	-19.68	3.57
Abaco	-7.63	-5.12	-17.47	-17.34	6.77

Table 7: Results of the 21-GCM Ensemble for The Bahamas (2050)

New Providence, Eleuthera and Exuma islands would experience up to 20% reduction in rainfall during the dry and wet seasons (March-August) by 2050.

The change in rainfall for The Bahamas would decrease by as much as 5-11% in most islands. Drier regions such as the southeast (e.g. Inagua) will become drier while the wet regions in the northwest will experience decrease in rainfall but not as much as the southeast region. Additionally, the seasonal differences will be greater ranging from 6-20% decrease. Figure 13 shows the spatial distribution of rainfall in the entire Bahamas archipelago.

Change in Precipitation for The Bahamas (2050)

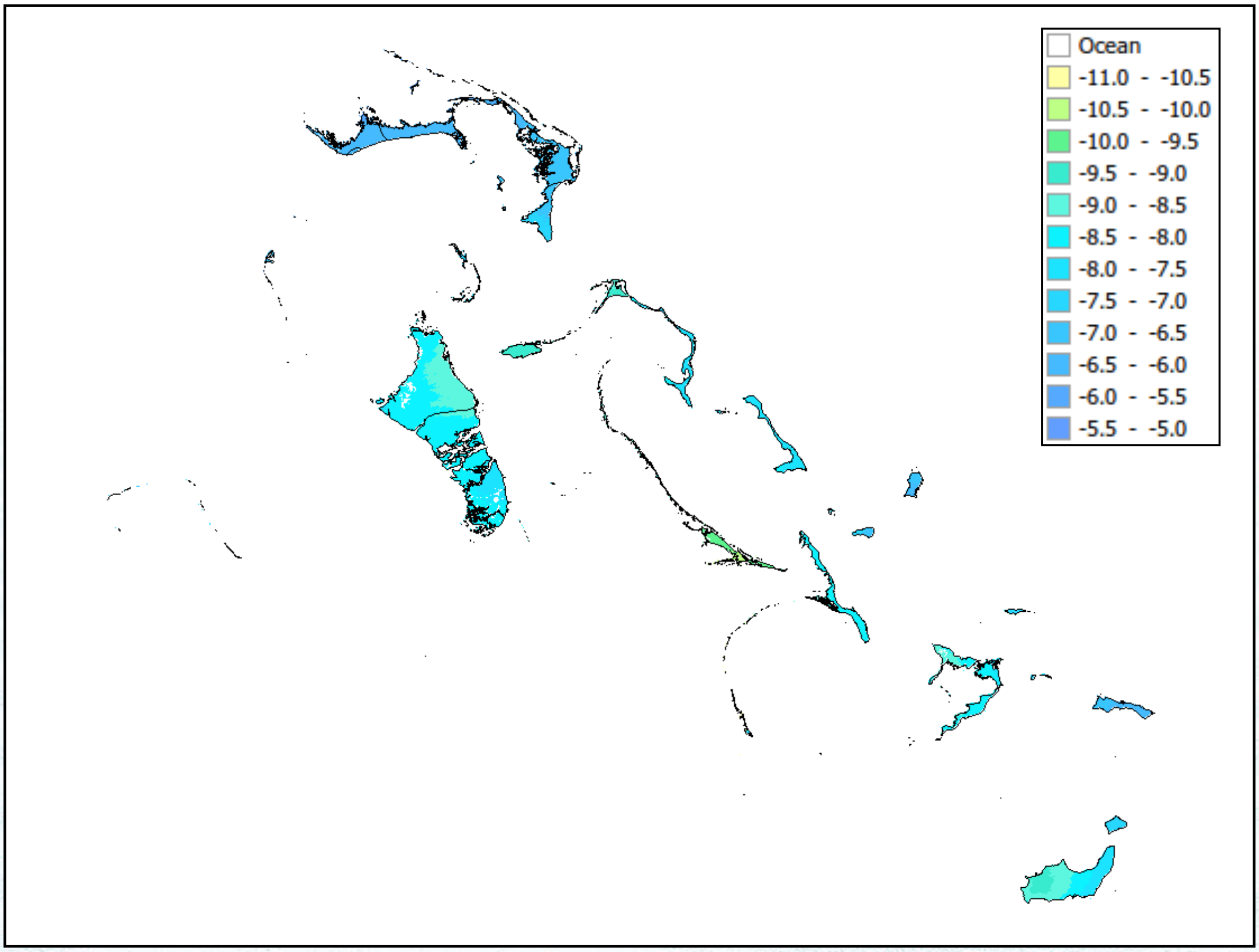


Figure 13: Change in precipitation for The Bahamas (A1FI, high, 2050)

Current climate variability was assessed through historic observations which are available for Nassau Airport (New Providence), with highly variable total annual rainfall ranging from less than 500 mm to 2500 mm per year (based on 1977-2009).

An extreme value analysis tool was used to analyse extreme events for current climate and climate change. It was also used to calculate return periods for certain extreme rainfall events. Figure 14 shows that the most extreme rainfall event at Nassau Airport (481 mm of rain in one day) has a return period[10] of once in almost 60 (58.07) years. A 1:100 year event is almost 560 mm of rain.

[10] A return period, also known as a recurrence interval, is an estimate of the interval of time between events like an extreme rainfall or extreme event of certain intensity or size. It is usually required for risk analysis (i.e. whether a project should be allowed to go forward in a zone of a certain risk and also to design structures so that they are capable of withstanding an event of a certain return period.

High Extreme Precipitation

The extreme event analysis shows that The Bahamas will experience a decrease in precipitation, suggesting future extreme high events would be less severe. However, when daily outputs of 12 GCMs are applied, the analysis shows that by 2050 (with A1FI-high), the return period for the current most extreme event will have dropped to 42 years (from 58), while the 1:100 year event increases to 622 mm (from 560 mm). This would mean that such events would become more severe and more intense.

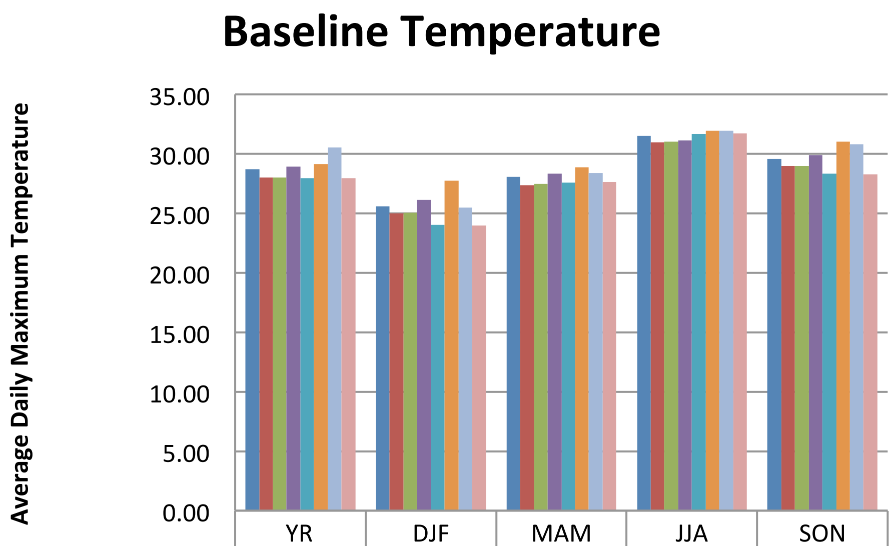
Low Extreme Precipitation

For low extreme rainfall, a low amount of rain in a given period is calculated as the extreme event. In this case a 90-day period (three months) was chosen. Using the example for Nassau Airport, and for every 10 years, at least one three-month period will have less than 24 mm of rain (extreme low rainfall). However, by 2050, under the A1FI-high scenario, and using a 21-GCM ensemble, this will have dropped to 20 mm of rain. While the driest period (DJF) only shows a decrease of up to 7%, this analysis shows that for extreme droughts, the decrease in rainfall is closer to 17%.

Temperature: Extreme (High) Temperature

The baseline for daily maximum temperature for The Bahamas and seven of its islands is shown in Table 8. Maximum daily temperatures range from 27^{o}C to 31^{o}C for most islands with an average maximum temperature of 28.70^{o}C for the entire Bahamas. Analysis of extreme or maximum temperatures shows a 5^{o}C change from winter (DJF) and summer months (JJA).

Average Daily Maximum Temperatures for The Bahamas, 1960-2006



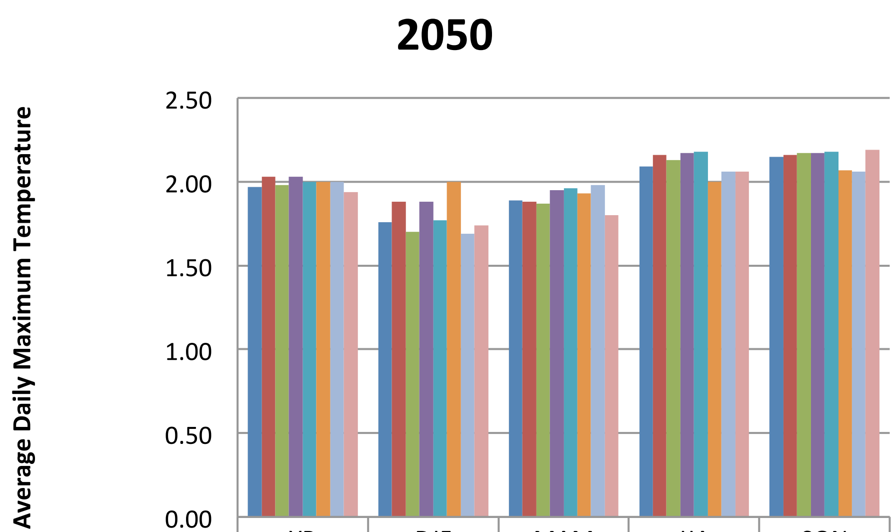
	YR	DJF	MAM	JJA	SON
Bahamas	28.70	25.61	28.08	31.49	29.58
New Providence	28.01	24.97	27.37	30.97	28.97
Eleuthera	28.02	25.05	27.47	31.00	28.99
Exuma	28.91	26.11	28.34	31.15	29.90
Grand Bahamas	27.97	24.02	27.57	31.69	28.31
Inagua	29.11	27.72	28.86	31.93	31.00
Andros	30.54	25.49	28.37	31.93	30.83
Abaco	27.95	23.99	27.61	31.70	28.27

Table 8: Average daily maximum temperatures for The Bahamas, 1960-2006

However, when projecting maximum temperature for 2050 by using a 21-GCM ensemble, and the A1FI emission scenario, with high climate sensitivity, the following changes for the daily maximum temperature are expected: (1) maximum temperature for The Bahamas will increase by 1.97°C while maximum temperature increases for individual islands will range from 1-2°C; (2) the average daily maximum temperature of the winter months will be less than 2°C while the summer months will be just over 2°C; (3) the drier islands in the southeast will experience higher temperatures during the winter months (DFJ) than the central and northwest regions. The range of daily average maximum temperature increase in The Bahamas is expected to be up to 2°C which compares favourably with the expected increase of 2.7°C global average daily temperature. The lower increase in The Bahamas is due to the moderating effect of the surrounding waters (Please see Table 9).

Increase in Average Daily Maximum Temperature Under A1FI, High Sensitivity, 2050

Increase in Average Daily Maximum Temperature Under A1FI, High Sensitivity, 2050



	YR	DJF	MAM	JJA	SON
Bahamas	1.97	1.76	1.89	2.09	2.15
New Providence	2.03	1.88	1.88	2.16	2.16
Eleuthera	1.98	1.70	1.87	2.13	2.17
Exuma	2.03	1.88	1.95	2.17	2.17
Grand Bahamas	2.00	1.77	1.96	2.18	2.18
Inagua	2.00	2.00	1.93	2.00	2.07
Andros	2.00	1.69	1.98	2.06	2.06
Abaco	1.94	1.74	1.80	2.06	2.19

Table 9: Increase in average daily maximum temperature under A1FI, High Sensitivity, 2050

Baseline Average Daily Maximum Temperature, New Providence

Using the example of spatial distribution of average daily maximum temperature in New Providence, it can be seen that there is an increase in temperature for New Providence (range 0.2^{o}C - 0.9^{o}C) from the baseline (1960-2006) temperature, which is consistent with the increase over the entire Bahamas (Figure 15). Depending on the geography of the island and the positioning of the prevailing trade winds, subtle differences can be experienced with respect to temperature and rainfall even under current climate, atmospheric and oceanic conditions. It is likely that these subtle differences could be amplified under future climate change.

Daily Maximum Temperature Projected for New Providence (2050).

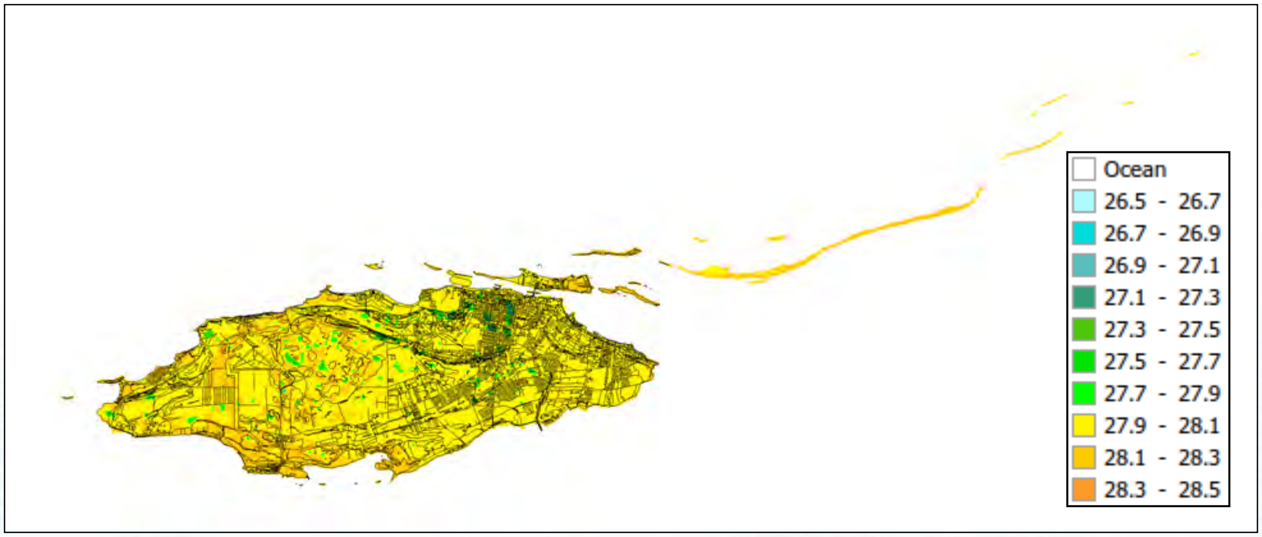


Figure 15: Average daily maximum temperature projected for 2050, New Providence.

Using the 21-GCM ensemble, under the A1FI high scenario by 2050, the projected temperature increase is spatially uniform over the island of New Providence (2.0^{o}C), ranging from 26.50^{o}C to 28.50^{o}C. However, for the entire Bahamas the increase in average daily maximum temperature ranges from 1.91^{o}C to 2.11^{o}C (Figure 16). The daily maximum temperature is highest in the northernmost island of Grand Bahama and in the southernmost island of Inagua (average over 2.0^{o}C). In the central part of The Bahamas the daily maximum temperature increase of 1.93^{o}C to 1.97^{o}C is expected.

Daily Maximum Temperature for The Bahamas Under A1FI for 2050

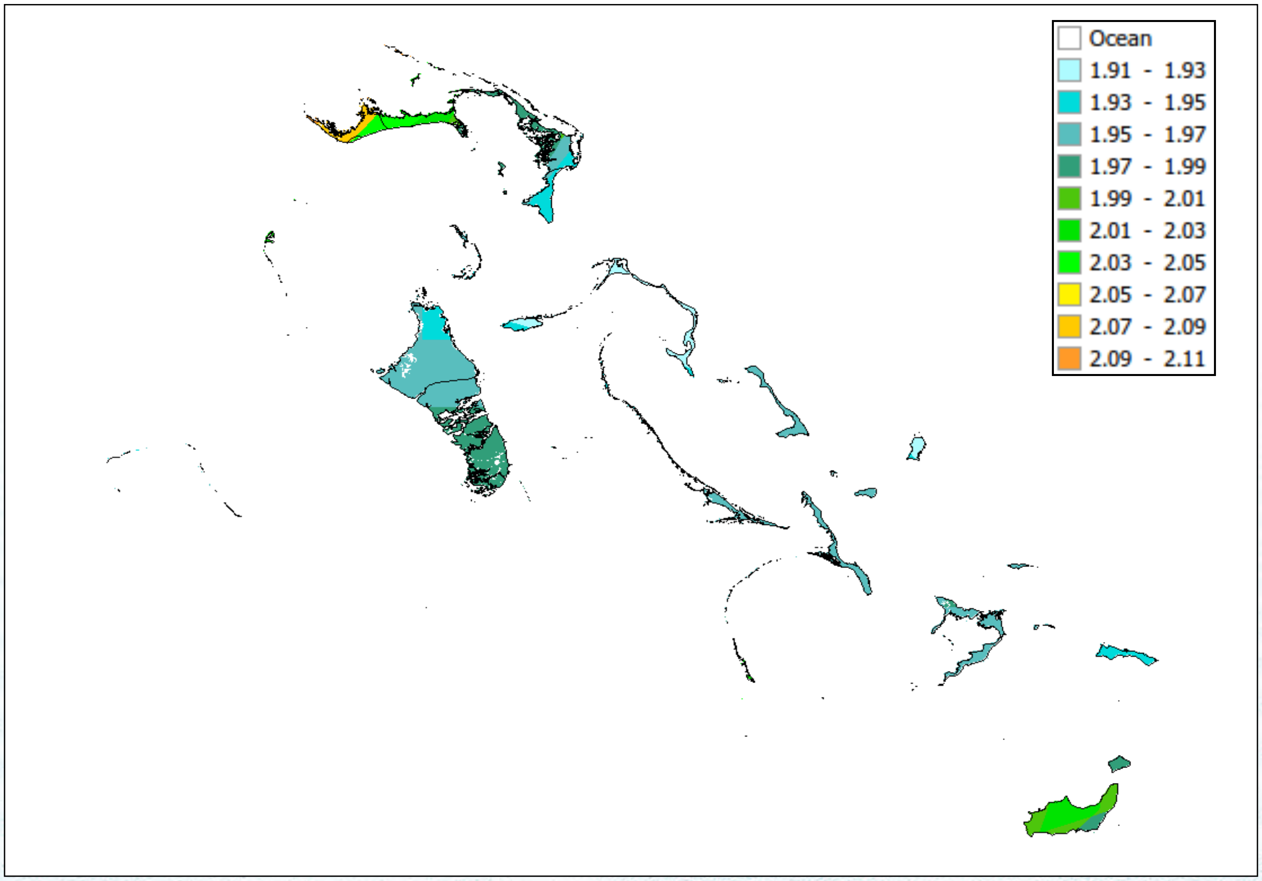


Figure 16: Average daily maximum temperature for The Bahamas under A1FI for 2050

Observational record at Nassau Airport shows a steady increase in average daily maximum temperature between 1974 and 2008 (34 years) (Figure 17).

Daily Maximum Temperature at Nassau International Airport (1974 -2008)

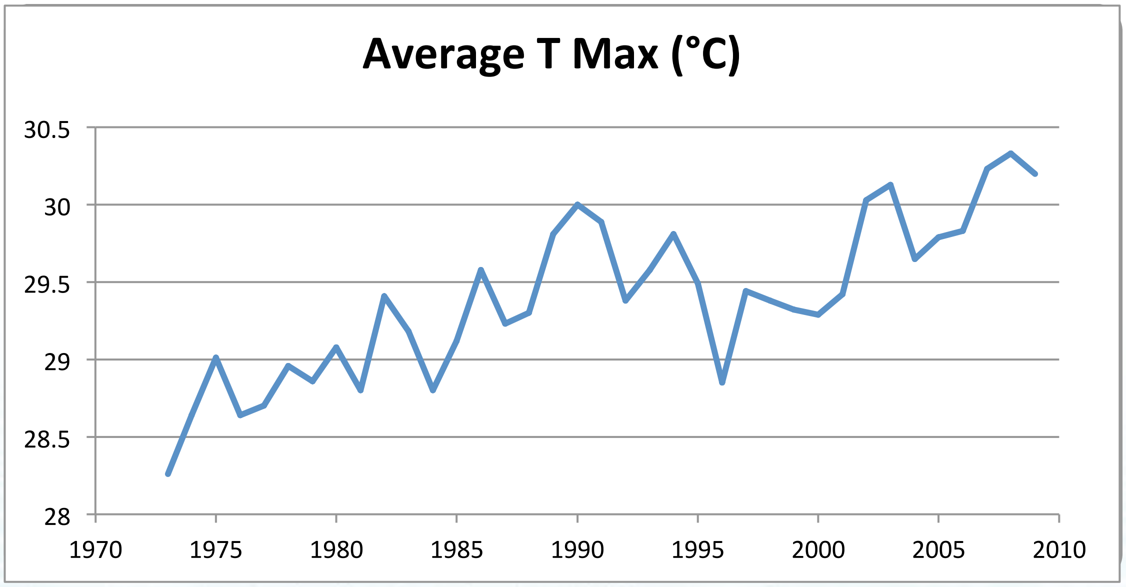


Figure 17: Average daily maximum temp. at Nassau Airport, New Providence (1974 -2008)

The use of extreme value analysis shows that the highest temperature extreme of 39.22^{o}C has a return period of 74.31 years. Under the A1FI-high scenario, using a 21-GCM ensemble, by 2050, the frequency will increase to 9.92 years. Thus, extreme temperatures are likely to occur more frequently by 2050.

As with extreme value analysis, the trends for maximum and minimum temperatures were analysed for Nassau Airport (Figure 18).

Temperatures Trends at Nassau International Airport (1973-2010)

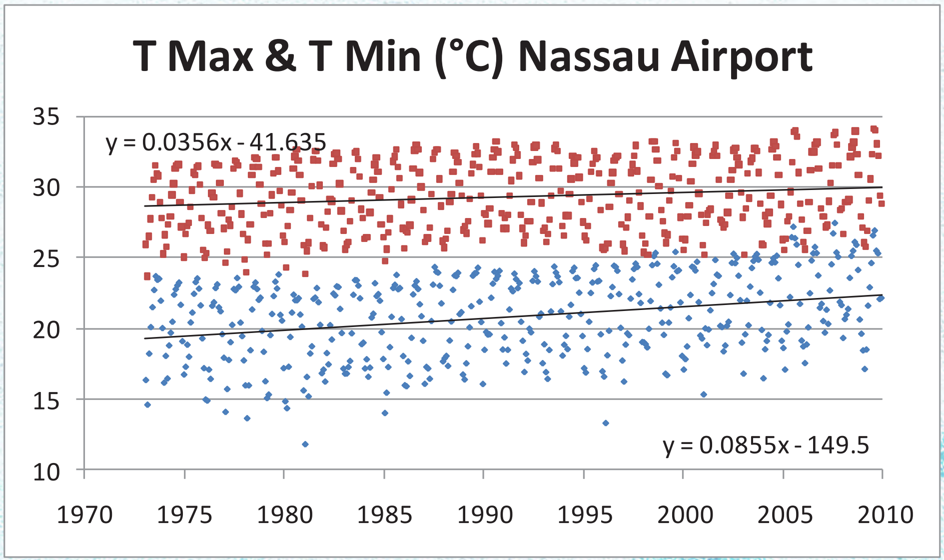


Figure 18: Trends for maximum (red) and minimum (blue) temperatures

Figure 18 shows that minimum temperature (TMin) has risen at a rate of 0.05°C/yr faster than the maximum temperature (TMax). The total increase for TMin was 3.24°C while the total for TMax was 1.35°C over almost 38 years. The increase in TMin is consistent with the faster rate of increases in night time temperatures than day-time temperatures globally (Meehl, et al. 2009).

Sea Level Rise

With respect to sea level rise, the analysis here uses historical hourly data from Settlement Point, Grand Bahama, which has a good data set to uncover a trend. Figure 19 shows that recursively fitting the data-points to a trend line assesses the rate of sea level rise in order to determine if the estimate converges. This analysis shows that relative sea level rise at Settlement Point (Grand Bahama) is between 0 and 0.5 mm/yr. Additionally, from the SONEL database (Santamaria-Gomez and Bouin, 2009) with vertical land movement data, the value of -0.7 mm/yr (land sinking) is estimated. Thus sea-level rise is slower than the vertical land movement (i.e. sinking/subsidence). This indicates that the impact of thermal expansion causing sea-level rise is minimal for Grand Bahama.

Sea Level Rise Recursive Estimate at Settlement Point, Grand Bahama

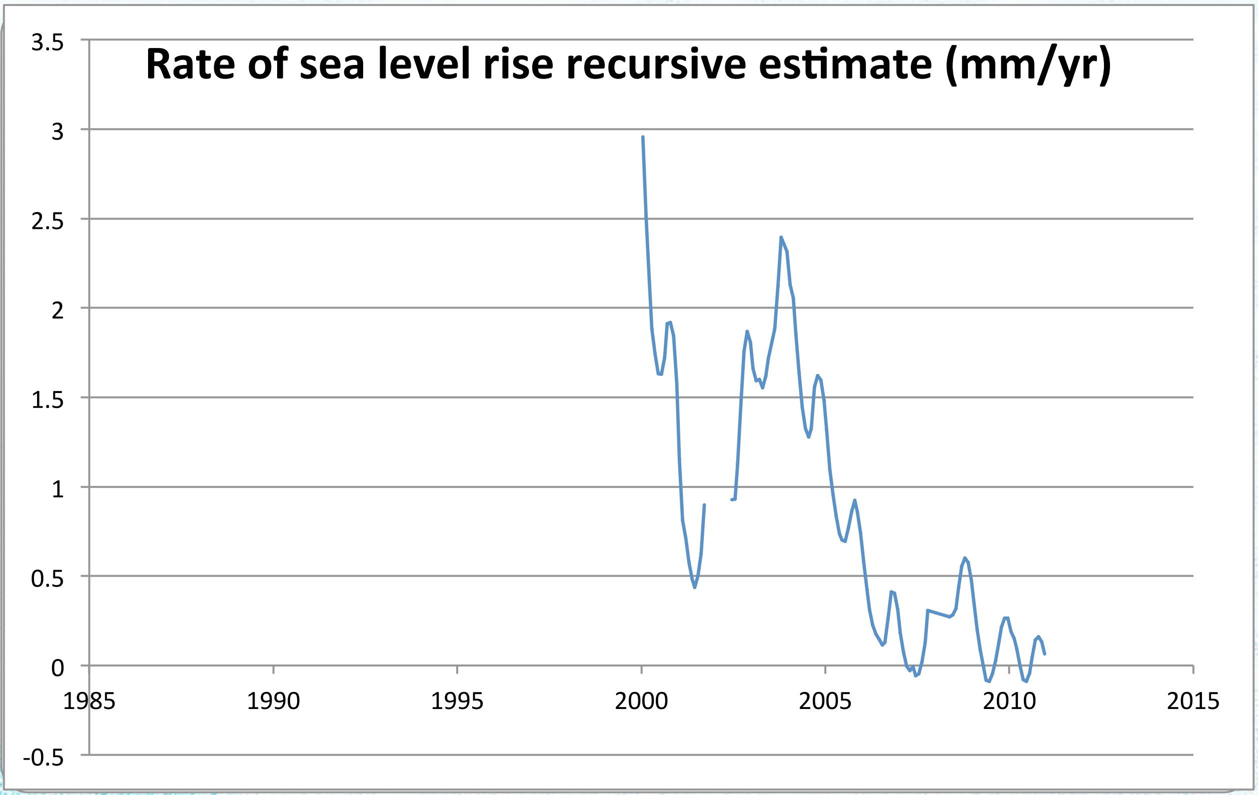


Figure 19: Sea level rise recursive estimate at Settlement Point, Grand Bahama (mm/yr).

While the historical evidence, as presented above, shows that sea-level rise is occurring at a slower rate than vertical land movement, it also indicates that sea level is rising at a rate of 0.2 mm/yr (the difference between vertical land movement and thermal expansion). Based on the

13-GCM Ensemble and using the A1FI scenario, the sea level rise is projected to increase by 2100 in The Bahamas. Figure 19 shows that by 2030 the sea level will have risen by 9.0mm and by 2050 the sea level rise will be 20mm and by 2100 it will be near or at 70mm. The increasing rate of sea level rise in the Grand Bahama is consistent with the global sea level trend.

Sea Level Rise Projections (AIFI), 2100 (local, 13 GCMs)

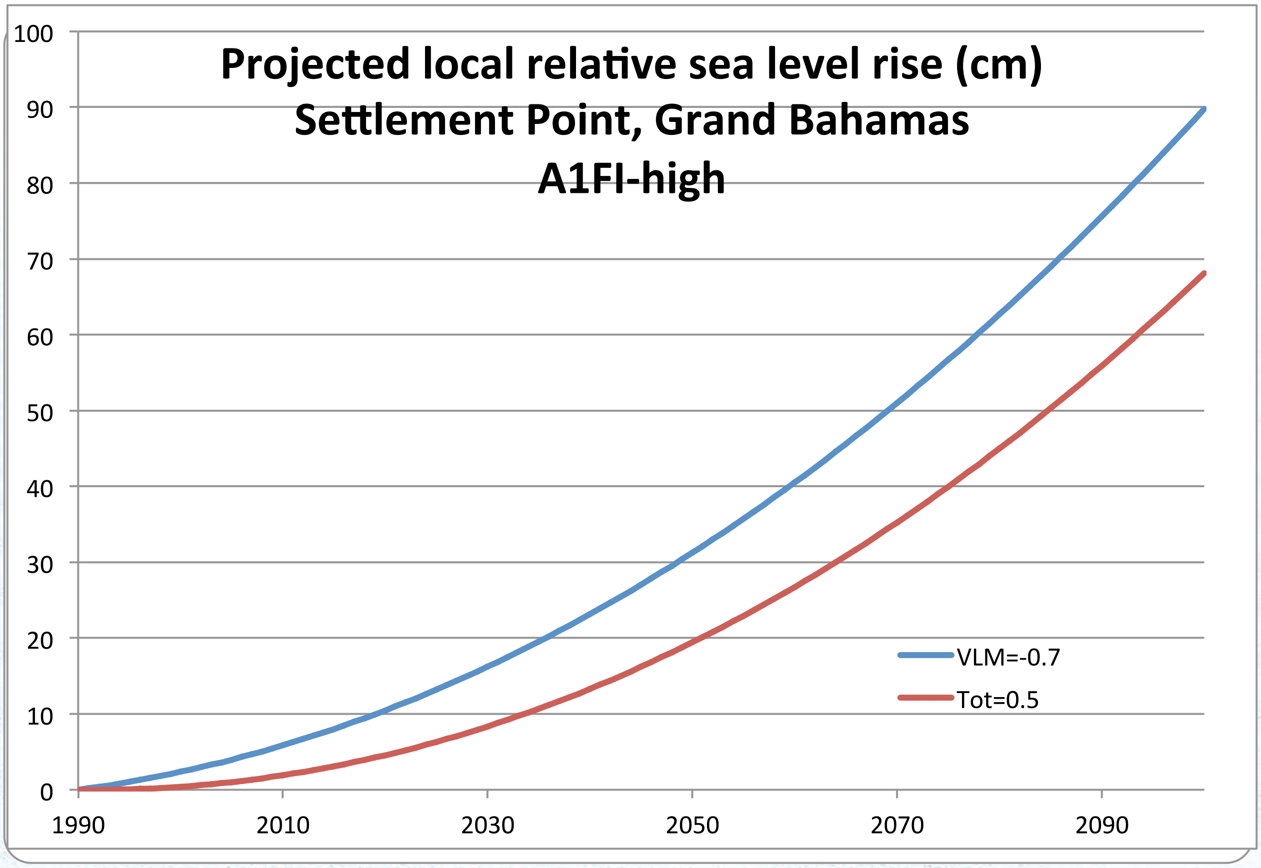


Figure 20: Sea level rise projections (AIFI), 2100 (local, 13 GCMs). The blue line shows vertical land movement (VLM), and the red line shows total sea level rise (Tot). The y-axis is in mm.

Storm Surge Modeling

The vulnerability of The Bahamas is further reinforced by Sea Lake and Overland Surges from Hurricane (SLOSH) modeling. Under the worst-case climate change scenarios and with variable intensity of hurricanes, the surge height overland in many of the islands will be up to 26ft (7m), which would render most parts of the islands under water.

A recent study of a comparative analysis of the impacts of sea level rise and storm surges in developing countries (Dasgupta, et al. 2009) indicates that relative exposure of coastal populations will be high for The Bahamas (73.02%), with most severe losses in coastal GDP (65.7%). The urban extent along the coast will be highly vulnerable to inundation from storm surges in The Bahamas (94.12%) while coastal wetlands will be subject to 71.4% inundation risk from storm surges. Of the top ten countries most at risk to storm surges, The Bahamas is ranked 1 (highly vulnerable) with respect to its coastal population, loss of GDP and coastal urban areas.

The foregoing analysis of climate change in The Bahamas provides a basis for taking action as early and urgently as possible to either cope with and/or adapt to imminent changes that are likely to be expected over the coming decades.

IMPACT ASSESSMENT AND KEY VULNERABILITIES

The key vulnerabilities in The Bahamas are water resources, forests, human health, agriculture, human settlement, disaster management, energy, tourism and coastal zones. These vulnerabilities were identified through consultative processes including expert workshops and synthesis reports[11] prepared by relevant experts.

Water Resources - The Bahamas depends almost entirely on groundwater resources, which are extremely vulnerable, particularly in the low-lying limestone islands. This vulnerability is caused by several factors: overexploitation of the water lens; development of canals and waterways for boat access and to increase the value of lots; seawater inundation in low-lying limestone islands; and pollution of the water resources. Of all the threats to water resources identified and outlined above, the most significant is water table rises, which generally occur in the flatter low-lying areas.

Human Health - Temperature increase of 1.5^{o}C to 2.0^{o}C is evident for all highly populated islands of The Bahamas. This will contribute to increases in vector-borne (e.g. dengue and malaria), water-borne and communicable diseases and increased costs associated with treating these diseases. Elevated temperatures with little rainfall can increase incidences of dengue fever that can put pressure on public health resources. Increased temperatures would also affect the lifestyle of an aging Bahamian population with increased incidences of respiratory and cardiovascular problems.

Human Settlement and Infrastructure - The main challenge of human settlement and infrastructure development is the extensive areas of pine forests that have been cleared and developed for housing and agriculture. Clearance of pine forests will affect water sources and public services. For example, there is no freshwater flowing on the island of New Providence, thus the capital city Nassau relies heavily on reverse osmosis for its water supply. Increasing population, land and infrastructure development makes the preservation of the pine forests and well fields more difficult. As the population continues to increase, groundwater sources are now

[11] Synthesis reports were prepared for water resources, energy, forests, human settlements and infrastructure, agriculture and tourism.

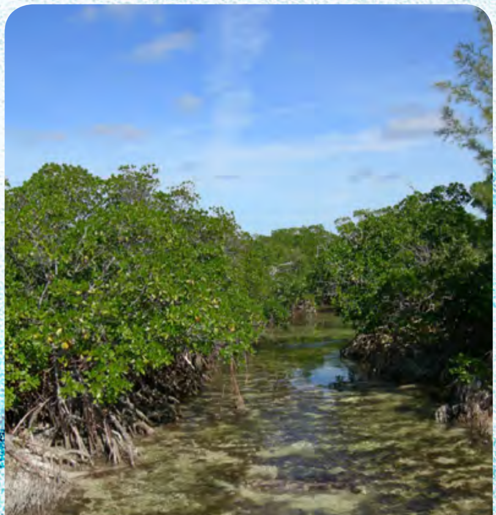
fully developed and no increased quantity from this source can be achieved easily in the near future.

Agriculture - Agricultural production in The Bahamas focuses on four main areas: crops, poultry, livestock, and dairy. Climate change will exacerbate the problems associated with food production in The Bahamas, as it currently experiences a limited capacity to grow food. Thus, climate-related extremes such as storm surge and sea-level rise would result in loss of arable land which can limit the capacity to produce crops. The expected changes in mean annual temperature are unlikely to have a major impact on Bahamian agriculture until the latter part of the century. However, warming of the magnitude that has been projected, coupled with CO_2 fertilization, may increase plant growth in the short term. Extreme high temperatures and an increase in global average temperature can damage food crops thus affecting food production and yield.

Coastal Zones - Much of the coastline of The Bahamas, particularly in the built-up areas, are protected by seawalls. However, infrastructure and investment is under serious threat from climate change, sea level rise and extreme events like storm surge associated with hurricanes. Construction of harbour facilities, such as at Gunpoint, Ragged Island, is necessary for quickly getting supplies safely to the island after a hurricane or other storm event.

Tourism - The Bahamas is the third most popular destination for the 43 million US dive market, 30% share. The industry supports the jobs of approximately 900 divers and contributes, on an annual basis, 49,000 room nights to the accommodation sector (Bahama Dive Association). Tourism contributed an estimated $365M to the economy in 2009. In fact, The Bahamas lost 10% of its GDP due to two hurricanes (Frances and Jeanne) at a cost of USD 551m. Additionally, destinations that are frequently hit by hurricanes or severe weather events suffer from the perception in the market that they are unsafe.

Forests - Presently, there is no information available on the potential impacts of climate change on Bahamian forests. It had been documented in other countries that the climatic variables directly influence plants and trees as a result of the increasing concentration of CO_2 in the atmosphere. Research will have to be conducted to determine the physiological effects as well as the correlation of forest health, fires, storm surges, hurricanes impacts, sea-level rise and soil salinisation levels. With the expected increase in temperature coupled with CO_2 fertilization effect may increase forest growth but this is likely to be compromised by the effects of intense hurricanes, which usually destroy large tracts of forests in The Bahamas.



Biodiversity - Impacts of climate change on biodiversity includes sea level rise, saltwater intrusion, coastal erosion; ocean acidification, and coral bleaching. The results of coral bleaching are far reaching. It reduces the ability of coral reefs to act as a natural defence system that will protect our beaches from storm surge and erosion. Beach erosion negatively affects the Tourism industry. Other impacts of climate change on biodiversity are droughts, floods, fires, storm surge, hurricanes, ENSO, vector and water-borne diseases and invasive species.

Energy - Direct impacts are those that directly influence processes related to energy production and power generation, including transportation, energy resource availability (effects of weather on shipment of energy sources), electricity generation, and transmission and distribution systems. Erosion of the coast impacts the maintenance and safe handling of fuel. Hurricanes, droughts, floods, fires and storm surge also pose a serious threat to infrastructure of the energy sector.

ADAPTATION MEASURES, STRATEGIES AND OPTIONS

The vulnerability analysis suggests that many of the issues, constraints, gaps and difficulties relating to climate change are not necessarily new. Rather they will become worse if no actions are taken to address them. From the foregoing, the evidence of climate change in The Bahamas will be seen by temperature increases by of at least 2^{o}C in the coming decades (by 2050). This will place additional pressure on the population, human systems and natural ecosystems that provide goods and services to sustain livelihoods. Some islands will become wetter and others will become drier with more frequent extreme events in The Bahamas.

In recognition of problems associated with sustainable development and the greater potential for worse problems under climate change, the Government of The Bahamas developed a National Policy for the Adaptation to Climate Change (NPACC) in 2005. This policy identifies the key vulnerable sectors to which resources would be directed to address climate change issues and concerns. The analysis of available information, on each of the key vulnerable sectors identified, indicates that only a handful of actions have been implemented including the development of policy actions for energy and forestry.

The adaptation measures, strategies and options identified were aided by information generated through vulnerability assessments, sectoral reports produced by national experts, stakeholder consultations and the several expert and training workshops.

Water Resources - Policies and measures that need to be adopted to protect the nation’s freshwater resources and related environmental concerns are as follows:

a) Enactment of laws and regulations, where needed. (The Water Management Consultants 2003 report outlines these needs in detail):
b) Prevention of further development in low-lying areas proned to flooding, now, or in the future;
c) Non-excavation of canals, waterways and areas below the water table;
d) Control of rock and sand mining activities that are restricted to approved locations only;

e) Protection of beach ridge and coastal dune formations;
f) Protection of mangroves and similar coastal features;
g) Adoption of appropriate physical planning policies that will protect infrastructure from storm surges and rising water tables;
h) Promotion of careers in Environmental Engineering and Hydrology.
i) Provision of local courses and training programmes for young Bahamians.

With accurate sea level projections and more knowledge of future changes in climate, it is anticipated that there will be a better understanding of how groundwater conditions will change. It should become feasible to plan how long a specific water resource area can be used as a supply; when it should be abandoned; and when plans will commence for the development of future alternate supply options. Alternative sources must be considered and the most obvious of these must be desalination. This accepted technology involves high energy usage and is costly. More attention has to be given to devise ways to produce alterative energy options that provide potable water at acceptable prices. Two other research areas of particular relevance to The Bahamas are Ocean Thermal Energy Conversion (OTEC), and current power. The Bahamas has a reverse geothermal energy profile that may permit the necessary cold water for OTEC use to be directly retrieved from deep wells.

Forests

Presently, there is no information to access the potential impacts of climate change on Bahamian forests. Research will have to be conducted to determine the physiological effects as well as the correlation of forest health, fires, storm surges, hurricanes impacts, sea-level rise and soil salinisation levels.

In order to meaningfully address the present state of affairs in the public forestry sector, the following realistic and fundamental mechanisms are prescribed for adoption;

a) Enact comprehensive forestry legislation, ensuring congruency with international standards and protocols;
b) Establish institutional arrangements for forestry (Forestry Unit) to effectively and efficiently undertake the mandate for sustainable forest resource management. This institution should be adequately resourced with qualified staff, and a sustained budget. It should be guided by the provisions of the National Forest Policy, Forestry Law and Regulations;
c) Review and evaluate the existing forest management plans for the sustainable management of all types of forests, on Crown Lands;
d) Plan and implement a comprehensive public education and awareness program on all aspects of forestry development and conservation in partnership and concert with relevant stakeholder agencies in The Bahamas;
e) Institute a program to allow for the sustainable utilization of the natural pine forest resources;
f) Actively participate on the Committee on Forestry (COFO) of the FAO, the Latin American and Caribbean Forestry Committee (LACFC) of the FAO, the Standing

Committee on Commonwealth Forestry, the Commonwealth Forestry Association and the Caribbean Foresters Association;

g) Develop a program to recruit and train Bahamian students from high schools, who show a keen interest in forestry and conservation; and
h) Provide In–Service Training Awards or Scholarships for training in forestry sciences & conservation.

Tourism

In response to the impact of climate change, variability and extreme events on the tourism sector, the Ministry of Tourism will engage in the following activities:

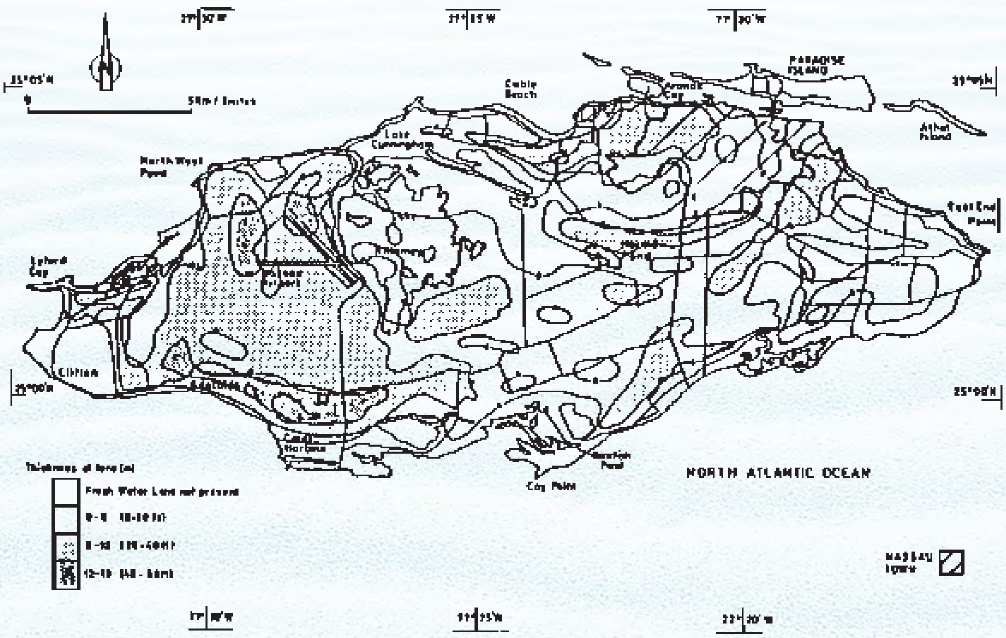
a) Awareness-raising of policy makers and other relevant stakeholders through workshops and symposiums to understandings of the impact of climate change on tourism and related sectors;
b) Introduction of the Foundation for Environmental Education Blue Flag certification program to marinas to encourage the development of programs that will protect the marine ecosystem;
c) Development of a hurricane preparedness and evacuation plan that will permit the tourism sector to respond and recover from any hurricane or extreme weather events in cooperation and collaboration with its public and private partners;
d) Assist communities to develop funding mechanisms and technical know-how in protecting their beaches and shoreline in conjunction with the Coastal Awareness Committee;
e) Educate the general public on the role of wetlands play in the protection of our coast from storm surges and as an important habitat for fisheries and wildlife;
f) Solicit the support and buy-in from local stakeholders and the travel public to educate persons on climate change and its impact; and
g) Establish an Integrated Coastal Zone Management Unit to manage our coastal assets.

Financial, technical and human resources are required to train additional Department of Meteorology technicians in the use of the SLOSH modeling to forecast hurricane landfall, and provide equipment to assist in mapping coastal areas vulnerable to sea level rise.

OTHER INFORMATION CONSIDERED RELEVANT FOR THE ACHIEVEMENT OF THE OBJECTIVES OF THE CONVENTION

The Bahamas has taken the following initiatives to implement the Convention:

Integration of Climate Change into National Policies - The Bahamas has a National Policy for the Adaptation to Climate Change. The policy outlines a framework for advancing the capacity and capability of The Bahamas to effectively adapt to climate change impacts and contribute significantly to the conservation and preservation of The Bahamas' natural resources for present and future generations. Integration of this policy and other aspects of climate change vary across agencies:



FRESHWATER LENS THICKNESS MAP OF NEW PROVIDENCE

- **Department of Meteorology** has no existing policies. They operate with based on the National Emergency Management Agency (NEMA) Plan of Action. The Department is involved in the Global Climate System (GCOS) program, and is looking at being involved in Global Earth Systems Observing System.

- **Bahamas Electricity Corporation's (BEC)** priorities include the reduction of electrical power produced from fossil fuels (this will lead to reduction in fuel costs). A draft national energy policy encourages BEC to look at solar, wind, waste-to-energy, Ocean Thermal Energy Conversion and plasma energy generation as alternatives.

- **Water and Sewerage Corporation's (WSC)** priorities include developing adequate service standards throughout the country, providing the populace with potable water and collecting their waste effluents.

- **Ministry of Education's** policies include educating young children about climate change. Climate change is incorporated in the national secondary school curriculum with more detail provided at Grades 10 through 12 levels.

- **The College of The Bahamas (COB)** has educational policies and programs for science, science majors and teachers. COB has a Small Island Sustainability programme that includes a curriculum related to climate change.

- **Port Department** contributes to statistics and GHG issues.

- **Department of Lands and Surveys** LUPAP (land use policy and administration project) is an attempt to create a base map of all the islands of The Bahamas starting with Grand Bahama, New Providence and Abaco. GIS maps or statistics would be the best format for relaying information.

- **Department of Agriculture** is looking at policies on land use and tenure, water use and management, pesticide use, animal and plant health, food security and production, wildlife conservation and research, import control, and rural planning. The Department is encouraging farmers to use greenhouses to start seedlings and grow crops. They are also fostering the use of improved seed varieties and drip irrigation instead of rain fed agriculture.

- **Department of Environmental Health Services (DEHS)** speaks to the issue of burning, and may make it illegal to emit any pollutant into the environment.

- **Ministry of Finance's** policies include a reduction in duty on solar panel and other equipment related to solar energy.

- **Bahamas National Trust (BNT)** does not include climate change, but is planning to review them to see how they can include this issue. Its priorities are biodiversity and wetlands conservation.

- **Ministry of Tourism** has no existing climate change policies, but it supports the national climate change policy. Priorities include conserving the natural resources of The Bahamas and making tourism thrive. Sustainable tourism guidelines exist that are provided to developers when new projects are presented to the Ministry for comment.

Other areas considered relevant for the achievement of the objectives of the Convention include the mechanisms for transfer and access of Environmentally Sound Technologies for adaptation and mitigation in agriculture, energy (including renewable), health, transportation, water conservation, land use, forestry and tourism. The Bahamas contributes and participates in Climate Change Research and Systematic Observations as a member of the World Meteorological Observations (WMO) and the Global Climate Observing System (GCOS). Systematic observations are made from a network of 21 automatic weather observing stations on 15 inhabited islands. Hydrological Observations include a data well wave rider buoy study of waves for use in marine forecasting for coastal management and planning. Sea level is monitored by three tidal gauges installed in Nassau Harbour, Lee Stocking Island and Inagua. A tidal gauge has been maintained and operated since 1978 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. Research Programmes range widely. They encompass regional and international initiatives, meteorological and socio-economic elements. A study on El Nino-Southern Oscillation is to design feasible regional early warning systems to ameliorate the impacts of the El Nino Southern Oscillation (ENSO).

Education, Training and Public Awareness carried out by The National Climate Change Committee (or NCCC), under the auspices of the BEST Commission, has tasked a public education and outreach subcommittee (or PEO subcommittee) with drafting and implementing a public education and outreach strategy on climate change in The Bahamas. Education on climate change includes general environmental education components, but no specific content on climate change. The national secondary school level curriculum currently includes specific components on climate change. Media has no specialist environmental journals or newspapers, and there is limited national scholarship on the issue.

Non-governmental organizations such as The Bahamas National Trust (BNT) have developed many educational programs and collateral material that aid in teaching the effects of climate change in the ecosystems of The Bahamas. Programmes include Treasures in the Sea Teacher Resource Manual, the Wondrous Wetland Workshop and teacher's resource that highlights the importance of mangroves in acting as barriers for hurricanes and storm surges. The Bahamas Reef Environmental Education Foundation (BREEF) conducts an annual summer Marine Conservation Teacher Training Workshop at the Gerace Research Center on San Salvador. The objective of the workshop is to provide Bahamian primary and secondary level educators with hands-on experiences in the marine environment that they could subsequently share with their students.

Public Sector participation in climate change issues has been encouraged through presentations by senior government officials, efforts to build capacity and report on the national involvement in the UNFCCC process. Public Participation and Access will be promoted with plans to enact a

Freedom of Information Act and the enacted Planning and Sub-division Act 2010. Sub-regional, Regional and International Cooperation is being developed through partnerships on climate change with the University of South Florida.

CONSTRAINTS, GAPS AND RELATED FINANCIAL, TECHNICAL AND CAPACITY NEEDS

Gaps, Needs and Priorities include a lack of national data collection and distribution initiatives; policy interactions; and prioritization of climate change at the institutional and executive level which further reduces the efficacy of any educational and outreach impetus. In order to address these gaps and needs, further funding will be required to implement the public education and outreach strategy. Capacity building is required for better management of the impacts of climate change and sea level rise on coastal resources, human settlements, and infrastructure. The Caribbean Planning for Adaptation to Climate Change (CPACC) seeks to strengthen regional cooperation and institutions to provide a cost-effective means for adaptation planning, data collection, sharing of information and skills and project benefits.

The 2005 National Capacity Needs Self-Assessment (NCSA) Report confirmed that “current levels of government funding are insufficient to adequately support the implementation of the four international environmental Conventions” with the UNFCCC being one of the four. A lack of financial resources at the systemic and institutional levels was identified as a key obstacle to staff training.

Technology Needs Assessment is scheduled to occur within the next 3 years, and will provide the basis for technology transfer to The Bahamas. Other Capacity Building Needs include the need for regulations related to climate change. Legislation is also required for environmental impact assessment guidelines to adequately address extractive processing, energy industries, industrial operations and manufacturing in the context of climate change. Funding is also required for a fully staffed Ministry of the Environment of 274 persons with necessary infrastructure and equipment.

CHAPTER 1: NATIONAL CIRCUMSTANCES

1.1 GEOGRAPHICAL CHARACTERISTICS

1.1.1 Location

The archipelago of The Bahamas contains the largest tropical shallow water area in the Western Atlantic. It is located on the northern and eastern margins of two large submerged banks. The Bahamas has over 700 islands that are low-lying and composed of limestone. The sub-tropical climate and a geographic position between two major warm ocean currents affect the region with seasonal variability. This variability of the seasons influences the biological communities inhabiting the ocean and coastal areas.

The Bahama Banks are separated from the North American continent by the Florida Straits and deep channels in excess of 6,561ft/2000m (see Figure 1). Two deep water channels cut into the larger Great Bahama Bank. Most of the marine area is shallow (65ft/20 m), and contributes to marine resources with both important ecological and economic value. The northern and central islands are located on two vast carbonate platforms averaging 33ft/10 meters in depth. Little Bahama Bank is located in the northern Bahamas while the Great Bahama Bank begins about 62mi/100km south, extending to the south and southeast. These two banks are separated by North-east-North-west Providence Channels and the Great Bahama Bank is split by two deep water channels: the Tongue of the Ocean (49,000-59,000ft/1500-1800m in depth), which separates Andros from New Providence and the Exuma; and the Exuma Sound forming a deep area to the east of the Exumas (Buchan 2000).

Thus, the Commonwealth of The Bahamas consists of an archipelago of 700 islands and more than 200 cays, islets and rocks in the western Atlantic Ocean. The islands cover approximately 100,000 square miles (mi^2) or 260,000 square kilometres (km^2) of ocean between latitudes 21° and 27° North and longitudes 72° and 79° West. The total land area is only 5,382 mi^2 (13,940 km^2). The archipelago stretches approximately 550 miles (mi) / 880 kilometres (km) from the northwest tip of Grand Bahama Island to the southeast coast of Inagua Island.. The Bahamas Platform, a distance of more than 840 miles (1,335 km), extends from the coast of Florida to the island of Hispaniola.

Thirty islands and cays are permanently inhabited. The economy, standard of living and population size among these islands are widely varied. All populated islands have basic infrastructure such as schools, roads, electricity and running water. Amenities such as cellular telephone, cable television and internet access are less accessible in more remote areas or less populated islands. Nassau, the capital city, is located on New Providence Island, which measures just 21 miles (34km) long by 7 miles (10km) wide. Andros Island is the largest island in the archipelago, and is a conglomerate of smaller islands separated by shallow creeks and waterways. Approximately 80% of Andros is within 3.3 ft (1m) 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. These islands are connected to Eleuthera and Long Island respectively by regular ferry service to the larger islands.

Map of the Commonwealth of The Bahamas

Figure 1: Location of The Bahamas archipelago showing Little Bahama Bank in the northwest, the Tongue of Ocean between Andros and New Providence Islands on the Great Bahama Bank, and the Exuma Sound to the east of the Exumas.

The island of Bimini, in the west, lies within 50 miles (80km) of the east coast of Florida and Inagua Island lies within 50 miles (80km) of the coast of Cuba and about sixty miles (96km) north of Haiti. The Turks and Caicos Islands are geographically and geologically part of the archipelago and share many plant and animal species. The Turks and Caicos Islands were under Bahamian Administration until about 1848 when they were placed under colonial administration from Jamaica.

1.1.2 Geology

The name, Bahamas, is a derivative of *baja mar*, which means shallow seas in Spanish and accurately describes the morphology of the archipelago. The islands of The Bahamas have generally low relief; around 80% of the land surface is within 3ft/1 meter of mean sea level. The

Bahama platform is partially covered by lithified Aeolian ridges, beach ridges, and areas of unconsolidated or partially consolidated sand. These formations contribute to the development of the islands, which form primarily on the eastern edges of the Little and Great Bahama Banks. The islands generally run northwest to southeast throughout the chain along the windward margins of the plateaus. Central ridges rising up to 100 ft (31m) may be found on most islands, including New Providence, with a maximum height of 127 ft (39 m) above sea level on the island. Cat Island boasts of the highest point in the archipelago at 206 ft (63 m). The highest point in Andros Island, the largest island in The Bahamas, is only 71 ft (21.6 m), and most of that island lies less than 20 ft (6m) above sea level. Throughout The Bahamas many rocks and sand banks are submerged at high tide and some connect larger islands at low tide. This low relief is evidence of sea level fluctuations, during the Pleistocene Epoch, which caused dune formation and the development of recessional beach ridge systems. These features then lithified due to the high level of calcium carbonate in the sands. Hearty and Kindler (1995) and Kindler and Hearty (1996) describe the carbonates of The Bahamas and the sea level changes that contributed to the islands' formation.

Geophysical data indicate that the carbonate deposits that comprise the Little and Great Bahama Banks range from 3.2 mi (5.4 km) and 6 mi (10km) thick. Sea level fluctuations during the Pleistocene Epoch exposed and inundated the upper portions of the islands at various times in the geological past. Radiocarbon dating has shown the rocks to be between 5,000 and 1,000,000 years old. Little et al. (1971 to 1976) compiled detailed reports on the geology, landforms, soils, water resources, vegetation and land use for the larger islands of The Bahamas. The studies were conducted by the Ministry of Overseas Development of the United Kingdom, under the auspices of The Bahamas Ministry of Agriculture.

1.1.3 Hydrogeology

The limestone rock, of which the islands are comprised, were formed due to wave action deposition of oolitic and skeletal sands from marine sources and cementation of these particles with calcium carbonate. Rainwater dissolves the calcium carbonate and penetrates even the microscopic pores between particles. The calcium carbonate may then precipitate out and cement nearby particles together. Conversely, rainwater may carve pathways through the rock as it dissolves away previous calcium carbonate deposits. The movement of water through the limestone rock may create holes and channels eventually carving subterranean tunnels, caves and chambers below the surface.

Housed below the land's surface are thin layers of fresh water. These thin destructible lenses float above the saline and brackish water below the islands' surfaces. Some of these lenses may be within a few feet of the island's surface and extend down to as much as 110 ft (40 m). The lens includes water enclosed or trapped in chambers, minute pores and cracks in the rock. These lenses may be exposed to the surface in some areas and are called blue holes. Well drilling on residential properties and within developments exploits this resource throughout the islands. Some settlements in the Bahama Islands are after the historically important wells that occur in the area such as Warderick Wells, Exuma and Spanish Wells, Eleuthera are two examples (Little et al. 1971-1976). The delicate nature of the freshwater lenses makes them prone to overexploitation or damage by salt intrusion in residential areas or within larger developments. Storm events and natural erosion within the limestone rock may also cause changes in the orientation, size or shape of the freshwater lenses in a given area (Cant 1986, Little et al 1971-1976). These factors provide for limited access to freshwater resources throughout The Bahamas. As the population of The Bahamas increases, access to potable freshwater resources is becoming increasingly important. Pollution of near surface lenses is highly probable since septic tanks are used on most properties (Cant, 1996, 1997). Freshwater supplies for the island of New Providence, where the vast majority of Bahamians live, is shipped from Andros Island by barge.

Groundwater resources also include fresh, brackish, saline and hypersaline waters found in the near and deep subsurface of the islands and in permanent and ephemeral water bodies. These bodies are affected by rainfall, geology, orientation and shape of surface and subsurface limestone.

1.2 CLIMATE

1.2.1 Weather Conditions

The Bahamas Archipelago spans 6° latitude and 9° longitude, across the Tropic of Cancer, so there are regional variations in weather patterns and a mix of climatic conditions throughout the island chain. The climate of The Bahamas is sub-tropical. It also has distinct winter and summer regimes (Halkitis et al., 1982). The Sub-tropical climate of The Bahamas lends itself to two distinct seasons. During the dry season from November to April, the islands experience less than 10 rainy days per month (Sealey et seq, 1994). Hurricane activity in any given year may increase rainfall in the month of November. Rain may fall 10 to 20 days per month during the wet season from May to October. The rainy months are considered the summer months in The Bahamas, when mean daily temperatures exceed 77°F (25°C).

There are no summits higher than 206 ft (63m). Therefore, mountain-induced rainfall or rain shadow zones are non-existent. Rain clouds that develop over the islands due to transpiration from vegetation may be displaced by the dominant Northeast trade winds. The rain subsequently falls on the western side of the narrow islands or out to sea (Little et al. 1971-1976). A distinct decrease in rainfall during the month of July creates a bi-modal rainfall distribution over the rainy season in southern islands. Rainfall is seen as highly localized and varies greatly even within small areas. The variation among rainfall gauges throughout The Bahamas would appear extremely high on a daily, weekly or monthly basis. Thus averages are generally calculated based on decades of data to determine trends (Department of Meteorology, 2009). Chenoweth (1998) provides an in-depth account and comparison of historical weather data for the islands from the 19th and 20th centuries.

The average maximum temperatures is approximately 88°F (31°C), but a temperature of 96°F (36°C) has been reached. The average minimum temperature is approximately 66°F (19°C),. However, a night time temperature as low as 41°F (5°C) has been recorded on January 19th, 1977 in New Providence. Mean daily temperatures generally lie between 60°F and 90°F (17°C and 32°C). Cool arctic air passing through the islands during the winter months may cause temporary drops in temperature called cold fronts from December to March and sometimes into April.

The climate in The Bahamas is described as tropical maritime wet and dry type climate with winter incursions of modified polar air. Generally, The Bahamas experiences neither frost, snow, sleet, hail nor extremes of temperatures. A unique exception to that occurred on January 19, 1977, when parts of the northern Bahamas experienced a brief flurry of light snow. The following climatological data (following) covers the 30-year period between 1971 and 2000. The lowest recorded temperature was 41.4°F (7^{o}C) on January 20th, 1981.

In New Providence, winter temperatures seldom fall much below 60°F (15.5^{o}C) and usually reach about 75°F (24^{o}C) during the afternoon. In the summer, temperatures usually fall to 78°F (25^{o}C) or less at night and seldom rise above 90°F (32^{o}C) during the day (Fig. 2). In the more northerly islands, winter temperatures are lower than New Providence and some 5°F (-15^{o}C) higher in the southern islands in summer months. Sea surface temperatures vary between 74°F (23^{o}C) in February and 83°F (28^{o}C) in August. Figure 2 shows the average maximum and minimum temperatures for New Providence.

Monthly Maximum and Minimum Temperatures for New Providence

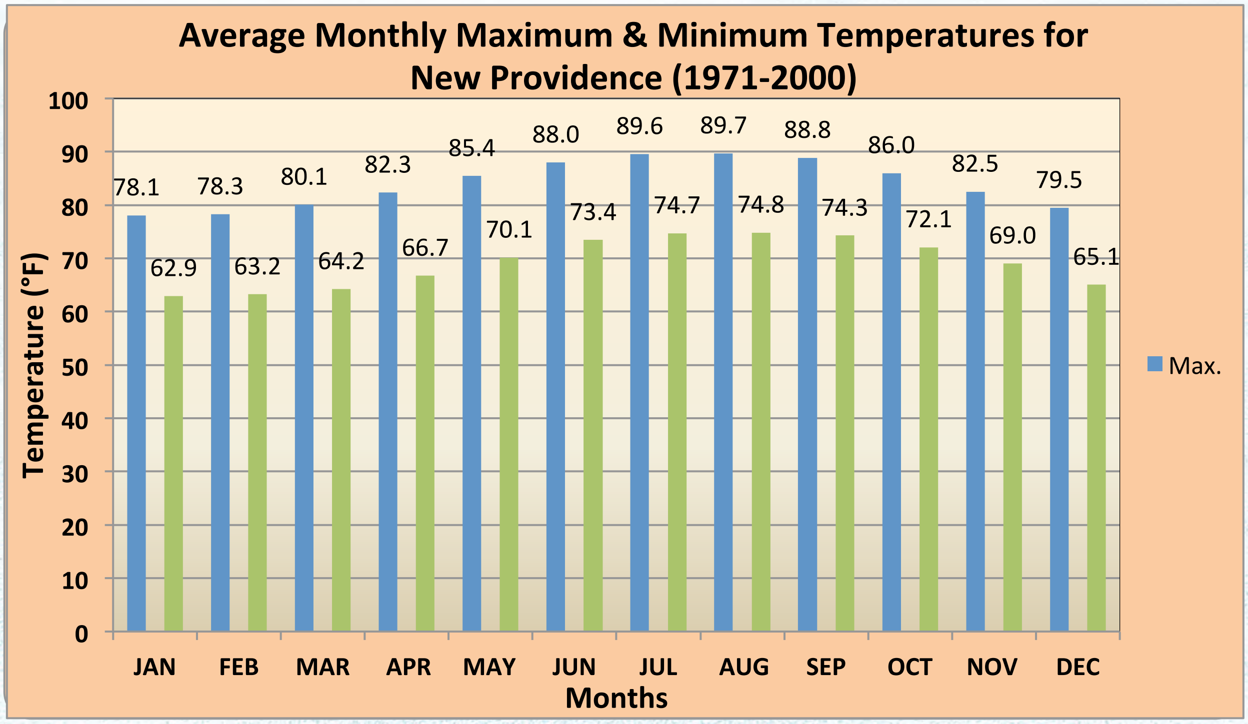


Figure 2: Average monthly maximum and minimum temperatures for New Providence

Humidity is fairly high, especially in the summer months. Winds are predominantly easterly throughout the year, but with a tendency to become northeasterly from October to April and southeasterly from May to September. Wind speeds are, on average, below 10 knots (18 km/hr); and in winter months, periods of a day to two of north and northeast winds of about 25 knots (42 km/hr) may occur.

On average, there is more than seven hours of bright sunshine per day in Nassau with periods of a day or two of cloudy weather at any time of year. The length of day (the interval between sunrise and sunset) varies from 10 hours and 35 minutes in late December to 13 hours and 41 minutes in late June.

Rain showers occur any time of the year, but the rainy months are May to October. For example, in Nassau, rainfall averages 2 inches (5.1 cm) a month from November to April and 6 inches (15 cm) a month from May to October. In the northern islands, rainfall averages are20% more. The southern islands normally receive half of the total rainfall in New Providence. Rainfall is mainly in the form of heavy showers or thundershowers, which clear quickly. Figure 3 shows the average (1971-2000) monthly rainfall for New Providence, indicating that more rain falls in the period June to October (summer). This period also coincides with the Atlantic Hurricane Season.

Monthly Rainfall for New Providence (1971-2000)

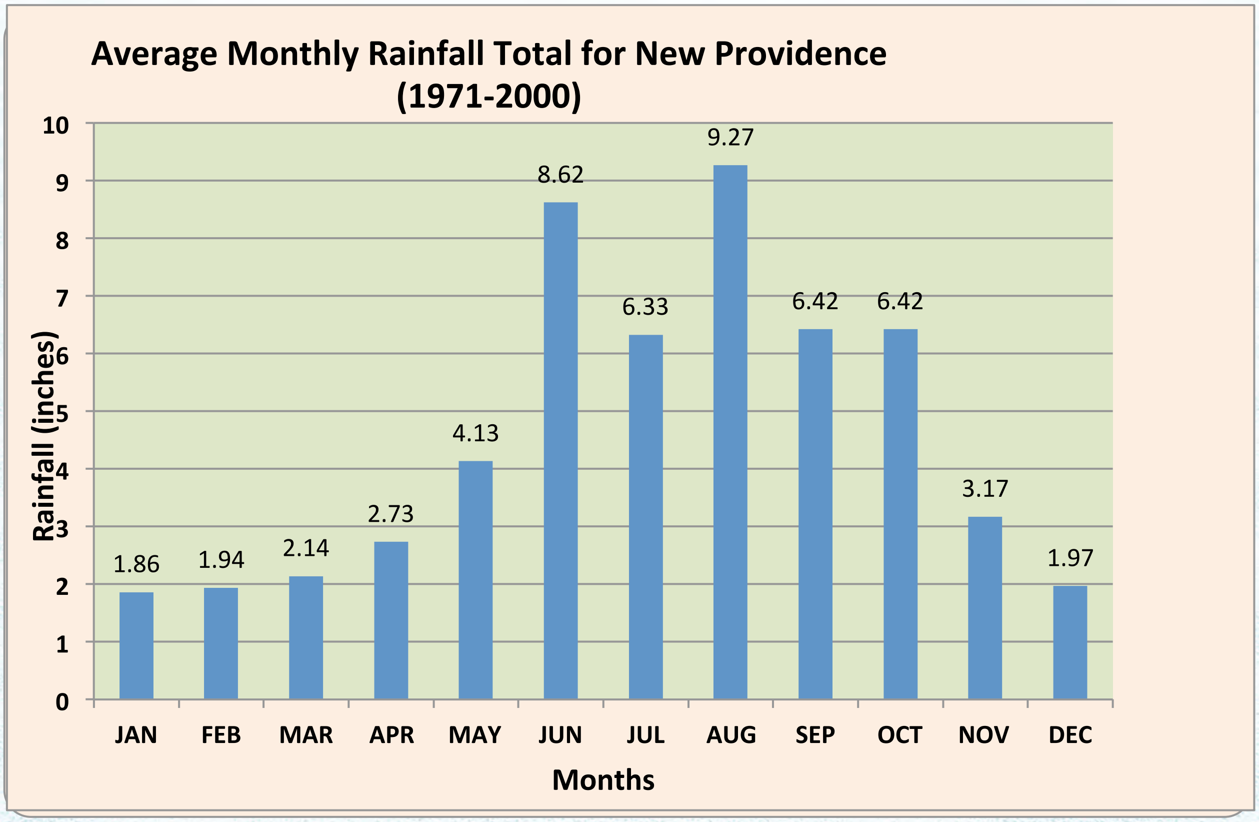


Figure 3: Average monthly rainfall for New Providence (1971-2000).

The Figure 3 above shows that the summer months in The Bahamas bring more rain than the winter months. This would have implications for agriculture where summer crops are suitable for good harvests. It is not known which of the summer crops would grow better under these conditions. However, the Department of Agriculture has conducted some studies relating to the impacts of climate change (especially on changes in temperature and rainfall) on crop growth.

The duration of daylight varies from 10 hours 35 minutes in late-December to 13 hours 41 minutes in late-June. 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.

1.2.1 Tropical Storms and Hurricanes and Non-tropical Processes

The Atlantic Hurricane Season (June 1 to November 30) produces several hurricanes each year to necessitate hurricane warnings and alerts in The Bahamas. Before sophisticated technology allowed the detection, tracking and monitoring of hurricanes, it is likely that many hurricanes went unreported. Customarily, hurricanes were reported when unless they were seen by ships or made landfall on inhabited islands. Hurricanes have been recorded in The Bahamas from the earliest settlers. Shaklee (1998) compiled 18th century hurricane data for the islands. There is little information given regarding the strength of these hurricanes beyond the amount of damage caused. The absence of rapid communication and early detection resulted in severe property damage because inhabitants had very little time to prepare for approaching hurricanes. It is unlikely that hurricanes affecting remote or uninhabited Family Islands (once called Out Islands) would have been reported. Based on the historic record, there were fewer hurricanes in the early twentieth century than in later years. This observation may be inaccurate if hurricanes were significantly under-reported. Forty-three hurricanes were reported in The Bahamas between the years 1900 and 1999. The mean of 4.3 storms per decade was exceeded in the first half of the century during the 1900s, 1920s, 1930s and 1940s. Four hurricanes occurred in 1933 making it the most active year for hurricanes affecting The Bahamas. The strongest hurricane recorded during that century was the category 5 (Saffir Simpson Scale) hurricane of 1947, which crossed Abaco and Grand Bahama before hitting Florida. However, this hurricane does not have a name like hurricanes of recent times, because it occurred before hurricanes were named.

Hurricanes are considered “major” when sustained winds exceed 111 miles per hour (mph) (178km/hr), which is a category 3 storm on the Saffir Simpson Scale. Since 2000, six major hurricanes have made landfall in The Bahamas or significantly impacted the islands.

Hurricanes that were notoriously destructive in The Bahamas include Hurricane Andrew (1992) and Hurricane Floyd (1999). The large separation between islands allows some islands to escape damage almost entirely, while others may be devastated.

Hurricane Andrew swept across North Eleuthera, Harbour Island, Spanish Wells, Current Island and the Berry Islands, while the Islands of New Providence and Andros were not so badly affected. The Disaster Preparedness and Response Act of 2006 established and published a network of emergency shelters throughout The Bahamas. Twenty-eight shelters are registered on the island of New Providence and 171 are distributed throughout the Family Islands.

Paths of all North Atlantic tropical storms and hurricanes from 1871 to present are provided in the United States Weather Bureau Technical Papers (Tropical Cyclones of the North Atlantic Ocean) and are updated every five years. The hurricanes and tropical storms passing within 100 miles (160km) of The Bahamas (distance to centre) are tallied in tables that follow.

Data on the number of tropical storms and hurricanes whose centre passed within 100 mi (160 km) of The Bahamas from 1871 to 1999 (129 seasons) are summarised in Table 1A. The data indicate that tropical storms and hurricanes most frequently occur in the months of September, October, August and November respectively.

Probability is calculated as the number recorded for any one month divided by the number of Atlantic hurricane seasons.

Hurricanes and Tropical Storms Between 1871-1999

1A: Number of hurricanes and tropical storms over the period 1871-1999 (129 hurricane seasons) by months								
Hurricanes & Tropical Storms	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**Total**
Number 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**	**----**
1B: Number of hurricanes over the period 1886-1999 (115 hurricane seasons) by months								
Hurricanes	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**Total**
Number 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**	**----**
1C: Number of tropical storms over the period 1886-1999 (114 hurricane seasons) by months								
Tropical Storms	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**Total**
Number per month	**2**	**4**	**7**	**14**	**19**	**28**	**12**	**86**
Probability per month	**0.02**	**0.04**	**0.06**	**0.12**	**0.17**	**0.25**	**0.11**	**----**

Table 1A: Hurricanes and tropical storms recorded over the period 1871-1999 (129 hurricane seasons) by months. Table 1B: Hurricanes recorded over the period 1886-2000 (115 hurricane seasons) by months. Table 1C: Tropical storms recorded over the period 1886-1999 (114 hurricane seasons) by months

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 1B and 2C, 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 information above indicates the total number of storms affecting any part of The Bahamas. Due to the variations in paths travelled by individual storms, these numbers may be significantly different for individual islands. As an example, Tropical Storm Chris passed south of Inagua in 2006 and its effects were not felt in the northern Bahamas. Storms of this nature may be reflected in national totals, though they may not affect some islands.

Between 1944 and 2010 the number of severe hurricanes (category 3-5) passing by within 69mi (111km) of The Bahamas was higher than in eastern and western Caribbean. Abaco and Grand Bahama had the most number of hurricanes in that period with a frequency of 40 in every 4 years. Thus, The Bahamas is more active than the eastern and western Caribbean (Caribbean Hurricane Network 2013). The island of Abaco in The Bahamas is considered the "Hurricane Capital of the Caribbean" based on the number of hurricanes between 1851 and 2010.

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 travelling 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 due to the the height of the waves, 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 often occur 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 (m3) 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. A newly constructed reinforced bridge deck, weighing several hundred tons, was moved off its abutments by an Atlantic Ocean surge and caused coastal flooding across the northern region of the archipelago.

1.2 HISTORY AND GOVERNMENT OF THE BAHAMAS

1.3.1 History

San Salvador is generally accepted as the island where Cristóbal Colón (Christopher Columbus) landed on October 12, 1492. There has however been recent debate by some persons who claim that Cat Island is the true landing site. The Europeans encountered Taino Amerindians called the Lucayans inhabiting the islands during this time. These aboriginal people were taken into slavery by the Europeans. The Lucayans died out soon thereafter because of the European diseases and slavery. Therefore, the islands remained uninhabited until around 1648 when English pilgrims from Bermuda, seeking religious freedom, came to the island now called Eleuthera (freedom). Piracy developed as the norm for The Bahamas by the early 1700's. The British government appointed Woodes Rogers as the first Royal Governor of the Islands of The Bahamas in 1718 with the intent to put an end to piracy in the islands.

The colony, which then included the Turks and Caicos Islands (until 1848), saw little growth. Most commercial agricultural ventures were unsuccessful and persons lived primarily through subsistence fishing and farming. After the American Revolutionary War, Loyalists and their slaves settled in The Bahamas. Many of them attempted to establish cotton plantations, which soon failed due to poor conditions and crop pests.

An economic boom developed during the American Civil War (1861-1865) when The Bahamas was used as a gateway for the exchange of goods and materials between Europe and the Confederacy. During this time, the Royal Victoria Hotel was built on the island of New Providence in the capital city of Nassau. Prohibition of alcohol in the United States (US) between 1919 and 1933 encouraged the return of smuggling operations between The Bahamas and the US. After the end of the prohibition era, The Bahamas began to establish itself as a tourist destination and the tourism industry experienced continued growth.

Party politics in The Bahamas began in 1953. The extension of voting rights to non-property owners and women came soon after. A new Constitution was adopted in 1964 along with internal self-government. The Progressive Liberal Party heralded in the beginning of majority rule in The Bahamas by defeating the United Bahamian Party in 1967 and retained power until 1992. The Bahamas gained independence from England on July 10, 1973 and now is considered a small island state within the Commonwealth of Nations (formerly the British Empire).

1.3.2 National Government

Head of State

Her Majesty Queen Elizabeth II is Head of State and is represented by the Governor-General. Her Majesty appoints the Governor General on the advice of the Prime Minister and the Governor General can be legally removed by the Prime Minister. His Excellency, the Honourable Arthur Foulkes is the tenth Governor General appointed to The Bahamas since Independence Day, July 10th 1973. The Governor General signs bills into law after they are passed by the House of Assembly and the Senate.

Executive Branch

The Executive branch of the government includes the Prime Minister, the Attorney-General and at least seven other members. The Prime Minister and Minister of Finance must be members of the House of Assembly. The other Cabinet Ministers and Ministers of State are appointed from the House of Assembly and up to three senators may be appointed as Ministers. The appointed Ministers and Ministers of State are responsible for running their Government ministries. Each ministry has a Permanent Secretary, a designated public officer, who is responsible for the organization and control of the work of the ministry on a day-to-day basis.

Legislative Branch

The Bahamas legislature is a two-chamber system based on the Westminster model, with a House of Assembly and a Senate. First convened in 1972, The Bahamas House of Assembly is the fourth oldest parliament in the English-speaking world. The House of Assembly is comprised of at least 38 elected representatives of the Bahamian citizenry. There 41 seats in the House of Assembly - 25 constituencies in Nassau and 16 in the Family Islands. The 16 members of the Senate are appointed as follows: nine members appointed by the Governor General on the advice of the Prime Minister, four on the advice of the Leader of the Opposition, and three on the advice of the Prime Minister after consultation with the Leader of the Opposition. This means that the Opposition will have at least four representatives in the Senate and may influence directly as many as seven Senate seats.

Laws in The Bahamas begin as “bills” introduced in the House of Assembly. Each bill must be read three times, debated and passed. If passed, the bills then enter the Senate to be read three times and debated. If passed after debate by the Senate, the bill is then sent to the Governor General. Once signed, the bill becomes law.

Judicial System

English Common Law is the basis of the judicial system, although there is a large volume of Bahamian statute law. The highest tribunal in the country is the Court of Appeal, which sits on a full-time basis througout the five year. Five Judges are appointed by the Governor General, inlcuding the residing president, three resident judges and one non-resident judge. Generally, three judges sit to conduct hearings. In practice, they are usually leading judges of Commonwealth countries, and they need have no former ties with The Bahamas.

The Chief Justice as well as the 11 justices who are appointed by the Governor General presides in the Supreme Court, which has general, civil and criminal jurisdiction. In addition there are two Supreme Courts. And one resident Justice in Freeport, Grand Bahamas, presiding over the northern region of The Bahamas, which includes Bimini, Abaco, and Grand Bahama. New Providence has 13 magistrates’ courts. Grand Bahama has four magistrates’ courts.

In addition, all Family Island administrators exercise summary jurisdiction in crimininal matters of a less serious nature and in civil matters. An appeal from a decision of a Family Island administrator acting in his capacity as a magistrate goes to the stipendary and circuit magistrate, and an appeal from a decision by a stipendary and circuit magistrate excercising origianal jurisdiction goes to the Supreme Court and in some instances directly to the Court of Appeal. An appeal from a Supreme Court decision goes to The Bahamas Court of Appeal, and an appeal from The Bahamas Court of Appeal goes to the judicial committee of the Privy Council in England.[12]

[12] Bahamas Handbook (2008), Judicial System, p. 425

Majority Rule

Elections in The Bahamas are held every five years. Voting is open to all Bahamian adults over 18 years of age and residing 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 (constituencies) in the election forms the government. The last general election was held May 2, 2007. The next general election must be held within 5 years, but may be held before if the Governor General, on advice of the Prime Minister chooses to dissolve Parliament.

Local Government

In July 1996, the Local Government Act of that year allowed twenty-three Family Island districts to hold elections. In the following month, elected officials assumed responsibility for their communities. Local Government allows greater autonomy in Family Island communities and makes Central Government more accountable to those communities. Local Government elections are held every 3 years and positions are open to certain public servants who can campaign without jeopardizing their current jobs, tenure or eligibility for promotion in the public service. New Providence is not included in the Local Government system though provisions in the Act allow for any part of the island to be added to the system by the responsible Minister. The 23 Local Government districts are listed below. Some Family Islands are divided into multiple districts while other Family Islands are grouped together to form one district. Having Local Government offices and officials allow the government to better oversee and account for the regular operations of each district.

The Local Government Districts are as follows:

- North Abaco
- Central Abaco
- South Abaco
- Acklins, Crooked Island and Long Cay
- North Andros
- Central Andros
- South Andros
- Berry Islands
- Bimini and Cat Cay
- Cat Island
- North Eleuthera
- Central Eleuthera
- South Eleuthera
- East Grand Bahama
- Exuma and Exuma Cays
- The City of Freeport
- West Grand Bahama
- Inagua
- Long Island
- Mayaguana
- Ragged Island
- Rum Cay
- San Salvador

1.4 POPULATION

The Statistics Act of 1973 established the foundation of the authority of the Department of Statistics to collect, compile, analyze and publish census data. The Act makes provisions for failure to furnish information and penalties for breaches in the confidentiality of the information by agents of the Department. A major task of the Department is to conduct a census every ten years.

The population of The Bahamas was determined to be 255,049 in 1990, 303,611 in 2000, and 351,461 in 2010 which is an average increase of 1.9% per year. The projected population for 2008 was 338,300. At the time of the 2010 census, 26.8% of the population was under the age of 15, 68.8% were aged 15 to 64 years and 6.2% of the population was over 65 years of age. The vast majority of Bahamians, 246,329 (70%) live on the Island of New Providence while Grand Bahama has a population of 51,368 (14.6%). The capital city of Nassau is located on New Providence and the second city, Freeport is located on Grand Bahama. Increased development, urbanization, and job availability on these islands account for relatively high population densities when compared to other islands. The population density for New Providence, which is only 21 miles long by 7 miles wide at its furthest points, was determined by the 2010 census as 2,635 persons per square mile (mi^2) or 6,825 square kilometres (**km^2**). Andros, Abaco and Inagua, are the first, second and third largest islands in the nation respectively. These islands have significantly lower population densities.

The national population density average of 65.3 per mi^2 was dwarfed by the population density on New Providence of 3,079 per mi^2 (7,974.5 km^2) in 2010. Grand Bahama with an area of 530 mi^2 (1373 km^2) had a population density of 96.9 per mi^2 (248.6 km^2). Andros the largest island in the country (2300 mi^2) has a population density of only 3.3 per mi^2 (2.58 km^2). The increase in tourism, banking and other jobs in New Providence has caused a dramatic population decline in some Family Islands as citizens' move to New Providence in search of better opportunities. These opportunities may include employment and education, which are not available on other islands. This emigration from Family Islands has served to slow development in each of the affected islands, which already have lower population densities.

Population growth in New Providence is rapidly approaching its space limits for homes, recreation and the availability of freshwater and other resources. New Providence saw a 14.4% population increase in the years 2000 to 2010. Fishing is a stable source of income or sustenance in most islands and ecotourism-related development is on the rise. The island of Andros saw a population decrease from 8,307 in 1980 to 8,177 in 1990 and at the last census in 2010, the population was 7,490.

Land Area, Population and Density of the Principal islands of The Bahamas

Island	Area(mi^2)	Population (2000 census)	Density (per mi^2) 2000	Population (2010 census)
New Providence & Paradise Island	80	210,832	2,635	246,329
Grand Bahama	530	46,994	89	51,368
Abaco	649	13,170	20	17,224
Acklins	192	428	2	560
Andros	2,300	7,686	3	7,490
Berry Islands	12	709	59	807
Bimini Islands	9	1,717	190	1,988
Cat Island	150	1,647	11	1,522
Crooked Island & Long Cay	93	350	4	368
Eleuthera, Spanish Wells & Harbour Island	187	11,165	60	11,515
Exuma & Cays	112	3,571	32	6,928
Inagua	599	969	2	913
Long Island	230	2,992	13	3,094
Mayaguana	110	259	2	277
Ragged Island	14	72	5	72
San Salvador & Rum Cay	63	1,050	17	1039
All Bahamas	5,382	303,611	56	351,461

Table 2: Land area, population and density of the principal islands of The Bahamas. *Source: Department of Statistics*

1.4.1 Growth Rates

Data from the past three censuses indicate that the national population experienced an average growth rate of 2.2% per year over 30 years (1980 – 2010) and 1.9% between 1990 and 2010. Table 3 below shows birth and death rates and the rate of increase between 1990 and 2010. Death rates remain fairly stable, but birth rates (per 1000) show a steady decline. This creates a decrease in the natural rate of increase throughout the population.

Vital Events, Rates and Natural Increase for Bahamas (1990 - 2010)

Year	Birth Rate (per 1000)	Death Rate (per 1000)	Rate of Increase	Rate of Infant Mortality (per 1000 births)
1990	24.0	5.3	18.7	24.4
1991	23.9	5.2	18.8	22.3
1992	25.6	5.5	20.1	24.9
1993	24.8	5.6	19.2	19.2
1994	22.3	5.6	16.7	19.7
1995	22.4	5.9	16.5	19.0
1996	20.8	5.5	15.4	18.3
1997	20.9	5.9	15.0	16.4
1998	20.1	6.1	13.9	13.9
1999	18.0	5.5	12.5	15.8
2000	17.4	5.4	12.0	14.8
2001	17.3	5.6	11.7	12.7
2010	14.4	5.8	14.4	8.1

Table 3: Vital events, rates and natural increase for Bahamas, 1990 to 2010

1.4.2 Demographics

As of the year 2010, the population of The Bahamas totalled 351,461 with 181,204 persons registered as females and 170,257 males. The following figure and table shows the number of persons registered in The Bahamas by age and gender at the time of the 2000 census. In 2010 the highest number of persons in The Bahamas was less than 40 years old. So, with a significant number of persons 20 years or less, The Bahamas is considered a large young population.

Population Demographics for The Bahamas – 2005

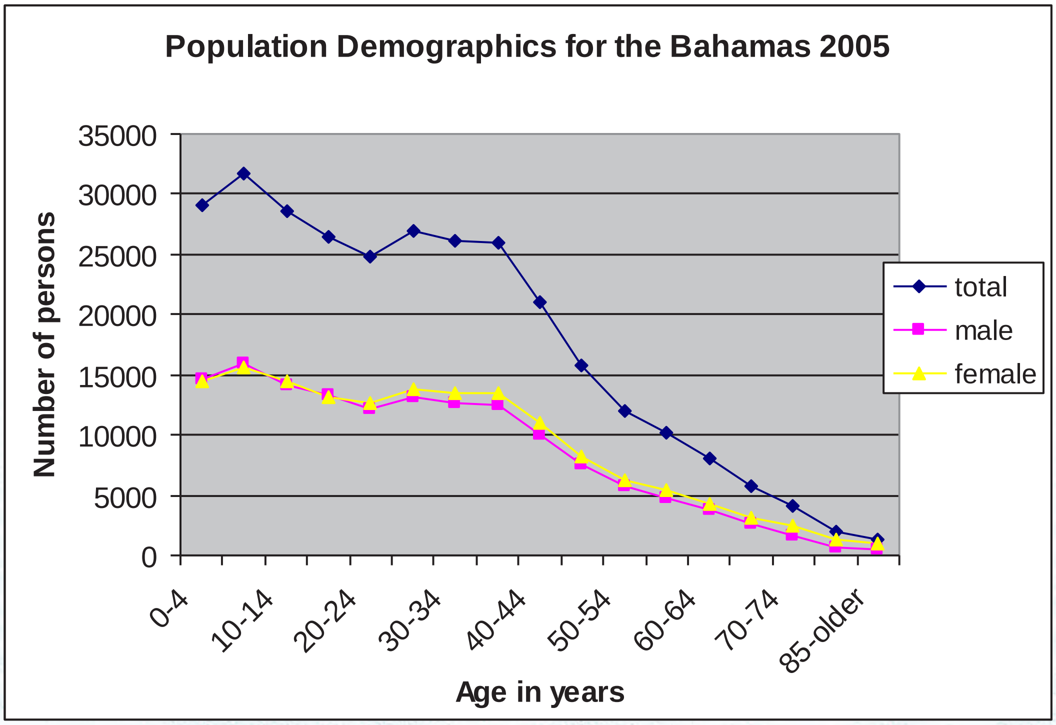


Figure 4: Population demographics for The Bahamas – 2005

1.4.3 Family Islands Population Trends

Excluding the islands of New Providence, Grand Bahama, Abaco, Exuma and Eleuthera, the total population of The Bahamas is 20,702 people. The >15 years of age group of these islands account for 73% of the population whilst the <15 years of age group accounts for the remaining 37%. Using this data, we can surmise that the total population of these islands are dominated by the >15 years of age group.

1.4.4 Causes of Death

Preliminary projections from the 2010 population and housing count estimated a total population of 353,658, a 16.48% increase over the 2000 population. There was a resultant increase in the population density per square mile (2.6 sq. km) from 56.7 in 2000 to 66.9 in 2010. The population distribution changed little over that period, with the exception of Exuma and the Cays, where the population more than doubled, from 3,571 to 7,314 persons. Most of the country's population (85%) resides in the most urbanized islands of New Providence and Grand Bahama.

The ten leading causes of death in The Bahamas during 2006-2009 period include hypertension (688) ischemic heart disease (605), HIV (566), cerebrovascular disease (517), diabetes (399) and assault (homicide) with 306 deaths (Bahamas 2013 http://www.paho.org/saludenlasamericas/.

1.3 ECONOMY

Tourism is the mainstay of the Bahamian economy, and the financial services sector is the second largest contributor to the gross domestic product (GDP). The 2012 annual preliminary results of gross domestic product are based on early estimates from major data sources such as the Central Bank, Ministry of Tourism, and the Foreign Trade Section of the Department of Statistics, etc. They are also based on indicators which normally mimic movements of particular industries such as Hotel Room Rates, Megawatt Sales, Building Permits, Chargeable Telephone Minutes, Consumer Price Index, etc. The 2012 GDP figures are preliminary and will be revised as more data becomes available. GDP is measured in both Current Market Prices and Constant 2006 Prices. The current measure utilizes current price levels and currency values, without factoring in inflation and determines the total value of the products and services produced in a particular year. The Constant Prices measures the effects of inflation and is more useful for studying trends in economic growth. According to the preliminary results, the GDP in Current Prices for 2012 had a positive growth of 3.5%, while GDP in Constant Prices grew at 1.83%. The hotel and restaurant expenditure in 2012 was $983.11 million.

Agriculture and fisheries make a much smaller contribution to GDP on the national level, but are very important in Family Island communities. The industrial sector is small, but growing. It stands to make increasing contributions to GDP in years to come as development continues. Government (utility) corporations and the public service currently employ more Bahamians than any other single employer. Government utilities include The Bahamas Electricity Corporation (BEC), The Bahamas Telecommunications Company Limited (BTC, formerly Batelco), The Bahamas Hotel Corporation, the Broadcasting Corporation of The Bahamas, Bahamasair Holdings (the national airline) and The Bahamas Water and Sewerage Corporation. The Government has begun privatization of the utilities by offering share sale of BTC in 2002. This sale will transfer management control and 49% stake in BTC to a “strategic partner”.

The Bahamas national per capita income for the year 2001 was approximately $15,925. The national per capita GDP has increased to $ 24,279 (2008 estimate). Income distribution varies widely between the urban New Providence and Grand Bahama and the Family Island rural communities. Subsistence fishing and farming is still widely practised. Commercial efforts to exploit the marine resources and large scale farming on select islands mainly in the Northern and Central Bahamas, continues.

1.5.1 Tourism

Tourism continues to serve as the core of the Bahamian economy. In 2008, 3.9 million visitors to The Bahamas spent approximately 2 billion dollars (Central Bank of The Bahamas). Growth in the tourism sector is being encouraged by the Ministry of Tourism through increased offerings. These offerings include ecotourism opportunities, increased access to Family Islands and mooring sites throughout the islands for sailing visitors. This diversification is essential to the future growth and stability of the tourism industry.

Tourism in The Bahamas includes cruise ship visitors, stopover visitors and sailing guests. Tourism directly or indirectly employs approximately 50% of the Bahamian population. These persons may be employed in hotels, resorts, or restaurants, which cater to foreign visitors or provide services and entertainment geared toward the foreign guest. Dependence on the tourism sector makes The Bahamas vulnerable to changes in the global economy. This means that while tourism may remain relatively lucrative when compared to other industries, individuals employed in this sector may experience pay cuts, lay-offs, or loss of pay as tourist behaviour changes from year to year. The global economic crisis of 2008-2009 resulted in thousands of lay-offs from hotels, resorts and guest service businesses throughout The Bahamas.

Aside from economic contributions, tourism has a broad range of impacts on the environment and resources. Hotel and resort construction has resulted in damage to both marine and terrestrial environments. Developments, such as golf courses, may pose threats to water quality and coral reefs due to leaching of fertilizers and chemical for lawns. Along with increased tourism, there are concerns for the generation of electricity, potable water, and waste disposal for guests that visit The Bahamas in addition to services required for the Bahamian population.

The primary destination for tourists to The Bahamas is Nassau, where the international airport serves as a hub to most other islands and bridges connect to Paradise Island.

A recent renaissance of sorts in the tourism sector has diversified tourism income and increased the number of visitors to Family Island destinations such as Abaco, Andros, the Exumas and Harbour Island. These islands are marketed as prime ecotourism destinations. Environmentally friendly offerings include sustainable catch and release bonefishing on the west side of Andros, bird watching of the ground-nesting Bahama parrots in Abaco or sailing and kayaking through the Exuma Cays Land and Sea Park. This designation as an ecotourism destination allows many Bahamians to benefit from tourism revenues with minimal impact on the environment, and encourages lasting sustainable use of the resources available.

1.5.2 Banking and Finance

Banking and financial services in The Bahamas include numerous offshore banks. Many of these banks generate no Bahamian dollar earnings, but make gains through foreign exchange. The Bahamas is in the process of developing Tax Information Exchange Agreements with countries including the US and Canada. This is in an effort to prevent The Bahamas from being named as a tax haven and tarnishing its reputation.

1.5.3 Fisheries

The seas around The Bahamas are home to numerous species of fish, shellfish, turtles and marine mammals. Game fish and sport fish include amberjack, bonefish, dolphin, blue marlin (the national fish), white marlin, sailfish, swordfish, tuna, and wahoo. Limits and guidelines for the capture of these fish are well documented and have been in place for some time. Commercially important food species include the Queen Conch, the Nassau Grouper, the lane snapper, jacks and the spiny lobster. The Nassau Grouper has been fished into extinction in most other Caribbean countries. The Bahamas Government recently established a closed season for Nassau Grouper between November and March. Total fisheries catch for the year 2007 was valued at B$80.3 million dollars.

The citizenry of The Bahamas does not traditionally participate in the hunting of any marine mammal. Eight species of cetaceans occur in The Bahamas: the bottlenose, Atlantic spotted and spinner dolphins; and the minke, sperm, beaked, shortfin pilot and humpback whales. Monk seals were hunted into extinction over a century ago. Sharks are common throughout The Bahamas and various species include: black tips, bull sharks, hammerheads, lemon sharks, makos, nurse sharks and tiger sharks. Four species of turtle (green, hawksbill, leatherback and loggerhead) are known to nest in The Bahamas. Turtle capture and consumption by local fishermen are conducted to a limited extent in The Bahamas. A total ban on commercial sale of marine turtles was instituted on September 1, 2009, as a measure to prevent these activities and protect these endangered species. Scientific names of these species are listed in Annex 2.

Bahamian fisheries resource legislation is founded in the Fisheries Resources Act of 1977. The Act relies on a network of fisheries officers throughout the islands that enforce the regulations of the Department of Marine Resources. These regulations include restrictions of equipment type, vessel size, catch limits and designation of The Bahamas' Exclusive Fishery Zone (EFZ). Long line fishing is prohibited in The Bahamas, and only Bahamians are allowed to participate in commercial fishing within territorial waters.

Successful fisheries regulation includes protection of near shore and wetland habitats, such as sea grass, mangrove and coral communities, which provide important nursery grounds for many reef and pelagic species. Global warming is of particular concern. Many fisheries resources rely heavily on coral communities, which are sensitive to even the slightest change in water conditions, such as temperature and turbidity. Climate change, overfishing, endangered species, poaching, invasive species introduction and pollution are all concerns of fisheries resource managers.

Corals and the reefs they form also protect the island coastlines against erosion and storm action. As natural breakwaters, coral reefs generate new sand through natural erosion of the coral skeletons. This protection of coastlines and the production of sand ties fisheries resource management directly to one of The Bahamas' major tourism products - sandy beaches. With the advent of ecotourism and recent biomedical discoveries of useful chemicals found in corals, the benefits of establishing Marine Protected Areas (MPA) to protect marine resources like coral reefs has been recognized within The Bahamas. Burke and Maidens (2004) indicate that about 30% of the 4,000 mi^2 of coral reef within The Bahamas is under threat from overfishing and coastal impacts.

Soft corals of the species *Pseudopterogorgia elisabethae* are now subject to harvest in The Bahamas and may form a new industry. Extract from *P. elisabethae* is known to be useful in reduction of irritation, swelling and redness of the skin (Nava Dayan in BEST 2002).

1.5.4 Agriculture

While small-scale agriculture is commonplace throughout the archipelago, it remains a very small percentage of the national GDP. Backyard farming is gaining popularity due to community initiatives throughout the country and focus on a small number of native and introduced fruit species. Food crops grown on the subsistence level also include corn, cassava, sweet potatoes, beans and pigeon peas. The number of farmers involved in subsistence agriculture is now on the decline, and the average age is increasing. Many farmers in Family Island communities also own goats, sheep or cattle for meat production, and there is significant egg and broiler production. Inputs for all agricultural products, such as feed and fertilizer, are imported.

The World Resources Institute (WRI) indicated in The Bahamas' Country Profile (2003) that the country produced an average of 1,000 metric tonnes of roots and tubers between 1996 and 1998, and 8,000 metric tonnes of meat during the same period. The total cropland in The Bahamas (1999) was estimated at 10,000 hectares (ha). From 1998 to 2000, The Bahamas imported roughly 98.1% of its total cereal consumption. Approximately 90% of food consumed in The Bahamas is imported, and includes all sugar, virtually all dairy products and most carbohydrate foods. Numerous bakeries operate in The Bahamas, but generally use imported ingredients. While there is room for growth in the agricultural sector, growth is seasonal and food import is necessary to meet the high demand in the hotel and restaurant industries.

1.5.5 Waste Management

The islands of The Bahamas currently do not have any factories engaged in the production of metal, paper or plastic. Therefore, all such material must be imported. Expenses associated with the export of these materials for recycling or other disposal hinders the removal of such waste from the country. Most communities have an area designated (officially or unofficially) as a dumpsite. The Environmental Health Services Act of 1987 provides regulations, penalties and provisions for remediation of pollution emission into the environment of The Bahamas. The regulations included in the Act govern emissions of pollutants and contaminants or disposal of solid waste and litter into the air, land or water. In Nassau, the landfill site has recently been reorganized, so that items brought into the dumpsite are now sorted. Ventilation of cells at the landfill allows methane gas to escape. This action prevents fires and collapsing pockets of gas, which present hazards to persons at the dumpsite and surrounding communities. Similar upgrades are in place in Grand Bahama, and the Family Islands are expected to follow suit.

Throughout The Bahamas, contamination of groundwater resources is an issue. The groundwater reserves are prone to contamination from various sources including: pathogens and nitrates from sewage; leachates from landfills or illegal dumping; industrial wastes, pesticides, fertilizers, fungicides and herbicides from agricultural use; leakage or spillage from underground fuel storage tanks; release of toxic chemicals and oils; improper waste handling from automobile repair and service; and zinc from wear of automobile tires on road surfaces (SENES 2005).

1.5.6 Energy Production and Transport

The Bahamas currently does not participate in energy generation from nuclear power. The primary source of energy for electricity generation, transportation and domestic use is the combustion of imported fossil fuels. These are also the primary sources of CO_2 emissions (65%) in the country (SENES 2005). Gasoline and diesel oil are used for transportation while liquefied petroleum gas (LPG) is used for cooking. Heavy reliance on air conditioning and refrigeration results in the release of hydrochlorofluorocarbons (HCFC's) into the atmosphere due to poor maintenance or improper disposal. A small amount of biomass may be used in the production of charcoal or as fuel wood for cooking particularly in rural areas. There are currently no facilities for the production of electricity from biomass. Boating, fishing, agriculture and other commercial industries contribute insignificant amounts to carbon emissions.

1.5.7 Industry

Brewing, distillation and furniture production represent the growing industrial sector in New Providence. Chemical and pharmaceutical manufacture industries are currently present in Grand Bahama. The oil refinery in Grand Bahama Island is no longer in operation. The Industries Encouragement Act of 1970 has been revised (1999) and provides benefits for persons wishing to develop industries in The Bahamas. The Act provides assistance for persons to source funds for necessary equipment, as well as, general tariff and tax breaks. The Act also contains safeguards against products or processes which may be detrimental to The Bahamas or its environment. Several companies produce and package food products such as fruit preserves and pepper sauces. Some small garment production operations exist in Nassau and Andros that produce hand-batiked garments. The industry producing straw work is of traditional importance to the islands of The Bahamas. Baskets, hats and accessories made by local artisans are popular souvenirs for tourists. There have also been recent developments in the jewellery industry, particularly with the use of conch shells. Morton Salt Company Limited has operated in The Bahamas since 1954, and was recently acquired (1999) by Rohm and Haas Company Limited.

1.5.8 Mining

Mining in The Bahamas is limited to the mining of rock and limestone sand. These activities are restricted by the regulations established in the Conservation and Protection of the Physical Landscape of The Bahamas Act of 1997. Only around 5% of the total surface area of The Bahamas is land and this land is needed for residential, agricultural and industrial development use. The quarry rock and sand resources mined throughout The Bahamas are generally not exported, but used instead to supply local demand for building material.

1.5.9 Ship Registry

The Bahamas' ship registry is among the three largest ship registry centres in the world. More than 1,600 ships were registered in The Bahamas in 1995. The Bahamas' Merchant Shipping Act of 1976 established guidelines for the maintenance of a ship registry and regulations for the vessels within the registry. Recent changes to the Act (2001) are in keeping with global standards and continue to make The Bahamas an attractive location for the registering of marine vessels. Some the changes include lowering of tariffs and fees for yachts and small cruise ships. Registration of foreign ships is limited to those ships that weigh over 1,600 net tons, are under 12 years old, and are considered pleasure yachts.

1.6 THE ENVIRONMENT

1.6.1 Introduction

The archipelagic configuration of the Islands of The Bahamas, allow the development of many distinct endemic species, and slight variations within species between islands. There are limited resources within the islands and this translates to fewer niches for terrestrial organisms. Considering the large expanse of open ocean that an animal must cross to arrive in The Bahamas from the neighbouring continents, animal diversity is very low, but highly unique. (Raffaele et. al 1998).

The Bahamas has a long history of environmental protection starting in 1952 with the Wild Birds Protection Act. This Act of Parliament makes provisions for protection of wild birds, enforcement through designation of wardens and punishment through fines and imprisonment. The Act also makes provisions for scientific collection and establishment of reserves.

The Wild Animals Protection Act of 1968 makes similar provisions for Abaco's wild horses, the Bahamian hutia and iguanas. The Bahamas National Trust Act of 1959 established The Bahamas National Trust (BNT) to preserve sites of "natural beauty". The BNT holds jurisdiction over more than 25 national parks and protected areas throughout the country and is the only non-governmental organization in the world with this mandate. The Bahamas continues to make strides in the protection of the environment. The establishment of The Bahamas Environment, Science and Technology (BEST) Commission in 1994 and the Conservation and Protection of the Physical Landscape Act of 1997 made way for increased conservation action and the promotion of the use of scientific data in future management decisions. The Bahamas Government has committed recently to protecting 20% of all near shore marine resources by the year 2020 through the Caribbean Challenge presented to the Convention on Biological Diversity in Bonn, Germany in May 2008.

1.6.2 The Bahamas Environment, Science and Technology (BEST) Commission

The Bahamas Environment, Science and Technology (BEST) Commission employs scientific officers who review plans for commercial, industrial or residential development within The Bahamas. Their mandate includes:

- Advising Government on the environmental implications of development proposals;
- Coordinating policies and programs for environmental protection;
- Fostering development of science and technology in The Bahamas;
- Developing a national conservation strategy and action plan;
- Proposing legislation to support national conservation strategy and plan;
- Preparing an inventory of natural resources, including species, habitats and ecosystems;
- Developing a national system of parks, protected areas and reserves, to provide for in situ conservation of inventoried resources; and
- Coordinating responses to the international environmental conventions to which The Bahamas is party.

The Government of The Bahamas has expressed its desire to achieve sustainability and eliminate poverty. The BEST Commission's review of proposals is a safeguard against development that is detrimental to The Bahamas, and ensures the sustainable exploitation of natural resources.

1.6.3 International Legal Instruments on the Environment

The Bahamas is a signatory to many International conventions and treaties that impact the national, regional or global environments. Each of the following treaties has implications on pollution, and the remediation of pollution, conservation and protection of natural resources, and the protection of endangered wildlife:

- 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 Trans-boundary 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); and
- Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention).

1.6.4 Biodiversity

The biodiversity of The Bahamas has been described by the BEST Commission in The Bahamas Country Study Report (1995). Raffaele et al describe the birds of The Bahamas as part of their guide to West Indian avifauna. White (1998) gives an in-depth, island-by-island description of the bird species occurring within The Bahamas. Correll and Correll (1982) describe the plant species in extreme detail. Issues pertaining to the prevention of biodiversity loss are contained in the National Biodiversity Strategy and Action Plan (NBSAP) prepared by the BEST Commission in 1998. This plan is essential to the fulfilment of the country's obligations under the CBD.

The flora of The Bahamas is generally referred to as "bush" by locals. The "bush" is classified as high coppice (inland hardwood forests) and seaside or coastal coppice (low growing salt tolerant trees and shrubs). Mangrove wetlands (referred to as swamps) and pine forests also are important plant communities in The Bahamas. All islands are covered to a greater or lesser extent with high and low coppice and mangrove forests. Pine forests, however, only occur in the northern islands referred to as the Pine Islands, mainly Abaco, Andros, Grand Bahama and New Providence.

Common hardwood species in the coppice areas include seagrape, mahogany, gum elemi, buttonwood, horseflesh, and poisonwood with numerous other trees, vines and shrubs. Black, white and red mangroves and silver and green buttonwood occur in the archipelago. Twelve tree species of traditional or ecological importance have been included in the Conservation and Protection of the Physical Landscape Act. These trees are protected from harvest. Agencies like The Bahamas National Trust are promoting xeriscaping in an effort to increase the use of native plants in landscaping to conserve water. Many non-native fruit trees have been introduced to The Bahamas for cultivation and some have escaped or become naturalized and can be found throughout The Bahamas.

Endemic animal species found in The Bahamas include various butterflies, moths, and other insects and arthropods, birds, lizards, iguanas, crabs, snakes and the Bahamian hutia, the only native land mammal. Some cave bats also occur throughout the islands.

Blue holes and subterranean cave systems in islands such as Andros are also thought to be home to unidentified species. The opportunity to see these organisms, which only occur in The Bahamas, presents a viable tourism product. The small populations and limited distributions of some of the organisms present a looming threat of extinction in some cases. Lack of research and scientific data further compounds the decision-making process regarding protection and sustainable use of living resources.

The Bahamian hutia was thought extinct until 1966 when it was found on East Plana Cay. It is believed that the hutia was driven to near extinction by the introduction of dogs and cats with the first settlers in the islands. Hutias have since been reintroduced to islands in the Exuma Cays Land and Sea Park. This reintroduction, however, may have been detrimental to the habitat on those islands. The high reproductive rates of hutias, along with the absence of animals, which may have preyed on them in the past, have allowed their population to bloom. They are voracious herbivores and the plant populations on cays with hutias have been altered drastically. Hutia seem to eat all the most edible plants first, and then consume other plant species virtually eliminating one species at a time until only the least edible plants remain in abundance. There is also evidence that the hutia may have spread to adjacent islands within the park.

The Abaco parrot has been the subject of various studies, and it is the only Amazon parrot known to nest in the ground. This behaviour makes the Abaco parrot vulnerable to predation by introduced animals such as dogs, cats, raccoons and feral pigs.

The iguanas present on various islands are protected along with the hutia, the Bahama Parrot and Abaco's wild horses, which some experts consider near extinction.

A large number of islands in The Bahamas may yet contain discoveries of new species or populations of other species thought to be extinct.

The primary human impacts on the environment throughout The Bahamas continue to be the introduction of invasive species, habitat destruction and pollution. The natural environment is annually exposed to risks associated with extreme events, tropical storms and hurricanes which are exacerbated by climate change climate and climate variability. Mean sea levels have risen across The Bahamas, since 1903, by one foot. Coral bleaching events were recorded, as well as storm surges, intense rainfall events and prolonged droughts which have resulted in damage to the mangrove, slow growing coppice and pine ecosystems.

1.6.5 Threat of Invasive Species

The Bahamas as a leader in the tourism sector is open to imports (deliberate and accidental) of exotic species from around the globe and even more so from neighbouring countries. As an archipelago, the proximity of the islands to one another within the chain and coral reefs that surround them may promote dispersal between the islands for some organisms. Conversely, the distance between the islands and their small size may prevent dispersal of organisms between islands, without human help.

Invasive plant species in The Bahamas are primarily escaped ornamentals brought to the islands for decorative purposes. These introduced invasive plant species such as Casuarinas, Hawaiian seagrape, paper bark tree (Melaleuca) and Brazilian pepper now occur on most inhabited islands. The aforementioned species are exceedingly common in the more populated islands of New Providence, Grand Bahama, and Abaco.

Invasive animals such as rats, dogs, cats, and livestock are common throughout the islands with many of them feral. Raccoons, introduced from the United States, are present in the northern islands of Abaco, Grand Bahama and New Providence. They cause crop damage to watermelon farms in Abaco and may impact the Abaco parrot population in coming years. Stray dogs and cats may kill or harass birds, snakes and lizards throughout the inhabited islands and may contribute to local extinction. Livestock consumption of specific plant species may significantly alter habitat in The Bahamas which can result in extreme changes in biodiversity over small areas. Donkeys, horses and hogs are also found on Abaco and Inagua.

The Pacific lionfish invaded the waters surrounding The Bahamas and are found in marine habitats, shallow waters and depths up to 400 feet. Stomach contents of lionfish have been found to include small fish, octopuses, and shrimp. This evidence is proof of potentially serious impacts on fisheries resources and biodiversity of Bahamian coral reef ecosystems. Perhaps because of the potential impact to the fisheries and tourism industries, cooperative lionfish removal initiatives are underway throughout the islands. This is also the first invasive species with a targeted exploitation campaign. The Department of Marine Resources and environmental NGOs in The Bahamas have recently begun promoting the consumption of lionfish.

Poaching of fish, iguanas and snakes in The Bahamas for the foreign pet trade are of concern to resource managers and law enforcement officers. Commercial poaching of fish by neighbouring countries is also a major concern, and the archipelagic nature of The Bahamas and limited resources of personnel and equipment make border control difficult. Burke and Maidens (2004) describe overfishing as the single greatest threat to coral reef ecosystems in The Bahamas and the wider Caribbean. Targeted removal of food species affect the natural balance in the ecosystem and eventually may cause trophic cascades (a systemic collapse) within communities.

Habitat destruction including clearing of land for development, dredging of harbours and destruction of mangroves and wetlands for the creation of marinas pose serious threats to Bahamian biodiversity.

Waste and refuse that wash ashore from illegal dumping into waterways and wetland areas and from sailing and boating activities can be seen on nearly all islands of The Bahamas.

1.6.6 Land Use, Land Use Changes and Forestry

The thin, dry, calcareous soils of The Bahamas are generally low in fertility and soon become exhausted when used for farming. Historically, subsistence farming was a common activity. The slash and burn farming method would see large plots cleared and the foliage burnt so that the ashes would quickly return a small amount of nutrients to the soil. The land would typically become exhausted after a few seasons of farming and when yield dropped significantly, a new area was cleared. Due to the rapid spread of this type of agriculture, most islands now have very little old growth or pristine forests.

Large-scale agricultural operations including cotton, citrus, pineapple, sisal, tomatoes and watermelon have seen limited or short-lived success in the thin Bahamian soil.

The tourism industry has boomed in recent decades and luxury resorts are being built throughout The Bahamas, predominantly along the coastlines. Some have been heralded as sources of jobs, while others have posed environmental concerns. New Providence coastlines have been extensively cleared for hotels, luxury housing complexes and private homes. The island’s interior is now subjected to unprecedented urban sprawl. Large tracts of land are being cleared for housing, business developments and road construction throughout the island.

Grand Bahama has been developed as a major oil transhipment point and its cruise ship facilities rival those of Nassau Harbour in New Providence. The Morton Salt Company on Inagua Island is the only large development on that island which otherwise remains mainly undeveloped.

Other islands in the archipelago have also been affected by rapid urbanization and development. Family islands such as Acklins, Crooked Island, the Exuma Cays, Mayaguana and Ragged Island remain virtually unchanged over the past century.

The lumber industry in the 20th century was not sustainably managed in The Bahamas. A sawmill operated in Abaco until 1943, and in Grand Bahama until 1970, leaving the pine forests virtually denuded. Similar operations in New Providence and Andros were much smaller though they amounted to similar effects on the environment. Abaco currently has the largest area of pine forest habitat in The Bahamas, but very few of the original trees remain standing there. After its eclipse, the logging industry left numerous logging and access roads throughout the aforementioned islands, which are now used by hunters in those islands and to a limited extent bird watchers and persons participating in ecotourism. The Abaco race of the Bahama Parrot is currently known to be the only Amazon parrot to nest in ground cavities. It has been suggested that this may be in response to the removal of the vast majority of trees, large enough to hold nesting cavities which is normal for the parrots in Inagua. Stahala (2004) and Gnam (1990 & 1991) discuss the ecology and conservation of the ground nesting Bahama parrot. The pine forests are recognized as an important and exploitable resource. Cutts (2004) and Patterson and Stevenson (1977) provide useful guides for identification of the trees of The Bahamas. The restoration of the forests is important to the viability of future sustainable use activities as well as to the many under-storey broadleaf plants, orchids, bromeliads, ferns and vines. Crabs in the forests of Andros are an intimate part of that island's heritage and culture. The Abaco Parrots nest exclusively in the pine forests of Abaco. Henry (1974) thoroughly describes the distribution of Bahamian pine forests. Little et al (1971-1976) described and inventoried the hardwood forests at that time.

The Bahamas has a long history of forest exploitation dating back to the 1700s when almost all large sized valuable hardwood species were exported. The last extensive exploitation ended in the early 1970s when the pine forests were harvested for pulpwood. Today, in The Bahamas the forests are rebounding and forestry itself is facing a revival. The country, once again possesses substantial natural forest resources comprising pine forests, coppice hardwoods and mangrove forests, with approximately 80% of forest resources on state lands (Crown land) and the remaining 20% on private lands.

Estimates of the extent of the natural pine forest resources is approximately 500,000 acres, and is widely deemed the most productive of the three vegetation types, based on inventory data collected in the 1986 under the FAO/BHA/TCP, forestry development project. The specie (Pinus caribaea var. bahamensis) is located on the four of the most northerly islands in The Bahamas, namely Abaco, Andros, Andros, Grand Bahama, and New Providence. The overall aim of FAO forestry development project was to determine the pine forest resource, to propose appropriate management and to assist in the development of management capability. The Coppice (hardwood) forest was never inventoried, and predominates in the central and southern Bahamas, comprising noteworthy valuable species such as mahogany, buttonwood, rat wood, gum elemi, black ebony, brazeletto, horseflesh, lignum vitae and red cedar. Mangrove ecosystems dominate on the leeward shores of most islands and its area is estimated at some 4,286 km2.

The Bahamas Parliament enacted the Forestry Act 2010, which established a Forestry Unit within the Ministry of the Environment and Housing. A Director of Forestry was appointed who has overall responsibility for the administration of the Forestry Unit, the Forestry Act, and for the management and development of forests.

The Forestry Unit is mandated to develop the forest resources of The Bahamas to their maximum potential by applying sound, scientific, and sustained yield forest management principles and concepts. The Act calls for the declaration of a national forest estate comprising forest reserves, protected forests and conservation forest to be managed in the national interest. A National Forest Plan and Forest Management Plans for the National Forest Estate will be prepared with appropriate guidelines to effectively and efficiently manage Bahamian forests. These plans will also assist in the development of small scale forest based industries to reduce wood imports. Also of great significance are the opportunities for biodiversity conservation, ecotourism, soil and water conservation, microclimate regulation, climate change, agro-forestry development and environmental enhancement.

1.7 HEALTH

The Ministry of Health holds responsibilities in human physical and mental health. It manages numerous public clinics throughout the islands and two major hospitals. The Public Hospitals Authority (PHA) and the Department of Public Health (DPH) are the two main agencies within the Ministry. The Department of Public Health oversees the development of healthcare programmes and manages health care clinics throughout The Bahamas. The Public Hospitals Authority now holds title to and responsibility for all the hospital properties previously held by the Government of The Bahamas. The PHA is also responsible for National Emergency Medical Services (NEMS), The Bahamas National Drug Agency (BNDA), the Materials Management Directorate (MMD) and Grand Bahama Health Services (GBHS). NEMS, BNDA and MMD are part of the shared services group with responsibilities shared between the PHA and the DPH. The Princess Margaret Hospital in New Providence and the Rand Memorial Hospital in Grand Bahama are the two public hospitals. Sandilands Rehabilitation Centre in Nassau cares for and rehabilitates persons with various infirmities and mental illnesses, including drug addiction, senility, and blindness. Health care professionals from other Caribbean nations contribute to the workforce in this area. Forty-three public clinics throughout the Family Islands provide limited health care to residents, but major medical needs are accommodated at the two hospitals. In the event of emergencies, air ambulances between islands provide transportation to the major hospital facilities.

1.7.1 Vector-borne Diseases

Vector–borne diseases represent a health and an economic threat to The Bahamas. Dengue, malaria, and yellow fever are not endemic to the country. Between 1998 and 2011, The Bahamas had a dramatic rise in the number of conformed cases of dengue fever. Thus in 1998 there were 365 cases, in 2003 155 cases and in 2011 there were 3,500 cases. The actual cases may have been higher than those reported (Bain, 2011). In 2006, 19 imported cases of malaria were reported in the island of Exuma due to *Plasmodium falciparum*, but with no associated mortality. In 2008, there was a single case of dengue fever reported.

The responsibility for vector control is shared between the Ministry of Health and the Department of Environmental Health Services. During the review period, vector control programs focused primarily on eradication and control of *Aedes aegypti* and anopheles mosquitoes. The vector control strategies employed included aquatic weed control, aerosol pesticide, larvaciding, education, training and other social marketing initiatives.

Despite active vector control programs, in 2006, 19 imported cases of malaria were reported in the island of Exuma due to *Plasmodium falciparum*, but with no associated mortality. In 2008, there was a single case of dengue fever reported.

The National Insurance Act of 1972 and the National Health Insurance Act of 2006 established the National Insurance Board (NIB) and the National Health Insurance Commission (NHIC) respectively. The National Insurance Act regulates payment of a form of social security by all employed Bahamians and allows all Bahamians access to health care and income in times of sickness, injury, disability, maternity, death, retirement or unemployment. The National Health Insurance Act allows insured citizens access to a standard package of health care services. Both of these legal instruments are aimed at improving the overall standard of health within The Bahamas and improving the overall quality of life for all people of the nation.

Summary of National Circumstances

CRITERIA	2010
Population (2010 Census)	**346,900**
Relevant area Total (Km^2)	**13,943**
Land area (Km^2)	**10,070**
GDP at current market price	**US$ 8.552 billion (2010 estimate)**
GDP per capita at current market price (2010)	**USD24,279**
Share of industry in GDP (%)	**14.7**
Share of services in GDP (%)	**84.1 (2001)**
Share of agriculture in GDP (%)	**1.2**
Urban population as % of total population	**83.9 (2009)**
Total labour force (2009)	**184,000**
Percentage of workforce unemployed (%)	**7.6**
Population in absolute poverty (% 2004)	**9.3**
Life Expectancy at birth (years)	**73 (2007)**

Table 5: Summary of national circumstances. *Source: Central Bank of The Bahamas*

CHAPTER 2: NATIONAL GREENHOUSE GAS INVENTORY

2.1 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 periodically on their national inventory of anthropogenic greenhouse gas emissions and/or removals. A National Climate Change Committee was formed and convened in March 1996. An initial inventory was conducted and reported to the UNFCCC Secretariat in The Bahamas First National Communication in 2001.

With a slightly different composition than the initial inventory, the National Climate Change Committee conducted the second national inventory of greenhouse gases in The Bahamas.

The National Climate Change Committee organized a National Communication Workshop in July 2007, which also served as a working session for the second Greenhouse Gas Inventory. At the working session the potential greenhouse gas sources, which were identified during the initial GHG inventory were reviewed for relevance and additional sources considered.

Subsequent meetings of the National Climate Change Committee provided for the review of data categories and the analysis of fuel sources for imports into The Bahamas.

Greenhouse Gas (GHG) emissions and their removal by sinks have been calculated for The Bahamas for the year 2000. Where appropriate the inventory relies on three-year averages of activities, except in the Energy Category where yearly average figures are used.

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, represent fuel exported through The Bahamas.

During the compilation of the initial national GHG inventory, it was recognized that there were problems “in the compilation, gathering and access to data held in the public domain”. The process for accessing and retrieving data collected for statistical purposes in The Bahamas was governed by rules that were not easily overcome and that “a framework for reporting of the data and obtaining access to the data did not exist”. As such, data held in statistical databases could not be made available for the inventory without violating existing rules and regulations. This issue applied to all sectors. The lack of disaggregated data did not allow for relevant information from sources to verify the reference approach. A statistical survey was required to collate and verify existing data.

The initial inventory relied on data obtained from the Central Bank of The Bahamas and from the Customs Department database. In order to perform the greenhouse gas inventory for The Bahamas, nationally derived import data was used.

In preparing the second national inventory, decision trees were developed for all sectors to identify data sources for the sectors.

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 Environmental Health, 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 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.

2.1 METHODOLOGY

The Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC), was used to produce the national inventory of greenhouse gases for The Bahamas. In some cases, the data available was not immediately suitable for input into the IPCC spreadsheets.

In such cases, assumptions were made to allow the incorporation of this data. The problems and constraints experienced in undertaking the inventory in 1994 were reviewed as part of the second inventory in 2000. All of the problems experienced in the initial inventory were encountered in the second inventory with the added constraint that many of the resource personnel had been re-assigned or left their positions associated with the focal point.

The IPCC Reference 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.

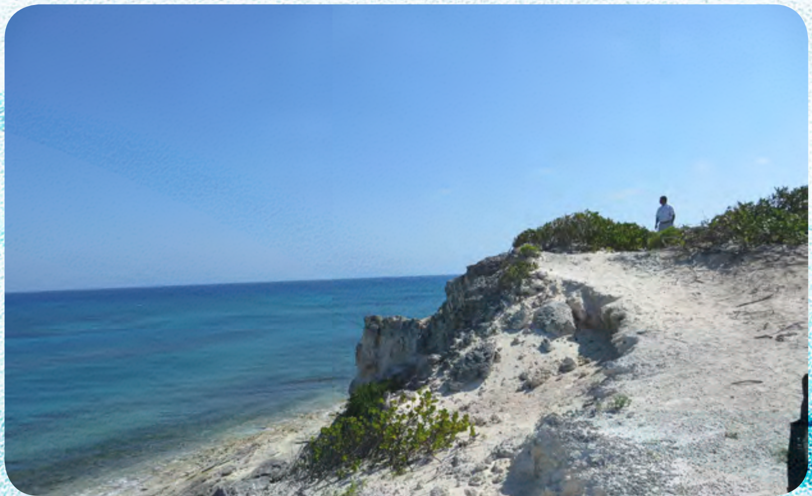
- A "top-down" approach was applied using the aggregate statistical data compiled by the Central Bank of The Bahamas on fossil fuels, but no "bottom-up" comparison was attempted, as the essential statistical data was unavailable in the disaggregated format required for input into the IPCC spreadsheet.
- In many cases, a new data collection exercise would have had to be conducted to obtain data in the format needed.
- 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.
- Limited data was available from the electricity sector which is dominated by two large power producers, and this allowed broad categorization of energy data into power production and transportation.

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, which 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, seven activities were proposed as part of the initial inventory:

Actions Proposed to Improve Inventory Process

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 needed 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, should be undertaken.
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 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.
Additional and continuous capacity building to assist with the performance of future inventories and the establishment of memoranda of understanding between Climate Change Committee and various statistical databases for retrieval of inventory data.



The IPCC guidelines were followed as data sources permitted, and default values provided were used. The IPCC reference approach was used for the energy sector. Thus, a top 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.

A verification exercise was carried out following the inventory process, which sought to verify sample data points obtained from the Central Bank report. The verification exercise revealed only one instance of discrepancy between Central Bank data and actual data.

The industrial profile of The Bahamas changed slightly between 1994 and 2000 with a contraction in the industrial output of the country. Industrial activities that remained included brewing and distilling, some chemical plant output, some pharmaceutical production, the production and export of solar evaporated salt, and the re-export of crude oil.

The Bahamas National Greenhouse Gas Inventory was organized into five main categories 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 (LPF), and lubricants (See Fig. 5). Table 6 summarizes the quantities of fuel imported for the two previous inventory years as well as the year 2000. The data was verified through discussions with the local oil companies and by reference to The Bahamas Customs database.

Fuel Imports in Thousands of Barrels of Oil Equivalent (BOE) for 1990, 1994 and 2000.

Fuel Oils	1990	1994	2000	% Total (2000)
Gasoline	**1287**	**1303**	**1499**	**34**
Jet Kerosene	187	148	235	6
Gas/diesel oil	**1759**	**1301**	**2685**	**56**
Residual Fuel Oil (Bunker C)	879	1442	33 (888)(1)	1 (27)
LPG	**156**	**160**	**96**	**3**
Other oils	225	33	93	1

Table 6: Fuel imports in thousands of barrels of oil equivalent (BOE) for 1990, 1994 and 2000.
Note: Revised figure (in brackets) based on information received from major users

Reported Trend of Petroleum Imports (1990-2000)

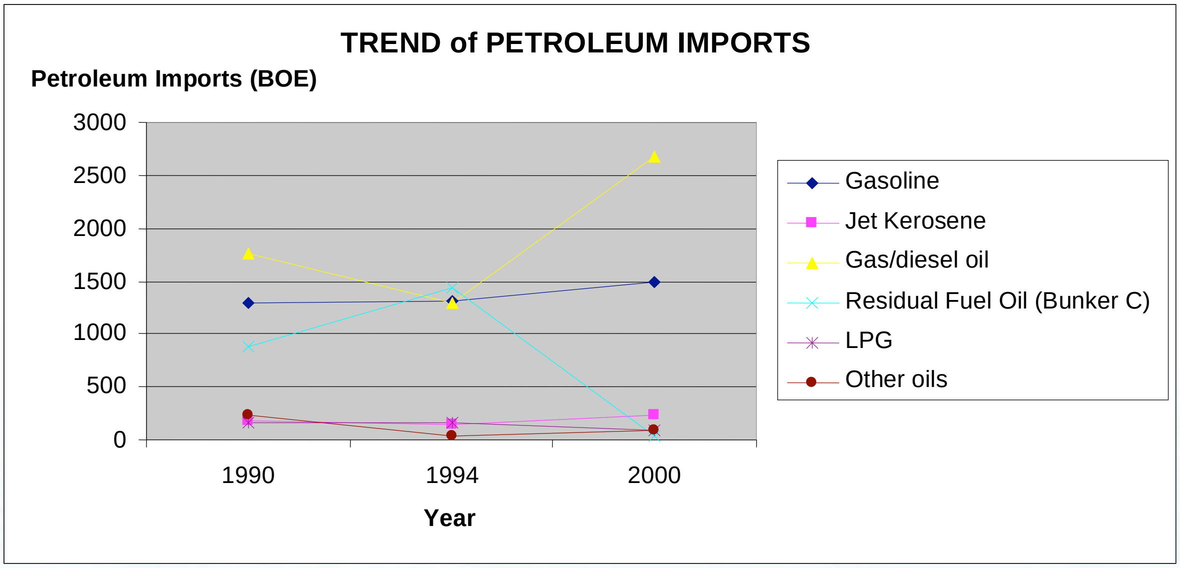


Figure 5: Trend of Petroleum Imports Reported for 1990-2000

INVENTORY PROCESS

Summmary of Emissions

A tabular summary of emissions by gas is presented in Table 7 below. CO_2 emissions are the most significant emissions for The Bahamas.

Summary of Emissions in 2000

Emissions by Gas	Gg	GWP	CO_2 Eq.	Tonnes CO_2
CO_2 Emissions				
Energy	660.4448	1	660.4448	660,444.81
LUCF onsite burning of forests	4.35	1	4.3500	4,350.00
Methane Emissions	Gg Gas			
Livestock	0.233737	21	4.9085	4,908.49
Solid Waste	0.06940	21	1.4574	1,457.39
Comm/Industrial Wastewater	0.002675	21	0.0562	56.17
Wastewater and Sludge	0.054368	21	1.1417	1,141.73
LUCF on site burning of forests	0.500000	21	10.5000	10,500.00
N_2O Emissions	Gg Gas			
Animal Waste Mgmt Systems	0.00115	310	0.3573	357.25
Grazing Animals	0.00387	310	1.2008	1,200.81
Agricultural Soils	0.00539	310	1.6705	1,670.46
Leaching	0.03414	310	10.5837	10,583.68
Human Sewage	0.01969	310	6.1054	6,105.39
LUCF	0.00013	310	0.0415	41.54
NO Emissions	Gg Gas			
LUCF onsite burning of forests	0.12000			
NMVOC Emissions	Gg Gas			
Fugitive Emissions	2.312			
Road Surfacing	0.17349			

Table 7: Summary of emissions in 2000

2.1 Emissions Process

Sources - Energy Sector

A list of potential greenhouse gas sources was compiled and organized into three broad categories during initial seminar(s), in July of 2007 (See Table 8).

GHG Point Sources in The Bahamas

Energy: Fuel Combustion	Halo-carbon Use	Solvents
Electricity Production	**Refrigeration**	**Paint Application**
Freeport Power / - (Diesel, Bunker 'C', Propane	Air-conditioning	Degreasing & Dry Cleaning
Diesel, Bunker 'C'	**Aerosols & Solvents**	**Anesthesia**
Manufacturing Industries		Propellant Usage
Diesel Oil – PFC		
Uniroyal, Borco, Polymer, Hotels, Laundries, Blanco Bleach		
Bacardi, Battery Companies		
Transportation		
Domestic – Mail Boats, Pleasure Craft & Other Vehicles		

Table 8: Potential GHG sources in The Bahamas

Energy for residential, commercial and limited industrial applications in The Bahamas is chiefly produced through the transformation of imported liquid fossil fuels. Residual fuel oil and diesel/ fuel oil account for the entire total of energy produced in the Electricity Sector. The data for energy production and consumption activities are based on the latest information as contained in the Central Bank of The Bahamas reports on petroleum imports, exports and usage.

The import of fossil fuels for use in power generation and transport represents the major use of fuel in the energy sector in The Bahamas. The storage of fuel represents a smaller fraction of fuels in the sector and is reported separately.

International Bunkers represents the largest fraction of CO_2 emissions in The Bahamas; it is inventoried as part of the inventory process, but is not counted in the National Totals.

Emissions from Energy

Greenhouse gas emissions for The Bahamas for the inventory year totaled some 660.48 Gg of CO_2 Equivalent. In 1994, some 85 % of all diesel/ gas oil was used in power generation. In year 2000, this figure had dropped to 52%, which represents a rapidly increasing contribution of the transport sector to the GHG emissions in The Bahamas as well as a movement away from the more expensive gas oil for electricity generation. The Carbon Dioxide (CO_2) emissions produced from the consumption of fossil fuels for public electricity production totaled some 37.1 % of the total CO_2 emissions in The Bahamas for the year 2000. The total installed capacity of power plants in The Bahamas for the year 2000 was approximately 500 MW with maximum demand of 327.9 MW. Total annual units of power generated between 1990 and 2000 grew from 750.4 million kWh to 1,664.8 million kWh.

Comparison of Carbon Dioxide Emissions From Fossil Fuel Energy Sources in The Bahamas for 1994 and 2000 (Gg CO_2).

Fuel Type	2000	% Total	1994	% Total
Gasoline	470.7	25.22%	476.5	25.53%
Jet Kerosene	55	2.95%	43.6	2.34%
Gas and diesel oil	802.4	43.00%	593.5	31.80%
Residual fuel oil	424.8	22.76%	696.9	37.34%
LPG	39.7	2.13%	40.8	2.19%
Other oils	101.5	5.44%	14.9	0.80%
Total (Gg CO_2)	1894.2		1866.2	

Table 9: Comparison of Carbon dioxide emissions from fossil fuel energy sources in The Bahamas for 1994 and 2000 (Gg CO_2).

Trend of Carbon Dioxide Emissions in 1994 and 2000

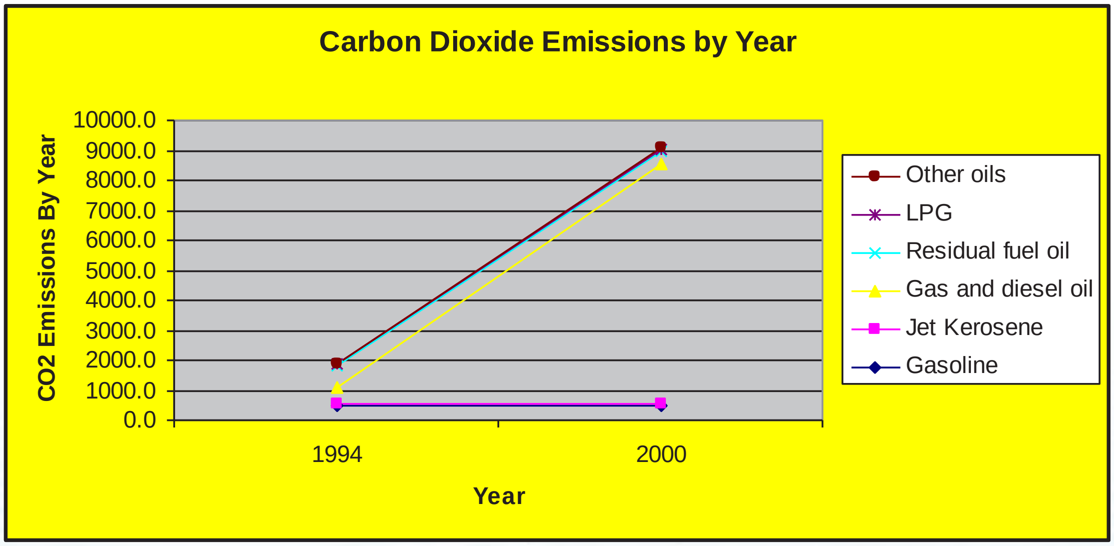


Figure 6: Trend of Carbon Dioxide Emissions in 1994 and 2000

Estimated Emissions of Other Greenhouse Gases in The Bahamas for the years 1990, 1994 and 2000 (Gg gas).

Year	Methane (CH_4)	Nitrous Oxide (N_20)	Carbon Monoxide (CO)	NMVOC's
1990	2	0	4	3
1994	1	1	4	3
2000	0.86	0.06	---	2.47

Table 10: Estimated emissions of other Greenhouse Gases in The Bahamas for the years 1990, 1994 and 2000 (Gg gas).

There were no significant variations between 1990 and 1994. There was, however, significant change between these years and 2000, for methane and Nitrous Oxide and this was attributed to shrinkage in the industrial sector.

Fugitive Emissions

Quantities on the order of 3,287 metric tons of fuel are stored on an annual basis and transshipped outside The Bahamas. Primary seals, in floating roof tanks are employed at the oil storage and trans-shipment facility. A single facility *(South Riding Point Holding Ltd.)* represents the primary source of fugitive emissions in The Bahamas which is estimated at 2.3 Gg of non-methane volatile organic compounds (NMVOC).

Memo Items: CO_2 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. A statistical exercise was conducted for 1990 in the initial inventory to disaggregate the data into the following: (i) gasoline for motor vehicles and small boats; (ii) jet fuel for aircraft; and (iii) gas oil for larger marine transport vessels leaving The Bahamas. This exercise was repeated for the 2000 inventory, as the data source and methodology were consistent with the previous inventory.

CO_2 emissions from the two categories of bunkering Aviation and marine accounted for 881.86 Gg CO_2 and 791.15 Gg of CO_2 respectively.

Carbon Dioxide Emissions From International Bunkering (Gg CO_2)

	1990	1994	2000	% Total (2000)
Aviation	**492**	**341**	**882**	**53**
Marine	**404**	**305**	**791**	**47**
Total all Bunkers	**896**	**645**	**1673**	**100**

Table 11: Carbon dioxide emissions from international bunkering (Gg CO_2).

Emissions from Waste

Liquid waste disposal is mainly by septic tanks as less than 20% of homes are linked to public sewerage drainage, collection, treatment and disposal facilities. A large tourism sector and a high standard of living contribute to the estimated 11.1 Gg of CH_4 emissions.

Municipal solid waste on New Providence Island is currently disposed of at the Harold Road disposal facility, a 100-acre site of which approximately 45 acres has been filled since it opened in 1972. Garbage is deposited on the surface, spread by mechanized equipment and partially covered.

Bahamians and visitors together generate more than 171,270,000 tonnes of municipal solid waste annually, with New Providence Island contributing about 77% and Grand Bahama 17% of this total, leaving only about 6% or 15,800 tonnes annually generated on the other Family Islands.

84% of waste generated in New Providence and Grand Bahama was assumed to be deposited to a managed site in the year 2000. The SWDS in Grand Bahama came into full operation in the year 2000.

Solid waste is disposed into unlined public dumps across The Bahamas. The estimated per capita waste stream from all sources was 1.82 Kg/person/day.

This report is also intended to provide the methodology and framework for future calculations.

Sources – Waste Sector

The table below shows a list of potential greenhouse gas sources, which is compiled and organized into three broad categories.

GreenHouse Gas Sources

Solid Waste Disposal Sites (SWDS)	Waste Water Handling	Waste Incineration
Nassau	**Nassau** **Commonwealth Brewery** **Caribbean bottling** **Pepsi Cola Bottling** **Bacardi**	**Nassau**
Freeport	**Freeport**	**Freeport**
Other Islands	**Other Islands**	**Other Islands**

Table: 12: Potential greenhouse gas sources

Emissions from Industrial Processes

This sector is being considered for the first time in the inventory process for completeness. Information on emissions is difficult to obtain with any degree of reliability. The sector is small and does not contribute significantly to the national emissions, with 0.0562 Gg CO_2 equivalent emissions estimated during the period from commercial and industrial wastewater.

Land Use Change and Forestry (LUCF)

The initial inventory documented the background of land use and land use changes in The Bahamas. "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 (C02) emissions. The Commonwealth of The Bahamas was covered with forests, mainly of tall, tropical hardwood and slow-growing trees in the drier south central and southeast. In the North and North Central Bahamas large areas of Pine (*Pinus caribaea* v. *bahamensis*) are found. Mangroves occupy the large marine inter-tidal expanses between the hard ground and sea. Large areas of the tropical hard wood forests were cut down to make room for plantations, housing, firewood and for their economic value in the tropical hardwood areas. Most of the primary forests were cut as land was converted initially to plantations and then as these failed to a rotating "slash and burn" agricultural uses. 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.

The regeneration of significant areas of tropical hard wood has been noticed in some regions of The Bahamas. This is being contrasted with recent developments that are competing with fauna for land space. No commercial logging activity is being practiced on the pine islands consequently; these islands are also in a young phase of re-growth."

As with the initial inventory, the entire landmass of The Bahamas - its mangroves, tropical hardwood forests and pine islands, including the understory, were accounted for as significant areas under some sort of native vegetation.

Forest Cover in The Bahamas by Type and Area

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	

Table 13: Forest cover in The Bahamas by type and area (kha).

A list of potential greenhouse gas sources and removals was compiled for the various LUCF Sectors as follows:

Potential Sources of LUCF Emissions and/or Removals

Changes in Forest and other Woody Biomass Stocks	Forest and Grassland Conversion	Regrowth
Tropical Forest Biomass Stocks	Moist long dry season	Moist long dry season
Plantations Other Forests	Dry Season	Moist short dry season
Moist; Seasonal and Dry Forests	On site burning	Abandoned Lands
Biomass Cleared	Off site burning	
Biomass burned	Biomass decay	
Decaying biomass	Non CO2 sources	
Forest and Grassland conversion		

Table 14: Potential sources of LUCF emissions and/or removals

Emissions/Removals from LUCF Sector

The LUCF sector records net emissions of CO_2 in the amount of 1513.67 Gg of CO_2. The sector has also recorded emission of trace gases in the amount of 0.12 Gg of CO_2. The sector has recorded removals of CO_2 in the amount of 4159.61 Gg of CO_2 as shown in Table 15 below.

Estimated Removals of CO_2 by LUCF Sub-categories

Removals of CO_2 by LUCF sub-categories			
Removals	Gg CO_2	CO_2 Equivalent	CO_2 (tonnes)
Abandonment of managed lands	2,802.34	2,802.34	2,802,340.00
Changes in Forest and other woody stocks	1,357.27	1,357.27	1,357,270.00
Total CO_2 Removed	4,159.61	4,159.61	4,159,610.00

Table 15: Estimated removals of CO_2 by LUCF sub-categories

Agriculture

The previous recorded trend in The Bahamas away from livestock husbandry to a heavy reliance on imports for all foodstuffs continues in the intervening period between inventories. Some local husbandry of livestock does occur in The Bahamas, but this is done on a relatively small scale. There are two commercial producers of fowl in The Bahamas. The Agricultural process suffers from heavy competitive forces of imports into the country.

Livestock numbers in certain islands continues to fall. The number of goats and sheep on islands such as Eleuthera, Long Island and Exuma has declined in recent time. Other islands are also recorded as having stock but in much smaller numbers. The Food and Agricultural Organization (FAO) was used as the basis of all estimates with the projected figures from The Bahamas' 1994 Census of Agriculture used a check on the FAO data. Agricultural soils were covered under Land Use Change and Forestry in the initial inventory and are included in this Sector for this inventory. Data on the total imports of fertilizers and or the types used was derived from Department of Statistics figures for the year 2000.

Livestock Numbers in The Bahamas From 1994 Agricultural Census

Type of Animals	Numbers of Animals	
	1994 Census	From FAO Year 2000
Cattle (non-dairy)	796	669
Sheep	6292	6292
Goats	13580	13580
Pigs	4777	4777
Poultry	750,000	2,350,000

Table 16: Livestock numbers in The Bahamas on the Agricultural Census of 1994. Sources: Department of Agriculture and Department of Statistics (1996) and FAO (2000).

Emission from the Agriculture Sector

Estimates of Methane (CH_4) emissions from Enteric Fermentation were 0.23 Gg. Total annual Emissions of N_2O from Domestic Livestock was less than 1/100 of a Gg per year. Direct Emissions of N_2O from Agricultural Fields excluding cultivation of Histosols was estimated at 0.01 Gg per year. Emissions of Nitrous Oxide (N_20) soil emissions from grazing animals pasture range and paddock was estimated at less than 1/100 of a Gg per year. Indirect emissions of Nitrous oxide (NO_2) from atmospheric deposition of NH_3 and NO_x were estimated at less than 0.01 Gg. Indirect N_2O emission from leaching was estimated at 0.03 Gg.

CHAPTER 3: NATIONAL MITIGATION ASSESSEMENT

3.1 INTRODUCTION

Climate change mitigation encompasses the activities, policies and measures enacted to reduce the emissions of greenhouse gases (GHGs) from sources and increase GHG removals by sinks in both energy and non-energy sectors. The Bahamas is a country actively investing in measures to mitigate climate change and increase sustainable action. This chapter provides an introduction to the initiatives being considered by the Government of The Bahamas to mitigate the effects of climate change. These initiatives cover a subset of all possible mitigation efforts for the country of The Bahamas

Based on Article 12 of the Convention, Non-Annex I countries to the UNFCCC are not required to set specific GHG reduction targets or commitments, but instead are encouraged to propose and quantify policies and measures to mitigate climate change within their countries.[13]

To address the UNFCCC guidelines for climate change mitigation, the Government of the Commonwealth of The Bahamas has committed to the following National Energy Vision as stated in the National Energy Plan:

> "The Bahamas will become a world leader in the development and implementation of sustainable energy opportunities, by aggressively re-engineering our legislative, regulatory, and institutional frameworks; retooling our human resources; and implementing a diverse range of well researched and regulated, environmentally sensitive and sustainable energy programmes and initiatives, built upon our geographical (both proximity and diversity), climatic (sun, wind, and sea) and traditional economic strengths (tourism and banking)."[14]

3.2 POLICIES AND MEASURES TO MITIGATE CLIMATE CHANGE

Of the numerous possible efforts to mitigate climate change, The Bahamas National Energy Policy Committee has proposed new measures focusing on energy efficiency and renewable energy deployment. The focus on the following proposed goals is meant to target a lower dependence on imported oil.

1. A reduction in energy demand due to energy efficiency measures of 30% relative to a business-as-usual scenario by 2030.
2. An increase in share of renewable energies in electricity generation of at least 15% by 2020 and 30% by 2030.

Policy Targets and Objectives

[13] UN, 1992 http://unfccc.int/resource/docs/convkp/conveng.pdf. p. 16
[14] NEPC report p.4 http://www.best.bs/Webdocs/NEPC_2ndReport_FINAL.pdf (exact text)

Short-Term Targets (1-5yrs)

Specific policy targets and objectives have been recommended that would allow The Bahamas to reach the goals stated above.[15] These policies focus on energy efficiency measures and renewable energy options. The Bahamas has developed a number of short-term, medium-term and long-term targets with specific objectives that the country intends to pursue in lessening its dependency on fossil fuel combustion for its energy needs and also to promote sustainable energy future. The short-term (1-5 years) targets include:

a) A Complete phase-out of incandescent light bulbs and their replacement with reduced mercury compact fluorescent light bulbs (CFL);

b) Investigate and implement waste-to-energy technology options for New Providence;

c) Develop a common basis to measure and compare the average annual unit cost of each form of energy consumed by sector and geographic area ($/gallon, $/kWh, $/bbl);

d) Initiate public buildings energy usage reduction strategies;

e) Explore interconnections between islands to enhance efficiency and promote the potential for renewable energy;

f) Assess the Commonwealth’s wind potential as well as identify potential sites for pilot and/or demonstration facilities;

g) Introduce an integrated traffic management system and public transport system by:

- Reducing average commute times on New Providence by 20%;
- Increasing ridership of public transport to 10-20%; and
- Employing advanced energy efficient lighting systems in public spaces supported by signage and traffic management systems.

The short-term objectives through (i) energy conservation are: to develop and implement a public sector energy conservation programme and marketing campaign; to develop and implement a consumer-oriented energy conservation campaign; to develop and execute an implementation strategy for the economic incentives announced in the 2008-2009 budget cycle; (ii) energy production management are: to review and establish a guideline for independent power producers and to explore the option of combining heat and power and cogeneration technologies to support the ongoing effort of capacity deferment. The short-term objectives through assessment of renewable energy potential are to: identify the data gaps and then formulate and implement solutions for closing the gaps and setting realistic targets and to

[15] Selected Policy Targets and objectives have been included in the text here. For a full list, please see Annex 2

investigate the potential exploitability of various renewable energy sources and technologies, including waste to energy, wave, tidal, wind, photovoltaic systems and solar water heating units.

Medium-Term Targets (5-10yrs)

The medium-term targets are to:

a) Increase the penetration of renewable energy sources in the Commonwealth to 15% of supplies;

b) Deploy renewable energy technologies in several small communities, aiming towards >50% of power from renewable sources;

c) Reduce dependence on imported fuel oils by:

- Increased building energy efficiency by introducing standards in public buildings for cooling public spaces, heating water, lighting and the deployment of the highest energy star ratings of equipment;
- Increased use of solar hot water systems to 20 to 30% of all households;
- Increased deployment and usage of energy efficient lighting systems and fenestration systems (windows) in public buildings;
- Increased public awareness and education on renewable energy potential and usage; and
- New requirements for all government financed homes and buildings to use, install, operate and maintain solar water systems.

d) Initiate a pilot of demonstration project for ocean thermal energy conversion potential starting with taking measurements at Clifton, New Providence and North Eleuthera;

e) Develop a means to estimate the average annual unit cost of renewable sources of energy; and

f) Increase fuel efficiency for motor vehicles to 30-35 mpg for 70% of licensed vehicles through the application of incentives to import and use more efficient vehicles in private and public sector transport.

The medium-term objectives through renewable energy implementation plan is to develop and implement a renewable energy programme to encourage the private sector to develop projects to produce electricity using renewable sources (e.g. solar, wind, ocean-thermal) for possible exploitation by The Bahamas Electricity Corporation. The programme can be used to establish targets for renewable electricity sales. Through the Energy Commission, the objective is to establish a permanent energy commission responsible for overseeing the implementation of selected national energy initiatives. , Using the national energy policy, the energy commission can develop energy efficiency standards that can be incorporated into existing regulatory regimes. Stakeholder consultation, compliance promotion and enforcement of the proposed standards should be done. With regard to fuel economy transport in the medium-term the objectives are to:

- Develop and implement a programme to increase the average fuel economy of vehicles. This program could include periodic vehicle emission testing as a part of the vehicle registration process, a ban on the import of vehicles older than five years, or improved enforcement of road traffic and safety legislation;
- Improve the quality of diesel oils imported for local consumption to reduce particulate emissions in order to improve air quality in urban centers; and
- Develop and implement a national strategy for integrated traffic and transportation system management.

Long-Term Targets (10-20 years)

The long-term targets include:

a) Increase the penetration of renewable energy sources in the Commonwealth to 30% of supplies;

b) All installations of water heaters are solar water heaters;

c) Develop a programme to pursue cost-effective opportunities in reducing energy consumption; and

d) Develop extended targets for changes in the energy mix based on extended unit cost and economic impact estimates by energy source, informed by local experiences and historical data.

The long-term objectives are to: reduce the rise in energy consumption and reduce use on a per capita basis; develop and implement a programme to pursue cost-effective opportunities to reduce further energy consumption by various target sectors and individual consumers; develop and implement a programme to minimize greenhouse gas emissions; and establish funding mechanisms for identifying, implementing and promoting sustainable energy use and technology innovation that support efforts to achieve the targets outlined in the national energy action plan.

Technical Potential of Renewable Energy

To further understand how the renewable energy measures can be met, The Bahamas recently underwent an assessment of renewable energy technical and economic potential. Technical potential amounts to approximately 50 times the present power demand in The Bahamas and is defined as the maximum electric generation yield of suitable sites (e.g. lands, roofs, etc.) taking into consideration natural and technical restrictions. Present economic potential is defined as the technical potential, which is economically viable in 2010 at oil cost of $70/barrel. Future economic potential in 2030 is expected to increase significantly due to decreasing costs of renewable energies and increased commercial viability.

Potentials of Renewable Electricity Generation in The Bahamas

Technology	Technical Potential	Present Economic Potential	Future Economic Potential
Solar Water Heaters	7,500	200	200
Building-integrated PV	3,700	-	220
Open-field PV Power Plants	12,000	-	12,000
Wind Power	82,000	150	200
Bio-energy	3,700	1,300	2,500
Ocean Energy: OTEC, wave	12,000	-	5,500
Waste to Energy	150	110	110
Total	**121,050**	**1,760**	**20,730**

Table 17: Potentials of renewable electricity generation in The Bahamas [GWh/year][16]

3.3 SCENARIO MODELING: LONG-RANGE ENERGY ALTERNATIVES PLANNING

In order to give a comprehensive picture of the policies and measures proposed in The Bahamas National Energy Policy, a scenario analysis was conducted using the Long-range Energy Alternatives Planning system (LEAP)[17] for the energy sector. LEAP is intended for energy planning and climate mitigation assessment and can be used to quantify energy demand and supply, greenhouse gas emissions and costs across any number of scenarios.

The scope of this analysis covers the energy and GHG emissions related to four specific measures in the energy sector over the time period of 2010 to 2030. Non-energy sector measures, transportation measures, and costs associated with each measure were considered outside the scope of this assessment. Though this kind of analysis will not show the total energy or emission savings that are possible for The Bahamas, it will provide a quantitative estimate for how the proposed measures will affect the energy system.

The analysis includes a comprehensive picture of historical energy demand and supply in The Bahamas from 2000 to 2009 based mainly on the in-country data, but supplementing with international data sources as needed. The energy data includes information on energy use by fuel in each major demand sector (households, commercial, industry, hotels and transport). Historical consumption data was compiled from electric utility reports and petroleum imports statistics. On the supply side, the data set includes information on transmission and distribution

[16]NEPC Report p.13 - GWh = 10^6 kWh; solar water heaters are expected to replace electrical water heaters; economic potential of solar water heater is limited to total hot water demand in The Bahamas; and economic potential of waste-to-energy power plant assumes a sufficient level of waste fees exist to run a 15 MW installation on New Providence.
[17] LEAP, developed by the Stockholm Environment Institute, www.sei-international.org; software distributed through the COMMEND website: www.energycommunity.org

losses in addition to electricity production. This historical data helps establish trends in energy consumption, which can be used as a starting point for the scenario analysis.

The analysis also includes one baseline scenario. It tells a story of how The Bahamas energy system could develop over the time period of 2010 to 2030, and presents a mitigation scenario that involves a subset of policies and measures discussed in this chapter. The result of comparing the mitigation and baseline scenarios showcases the energy and emission savings that result from enacting the included mitigation policies.

For a detailed listing of assumptions and results associated with this LEAP modeling, see Annex II.

Baseline Scenario

A baseline scenario is a story of how a particular energy system might evolve over a future time period. This baseline scenario is not a prediction of what will happen with particular certainty, but rather is a representation of one reasonable future for The Bahamas over the time period of 2010 to 2030 in the absence of any additional policies or measures.

The baseline scenario includes demand projections for electricity and petroleum products within five sectors: households, commerce, industry, hotels and transport.

Energy consumption in The Bahamas is dominated by the household, commerce and transport sectors. Measures have been included in the mitigation scenario to target reductions in demand in the household, commerce industry and hotel sectors. No transport sector measures have been modeled for this exercise due to a lack of detailed data. Note that all data points from 2000-2009 are historical values. Projections begin in 2010.

Total Energy Demand by Sector

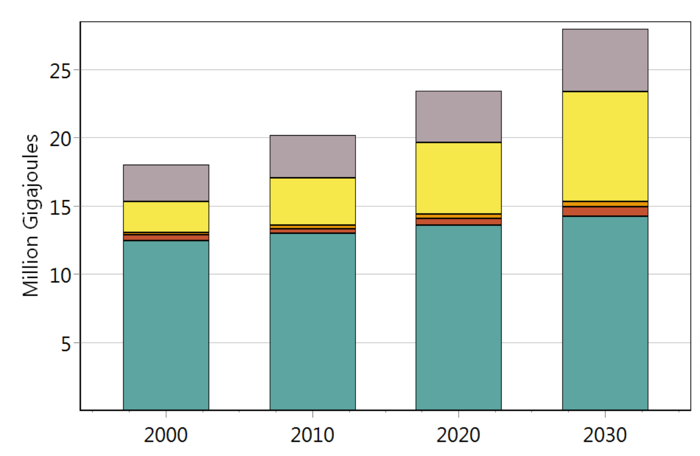


Figure 7: Total energy demand by sector, baseline scenario [Million Gigajoules]

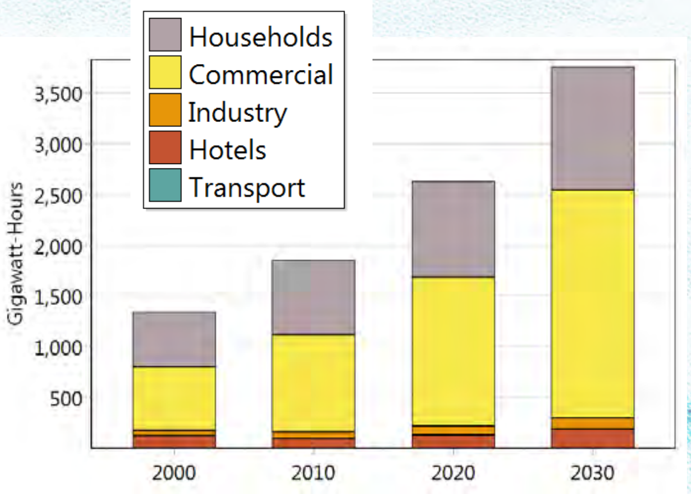


Figure 8: Total electricity demand by sector, baseline scenario [Gigawatt-hours]

Energy consumption was projected based on current conditions established by historical data and population and GDP projections. In LEAP, energy consumption is calculated using two variables: activity level and final energy intensity. An activity level is an indicator of the social or economic activity for which energy is consumed in a given sector, such as population or GDP. Final energy intensity defines the energy consumption per unit of activity level, such as Gigajoules per capita. Specific projections for each sector are defined in the sections that follow. These assumptions are used in years 2010 through 2030.

3.1.1.1 Households

The household sector included national consumption data and projections for electricity, kerosene and propane fuels. The sector is dominated by electricity consumption, and is assumed to increase as electric devices replace kerosene and propane.

Fuel Shares in the Household Sector

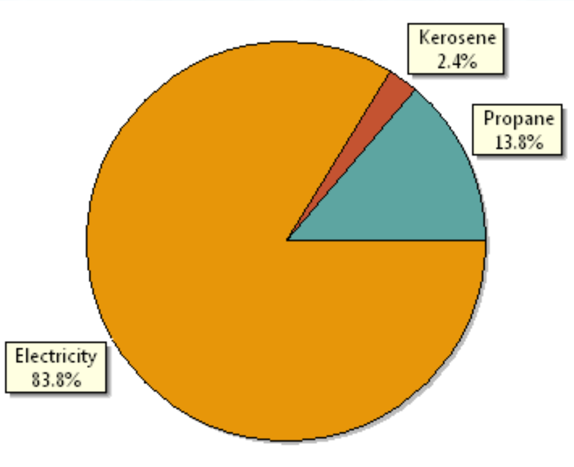


Figure 9: Fuel shares in the household sector in 2010, baseline scenario [%]

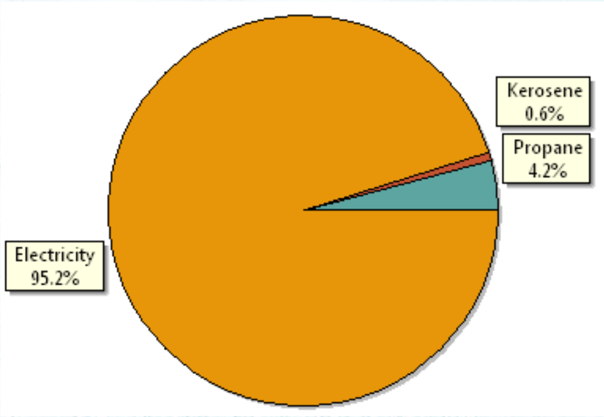


Figure 10: Fuel shares in the household sector in 2030, baseline scenario [%]

Total energy consumption was projected forward to the year 2030 using total population projections and historical trends of per capita consumption by fuel. Population projections were provided by the Department of Statistics[18] and yield a growth rate of about 0.94% per year from 2010 to 2030. Historical trends of per capita consumption led to an assumption of 0.89% annual growth.

[18] http://statistics.bahamas.gov.bs/

3.1.1.2 Commerce

The commercial sector includes only electricity data due to available data. Sectoral electricity consumption was projected based on historical trends for electricity consumption and commercial GDP data (i.e. the subset of national GDP allocated to commercial activities) from The Bahamas Central Bank[19]. In the commercial sector, GDP is expected to grow at a rate of 1.3% per year and energy consumption per unit of GDP is expected to increase at a 3.0% annual rate.

3.1.1.3 Industry

For the purposes of this assessment, it was assumed that electricity is the only fuel consumed in industrial processes. The industry sector is modeled much like the commercial sector, making use of trends in sectoral GDP data and electricity consumption. Industrial GDP was assumed to grow 2.7% every year and electricity consumption per unit of GDP was assumed to be constant due to a lack of consistent trend in historical data.

3.1.1.4 Hotels

Hotels were assumed to consume only electricity, and like the commerce and industry sectors, consumption was projected based on trends in sectoral GDP data and electricity consumption. GDP from the hotel sector was assumed to grow 3.6% every year and electricity consumption per unit of GDP was assumed to be constant due to a lack of consistent historical trend.

Fuel Shares in the Transport Sector

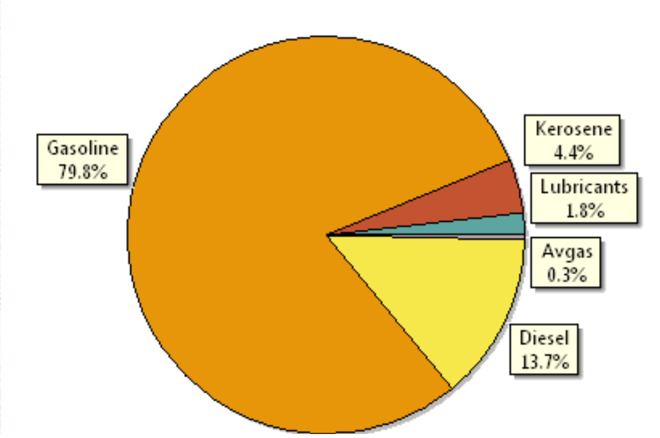


Figure 11: Fuel shares in the transport sector in all years, baseline scenario [%]

[19] http://www.centralbankbahamas.com/

3.1.1.5 Transport

The transport sector consumes a combination of various petroleum products. Historical consumption and fuel shares, which can be seen in Figure 11, are based on data related to annual oil imports to The Bahamas, and were assumed to remain constant over the period of 2010 to 2030. Total consumption was projected forward based on trends in transportation GDP, assumed to grow at 3.3% per year, and historical fuel consumption, assumed to decrease at 2.8% per year.

Capacity Expansion

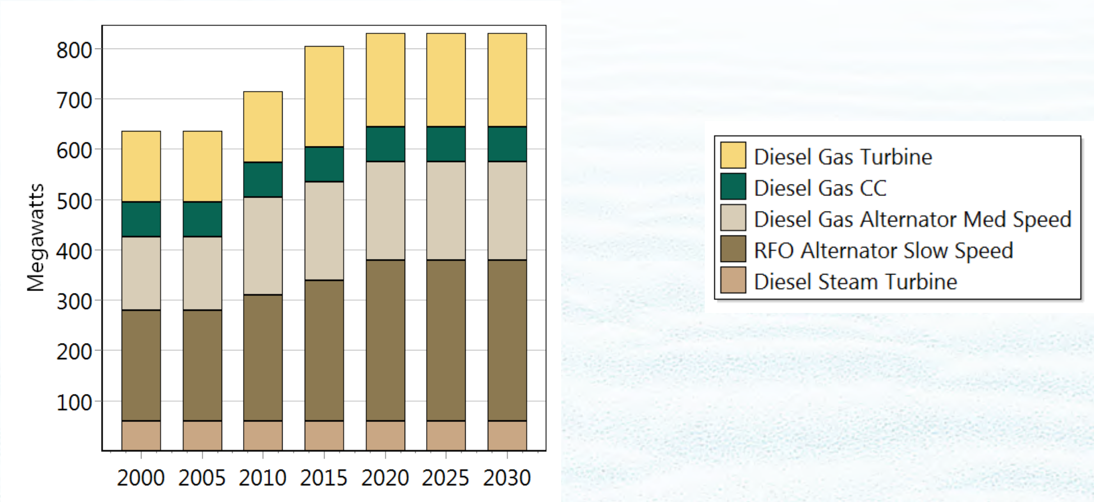


Figure 12: Capacity expansion, baseline scenario [MW]

3.1.1.6 Electricity Generation

The baseline scenario also includes projections for fossil fuel-based power plant capacity in The Bahamas.

All future power plants are built according to utility expansion and retirement plans, and include mainly diesel and residual fuel oil gas turbines and alternators.[20] Figure 12 shows the plans for installations of new power plants in MW. Plants are then dispatched to meet electricity consumption defined in the demand branches above in proportion to the available capacity.

Mitigation Scenario

This mitigation scenario is a representation of an alternative future for The Bahamas. The mitigation scenario follows the same basic approach as the baseline and includes the same historical data up to the year 2009. Based on the key policies and measures being explored by the Bahamian government, this mitigation scenario included the following four components:

1. *Rooftop Solar Thermal Hot Water Heaters Replacing Electric Hot Water Heaters In Residential Homes* - It was assumed that 100% of the hot water demand could be met by solar thermal by 2030;
2. *Distributed PV Generation In Residential Homes* - It was assumed that 100% of household photovoltaic (PV) potential could be achieved by 2030;
3. *Energy Efficiency Measures* - It was assumed that all other energy efficiency measures would amount to a 30% reduction in electricity demand compared to the baseline by 2030; and.
4. *New Renewable Generation Mix* – It was assumed that renewable power plants would be introduced to allow for 15% renewable generation by 2020 and 30% renewable generation by 2030.

Components one, two and three were modeled as demand-side measures, diminishing the requirements for grid electricity in The Bahamas. Component four is a supply-side measure, changing the electricity mix of the Bahamian grid. These quantitative targets are based on the Fichtner potential reports.[21] Each of these is described in more detail below.

Rooftop Solar Thermal

Approximately 90% of Bahamian households use electric water heaters, and this demand accounts for 10-15% of electricity production.[22]

Solar thermal hot water heaters are a well-established alternative technology, available with a variety of features to match the budgets of individual households.[23] Based on the study

[20] CC = combined cycle power plant; RFO = residual fuel oil
[21] Fichtner, Explore Alternatives for BEC's Expansion Plan, Preliminary Report II, Strengthening the Energy Sector in The Bahamas, September 2010.
[22] Fichtner, Promoting Sustainable Energy in The Bahamas, Preliminary Report II, Strengthening the Energy Sector in The Bahamas, June 2010. P. 2-1.

referenced in the Technical Potential section, available rooftop area is sufficient to cover the entire electric hot water demand in The Bahamas. It was therefore assumed that 100% of hot water demand would be met by solar thermal technologies by 2030, and this capacity would ramp up incrementally starting in 2010.

Residential Photovoltaic

Two types of photovoltaic (PV) measures are considered in the mitigation scenario: distributed generation in the residential sector (component 2) and grid-connected generation on the supply side (component 4). This measure includes only the portion of PV potential allocated to households.

Distributed generation from rooftop PV is an efficient way to make use of available roof areas and avoid transmission and distribution costs. It is assumed that this generation will come from households under net billing or net metering arrangements. This measure assumes that household PV installations will be gradually taken up starting in 2010, and will reach 100% of household PV potential by 2030.

Energy Efficiency Measures

In addition to the solar hot water heaters and residential PV measures that will decrease overall demand for electricity, many other energy efficiency measures are achievable by The Bahamas over the time period of 2010-2030. Energy audits of households, hotels and public buildings were conducted to give insight into currently available technologies and potentials.[24] Energy efficiency measures to reach the target of 30% by 2030 may include:

- Improved use of passive measures such as natural shading and ventilation;
- Installations of intelligent systems and monitoring (e.g. motion detectors for lights and air conditioning, monitoring of energy consumption);
- Reuse of grey water for gardens and parks; and
- Education programs.
- Replacement of old inefficient appliances (e.g. refrigerators, freezers, washing machines)

A combination of these measures (and many others) is assumed to collectively be able to reduce electricity consumption in 2030 by 30% compared to the baseline scenario. This measure has the greatest electricity reduction potential of the demand-side policies when compared with the baseline scenario, as can be seen in Figures 13 and 14.

Total Electricity Consumption for Three Demand-side Policies

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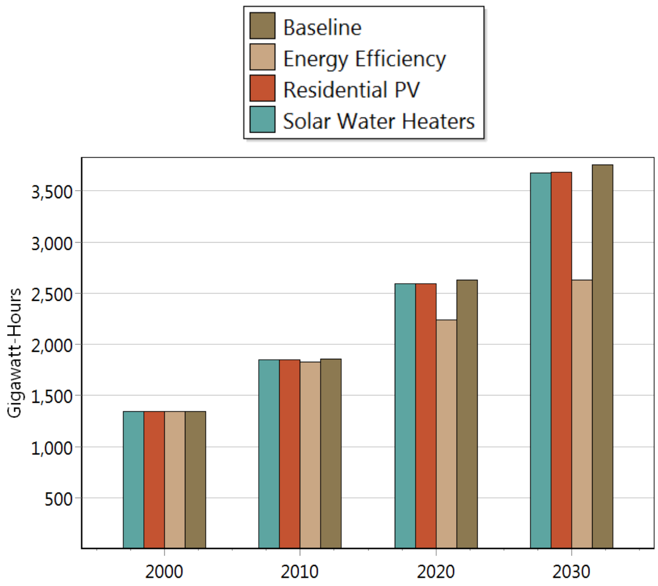
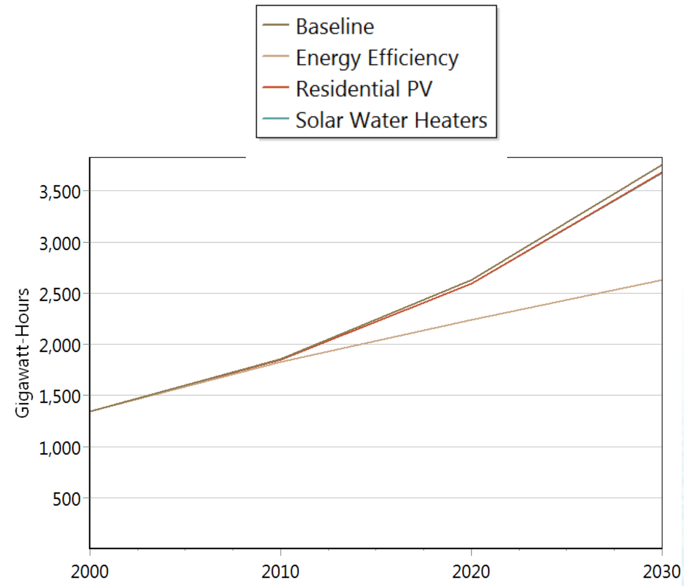
[23] Fichtner, Promoting Sustainable Energy in The Bahamas, Preliminary Report II, Strengthening the Energy Sector in The Bahamas, June 2010. P. 1-8.

[24] Fichtner, 2010, Promoting Sustainable Energy in The Bahamas, Preliminary Report II, Strengthening the Energy Sector in The Bahamas, June 2010. P. 3-1.

Total Electricity Consumption for Three Demand-side Policies





Figures 13 and 14: Total electricity consumption for three demand-side policies as compared with the baseline scenario [Gigawatt-hours][25]

Renewable Grid Electricity Generation

The fourth component to the mitigation scenario was the only supply-side measure included. To reach the renewable generation targets, five technologies were considered. All quantitative mitigation targets are based on the potentials developed by the Fichtner studies.[26] Biomass shows the most promise in terms of near-term electricity production potential in The Bahamas. The 15 Megawatt waste to energy power plant is being considered both for electricity generation purposes and also for waste management purposes. The ocean thermal electric conversion (OTEC) systems considered are expected to be a viable technology option for The Bahamas by 2030. Table 18 shows the renewable capacity additions modeled in the mitigation scenario.

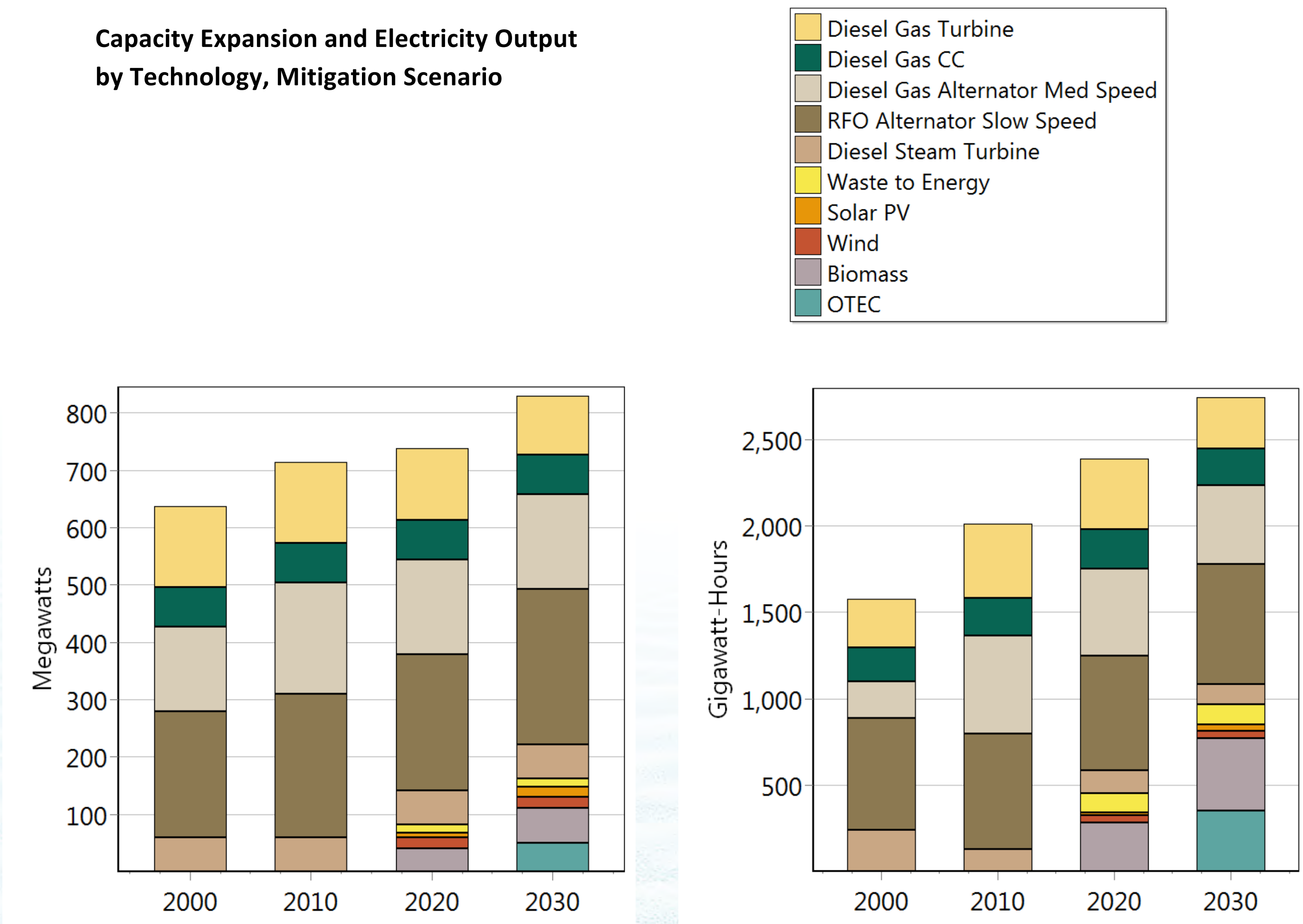
[25] The Residential PV measure and the Solar Water Heater measure have very similar reductions, and therefore the line for solar water heaters cannot be seen in Figure 8.
[26] Fichtner, Explore Alternatives for BEC's Expansion Plan, Preliminary Report II, Strengthening the Energy Sector in The Bahamas, September 2010. P. 4-7.

Renewable Electricity Generating Capacity and Generation in 2030, Mitigation Scenario

Technology	Capacity [MW]	Generation [GWh]
Biomass	60	1510
Waste to Energy	15	400
Solar PV	17	130
Wind	20	150
OTEC	50	1250

Table 18: Renewable electricity generating capacity and generation in 2030, mitigation scenario

Figures 15 and 16 show the additions of renewable energies to national electric grid capacity in an overall electricity generation. Note that renewable additions to capacity are not always proportional to electricity generation by the same technology because of performance parameters and the intermittency of renewables such as wind and solar. Biomass, OTEC and waste to energy are base load plants, and can therefore generate more electricity than wind and solar per unit of capacity.



Figures 15 and 16: Capacity expansion [MW] and electricity output [GWh] by technology, mitigation scenario.

3.2 RESULTS

Outputs of the mitigation scenario are put into context by comparing them back to the baseline scenario. This comparison highlights the potential demand reductions and emission savings possible if such policies and measures were enacted.

Solar hot water heaters and residential PV policies are able to reduce household electricity demand by 6% and 5%, respectively in 2030. The energy efficiency scenario reduces electricity demand across all sectors by 30% in 2030. Total electricity demand reductions in the mitigation scenario amount to over 1200 Gigawatt-hours, approximately 34% of the baseline electricity consumption in 2030.

Electricity Demand and GHG Emission Savings in 2030

Policy/Measure	Electricity Demand Savings [GWh]	GHG Emission Savings [kT CO_2e]
Solar Hot Water Heaters	75	69
Residential PV	69	64
Energy Efficiency	1125	1032
Renewable Generation	0	843
Mitigation	1269	1988

Table 18: Electricity demand and GHG emission savings in 2030 based on individual policies explored and the comprehensive mitigation scenario

Figure 17 shows the dynamic reductions in electricity demand over time based on the three demand-side mitigation policies included in the mitigation scenario. The dotted white bar represents the avoided demand, or the amount that is required in the baseline scenario that is not required in the mitigation scenario.

Avoided Electricity Demand in Mitigation Scenario as Compared With the Baseline Scenario

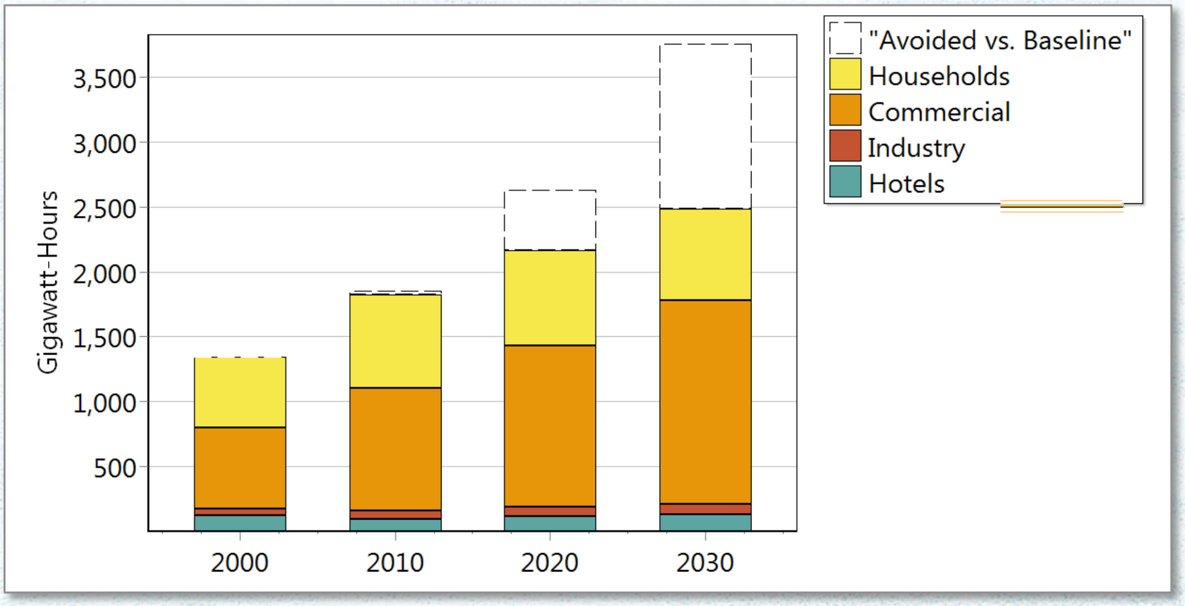


Figure 17: Avoided electricity demand in mitigation scenario as compared with the baseline scenario [Gigawatt-hours]

The electricity demands avoided due to solar PV, solar water heaters and energy efficiency in turn decrease the overall electricity generation required by power plants. Figure 18 shows a comprehensive picture of the electricity supply mix and the avoided electricity generation leading up to 2030.

Avoided Electricity Generation by Technology in the Mitigation Scenario as Compared With the Baseline Scenario

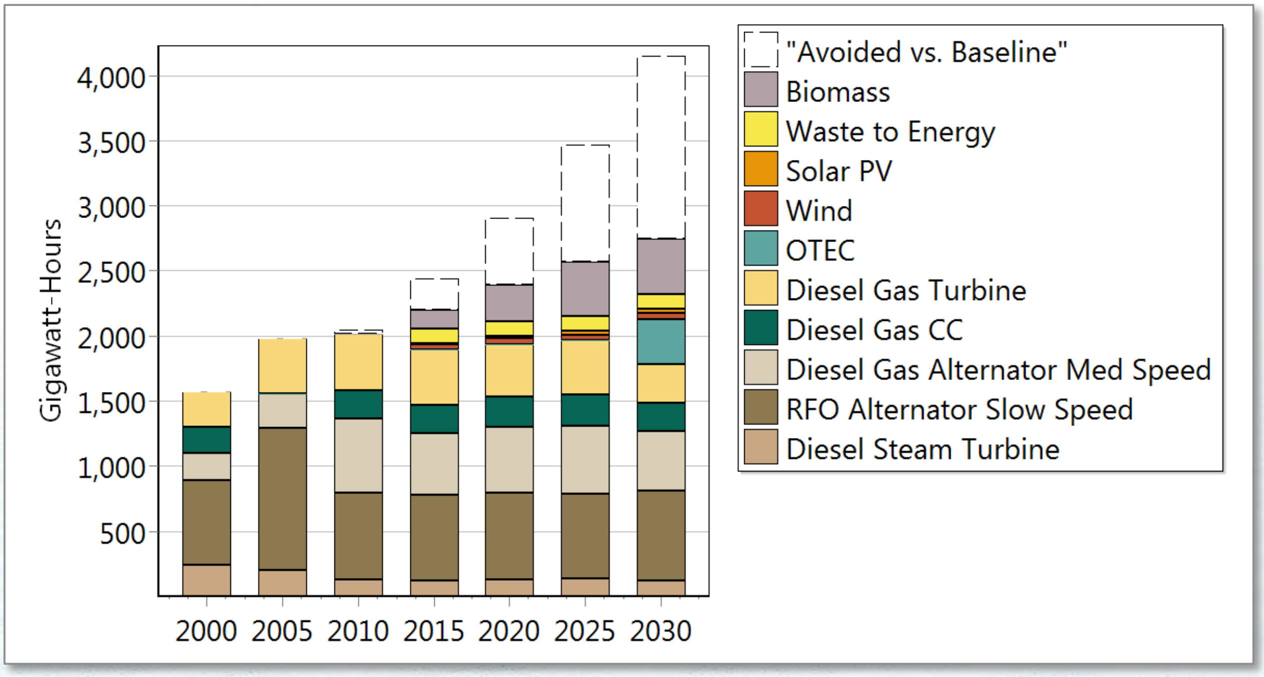


Figure 18: Avoided electricity generation by technology in the mitigation scenario as compared with the baseline scenario [Gigawatt-hours]

Based on the renewable energy potential in The Bahamas and the power plant expansion plans assumed for the mitigation scenario, The Bahamas could feasibly produce over 30% of their electricity from renewable generation sources by 2030.

Renewable Electricity Generation by Technology in the Mitigation Scenario

Table 19: Renewable electricity generation by technology in the Mitigation scenario [GWh]

	2010	2015	2020	2025	2030
Biomass	0	140	280	420	420
Waste to Energy	0	112	112	112	112
Solar PV	0	4	15	26	37
Wind	0	44	44	44	44
OTEC	0	0	0	0	350
Total Generation Required	2,014	2,195	2,338	2,568	2,743
% Renewable Generation	0%	13.6%	19.3%	23.4%	35.1%

Table 19: Renewable electricity generation by technology in the Mitigation scenario [GWh]

Table 19 includes overall GHG savings from each policy measure found in the mitigation scenario. The energy efficiency and renewable grid electricity measures provide the majority of the savings. These measures mainly displace residual fuel oil and diesel fuel from electricity generation.

Avoided GHG Emissions by Fuel in the Mitigation Scenario Compared With the Baseline Scenario

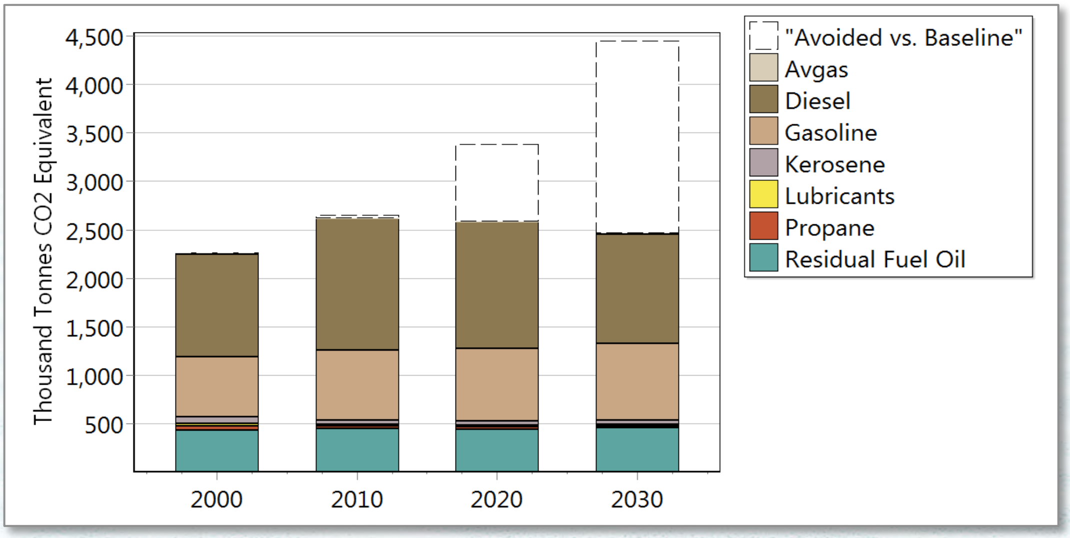


Figure 19: Avoided GHG emissions by fuel in the mitigation scenario as compared with the baseline scenario [Thousand Tonnes CO_2 equivalent][27]

The scenario analysis for The Bahamas included only policies for the energy sector, and more specifically policies related to the generation and consumption of electricity. As documented in the Greenhouse Gas (GHG) Inventory chapter, The Bahamas also has a GHG emission sink from the land use change and forestry sector. If these savings were to be included in an analysis like LEAP based on the estimates in GHG inventory calculations, net emissions would be negative, as can be seen in Figure 19.

[27] Only primary resources are included in this graph. This means that electricity is not included, and instead, the fuels used to produce electricity are shown (i.e. diesel and residual fuel oil).

Avoided Emissions by Sector for the Mitigation Scenario compared With the Baseline Scenario Including Land Use Change and Forestry

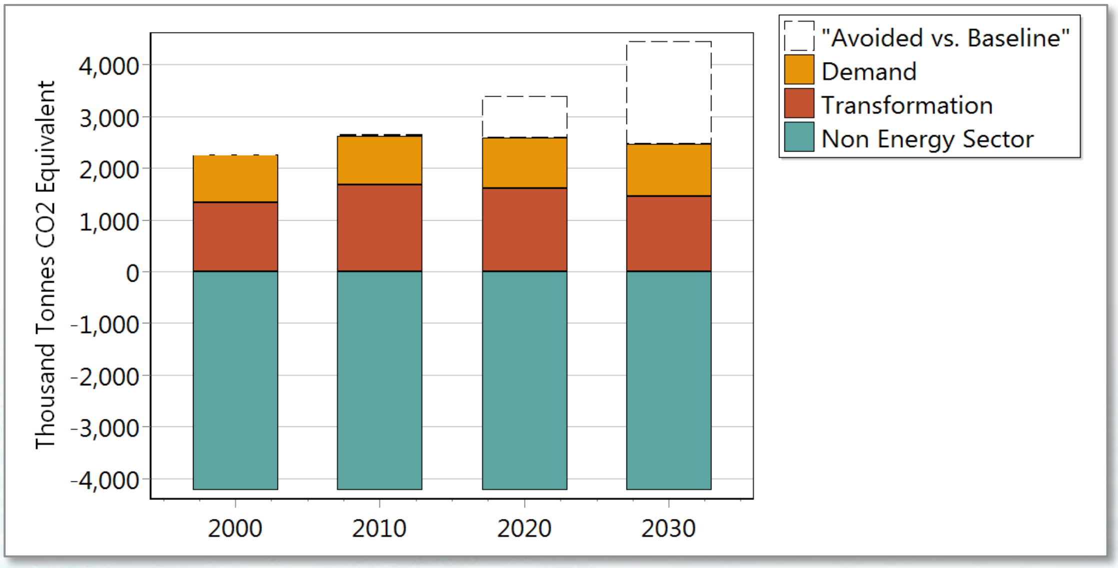


Figure 20: Avoided emissions by sector for the mitigation scenario as compared with the baseline scenario including land use change and forestry [Thousand Tonnes CO_2 equivalent][28]

[28] This assumes no change in GHG emissions or savings from the non-energy sector from the 2000 GHG inventory. Transformation includes emissions from electricity production, transmission and distribution.

3.3 NEXT STEPS

The mitigation assessment described in this chapter is purely theoretical. In order to establish, enforce and monitor the policies and measures discussed in this chapter, barriers related to energy efficiency, scaling up renewables and the transport sector would first have to be addressed.

Barriers to Energy Efficiency

The large-scale deployment of energy efficiency measures faces the following non-economic barriers:

- Lack of awareness, knowledge and skills among users, planners, designers and service providers about energy efficient alternatives to the incumbent technologies and the opportunities of energy efficiency;
- Higher up-front investments – albeit most energy efficiency measures are highly cost competitive. In particular, private consumers tend to prefer no/low investment and low running costs instead of high running costs to high up-front investments;
- Limited availability of high efficient technologies – the size of the Bahamian market limits the choice between different appliances, etc., so that often only inefficient default technologies are promoted; and
- Landlord-tenant problem, i.e., the house owner who installs and invests in a renewable energy plant does not benefit from the lowered running energy costs, but the tenant as the energy consumer does. [29]

Barriers to Renewable Energy Deployment

Scaling up renewable energies to meet the proposed policy measures will undoubtedly face the following barriers:

- Lack of awareness, knowledge and skills among users, planners, designers and service providers regarding how renewable energy technologies and opportunities can be applied;
- Lack of access to capital to cover the high up-front investments e.g. financial institutions/ lending facilities are not ready to finance renewable energy projects since they are not familiar with the concept;
- Independent power producers (IPP) are not granted grid access by law;
- Lack of incentives for The Bahamas Electricity Corporation (BEC) to buy electricity from IPP rather than transferring all costs to the final customer;
- Lack of clear technical and commercial grid connection rules, i.e. grid connection must be negotiated by case, which is time consuming; and
- Uncompetitive technologies under present conditions. However, this picture may change with costs of some renewable energy technologies further decreasing, and prices of competing fossil fuels increasing. [30]

[29] Policy report p.23/44 (exact text)

Barriers to Transport Modelling

As mentioned previously, the transport sector was not included in the quantitative mitigation assessment due to a lack of detailed data. If addressed, the following data gaps will greatly broaden the scope of future mitigation studies:

- Passenger vehicle numbers, types, model years;
- Commercial land vehicle numbers, types, model years;
- Passenger, recreational, cargo and commercial marine vessel numbers and types;
- Passenger and private aircraft numbers and types;
- Mileage and consumption data of all fuel types and vehicle categories and classes;
- Existing traffic control systems;
- Public transit statistics;
- Petroleum product pricing and marketing trend factors; and
- Petroleum product shipping, delivery and distribution frequencies and practices. [31]

[30] Policy report 19/44 (exact text)
[31] Policy report 13/44 (exact text)

CHAPTER 4: CLIMATE CHANGE IMPACTS, VULNERABILITY AND ADAPTATION

4.1 INTRODUCTION

Like other Small Island Developing States (SIDS), The Bahamas is highly vulnerable to adverse impacts of climate change and sea-level rise. The clear, warm waters, white sandy beaches, warm climate and close proximity to large tourism demand centers, such as the United States of America (USA) and Canada make The Bahamas a prime tourist destination. Thus, tourism is the mainstay of its economy accounting for 60% of the gross domestic product (GDP).

The existing mechanisms and infrastructure for addressing disasters and to responding to the adverse effects of climate change include the National Emergency Management Agency (NEMA), and an effective early warning system. In addition, the GOB has had to provide infrastructure and support mechanisms to respond to sow on-set events, for example, the placement of seawalls.

However, the development and effectiveness of these mechanisms is hampered by limited resources, the frequency of extreme events and the extent of impacts across the archipelago. Further, as is shown in this assessment, The Bahamas will not be able to sustain the level of economic development highly skewed by tourism for the long-term unless it addresses the root causes of the adverse impacts of climate change and sea-level rise.

The vulnerability and adaptation assessment conducted and presented here fulfils the requirements of and obligations to the United Nations Framework Convention on Climate Change (UNFCC). It also serves to highlight the imminent threat of climate change and sea-level rise to its long-term survival. The vulnerability and adaptation assessment further highlights the efforts made by the Government of The Bahamas (GOB) in dealing with concomitant issues relating to the adverse impacts of climate change and sea-level rise, variability and extreme events. Some of these issues are covered in the Chapter on National Circumstances (pages 40 - 71).

The capacity of The Bahamas in addressing adverse effects of climate change are often compromised of limitations on response capabilities, socio-economic conditions, financial resources, insurance and associated economic services for managing climate change risks. While this may constitute a limitation in the assessment, many of the vulnerable sectors in this study have direct/indirect implications and linkages to the overall capacities and capabilities.

This is the first V&A assessment conducted in The Bahamas, and it focuses on the most vulnerable sectors of the economy. The V&A assessment was conducted using a range of frameworks underpinned by consultations with the following: key stakeholders; literature surveys; analysis of information contained in the First National Communication; data and information generated from national, regional and international sources; and from modeling the impacts and adaptations of climate change and sea-level rise under the various greenhouse gas emissions scenarios provided in the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emission Scenarios (SRES 2003).

4.1.1 Implications from IPCC Fourth Assessment Report (AR4)

The Intergovernmental Panel on Climate Change (IPCC) in its Fourth Assessment Report (AR4) concluded that "for the next two decades, a warming of about 0.2°C (32°F) per decade is projected for a range of SRES emission scenarios. Even if the concentrations of all greenhouse gases and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1°C per decade would be expected. Continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would *very likely* be larger than those observed during the 20th century." The IPCC (IPCC 2007) further concluded that while there is now higher confidence in projected patterns of warming. Other regional-scale features, such as including changes in wind patterns, precipitation, some aspects of extremes, ice, global warming and sea level rise are all a result of human activities. These features would continue for centuries due to the time scales associated with climate processes and feedbacks, even if greenhouse gas concentrations were to be stabilised.

These conclusions have serious implications for many countries including SIDS like The Bahamas. The Bahamas is already committed to at least a warming of 0.2^{o}C over the next two decades. Recent analysis of temperature records show that the average annual temperatures have been steadily increasing over the last 30 years (1971-2000), and this trend is likely to continue in the foreseeable future.

The observation record of temperature in The Bahamas has shown that the mean annual temperature has increased by about 0.5^{o}C since 1960, at an average of 0.11^{o}C per decade (McSweeney, et. al. 2009). The rate of increase is most rapid in the warmest seasons (JJA and SON) at 0.13^{o}C and 0.15^{o}C per decade respectively. As for rainfall, observational record shows that mean rainfall over The Bahamas has not changed significantly since 1960.

4.1.2 Sea Level Monitoring

With regard to sea level monitoring, The Bahamas has four tide gauges at Nassau Harbour, Lee Stocking, Inagua and Settlement Point, Grand Bahama. The first three tide gauges were provided and installed in 2002 under the project - Caribbean: Planning for Adaptation to Climate Change (CPACC) Project of the Organization of American States (OAS). Unfortunately, data strings for Inagua and Lee Stocking Island have been shortened due to monitoring disruptions caused by tropical cyclones. A tide gauge at Settlement Point has been operated and maintained by the United States of America's National Oceanographic and Atmospheric Administration as part of the Global Sea Level Observing System (GLOSS) network, since 1978.

The Perry Institute for Marine Sciences has made additional observations, at Lee Stocking Island in the Exuma Cays that 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.

4.2 APPROACHES AND FRAMEWORKS FOR VULNERABILITY AND ADAPTATION ASSESSMENT

The vulnerability and adaptation assessment (V&A) report presented here is in line with the guidelines provided by the UNFCCC guidelines for the preparation of the national communications adopted at the eighth session of the Conference of the Parties to the UNFCCC. The information generated for the V&A assessment followed two principal approaches: (i) a consultative process involving key stakeholders and/or sectors and (ii) a modeling approach using climate change and sea-level rise projections for different time horizons in the future. These approaches enable the impact analyses, identification of adaptation options, measures and strategies. The V&A assessment is regarded as a living document; i.e., it will be updated and presented on a regular basis and will depend on the availability of resources and expertise. The periodicity of V&A assessment is considered significant for The Bahamas as the needs and priorities for adaptation to climate change over the long term will more than likely change as with the projected changes in climate change and sea level.

A number of approaches and frameworks were used in conducting the assessment of vulnerability and adaptation in The Bahamas. All of the frameworks and approaches are based on and are closely aligned with the common methodology of the following Intergovernmental Panel on Climate Change (IPCC 1996); United States Country Studies Handbook on Vulnerability and Adaptation Assessments (1996); and the UNEP Handbook on Vulnerability and Adaptation Assessments (1998). Additionally, a number of other approaches were used to collect information and to help characterize future climate change risks. These include focussed meetings and consultations to find out past, present and future activities relating to V&A in the various sectors and to ascertain the needs and priorities for V&A within each of the sectors. Stakeholder consultations initially took about one month and continued through the V&A process. Consultations were held with the following organisations:

Government Departments/Agencies	
Bahamas Environment, Science and Technology (BEST) Commission	Department of Environmental Health Services
Department of Meteorology	Bahamas National Geographic Information System
Department of Marine Resources	Water and Sewerage Corporation
Tourism	Lands and Surveys
Bahamas Electricity Corporation	Department of Forests
National Emergency Management Agency	
Non-Government Organisations	
The Bahamas National Trust	Bahamas General Insurance Association
The Nature Conservancy	Pan-American Health Organisation

4.2.1 Assessment of Vulnerability and Adaptation

The consultations found that while climate change and sea-level rise are recognised as serious threats to relevant sectors of the economy most sectors do not necessarily incorporate climate change issues in their operations. With the exception of the Department of Meteorology, BEST Commission, and the Water and Sewerage Corporation, climate change and sea-level rise concerns and issues are not explicitly addressed in other sectors. Many of these sectors have indicated that this may be attributable to the lack of information on the adverse impacts of climate change except for the most identifiable impacts resulting from hurricanes.

The stakeholder consultations were followed by a kick-off workshop on climate change vulnerability and adaptation assessment to: (i) brief the stakeholders (thematic working group on V&A/participants) on V&A assessment in the context of preparing the second national communication under the new UNFCCC guidelines[32]; (ii) introduce a range of frameworks, approaches, methods, tools, and data sources for conducting V&A assessment; (iii) provide a forum for participants to share knowledge, experience, and difficulties in preparing the V&A component; and (iv) examine ways of overcoming these constraints/gaps.

The workshop brought together participants from the various government departments, agencies and ministries, as well as, representatives from the non-government organisations. The workshop involved presentations on specific topics covering the various aspects of V&A assessment and group exercises. The group exercises focused on vulnerability analysis using

[32] The UNFCCC guidelines for the preparation of national communications from Parties not included in annex I to the Convention is contained in decision 17/CP.8 http://unfccc.int/resource/docs/cop8/07a02.pdf#page=2 .

both bottom-up and top-down approaches. A number of resource people were available to help facilitate and respond to queries and/or comments raised by the participants.

4.2.2 Training: Learning-by-doing

The second component focusing on climate change vulnerability and adaptation assessment (V&A) for The Bahamas was facilitated by a training workshop on climate change. The workshop focused on building the capacity of The Bahamas experts to conduct V&A. This will help to identify, evaluate and prioritise key vulnerabilities, adaptive strategies, policies and measures that need to be implemented to improve and enhance the adaptive capacity of The Bahamas, as a nation.

The training of The Bahamas *Experts to Assess Climate Change Impacts, Vulnerability and Adaptation*, was held from May 3 to 8, 2010, in Nassau, The Bahamas. The workshop was organised by The Bahamas Environment Science and Technology Commission (BEST). National experts representing the key sectors (agriculture, forests, water resources, energy, coastal resources, and health) attended and participated in the training workshop.

The overall goal of the training workshop was to provide training in the use and application of BahamasSimCLIM[33] for examining impacts and adaptations to climate variability and change in The Bahamas. The workshop was organised to achieve the following:

1. To build the skills for integrating and testing model components to be used for examining the effects of climate variability and change, through hands-on training on: -
    - The use of BahamasSimCLIM software programme;
    - Adjustment and/or selection of the parameters of the climate change models to fit The Bahamas situation; and
    - Evaluation of the performance and sensitivity of the impact models under the various environmental and climatic conditions found in The Bahamas.
2. To conduct an initial model-based impact assessment using SimCLIM for The Bahamas (BahamasSimCLIM), in order to ensure that the team members have the knowledge and skills to use the system for impact assessments to:-
    - Identify a set of scenarios and protocols for use in the assessment, including consideration of: the baselines for comparison; the time horizons; GCM patterns; emission scenarios; climate sensitivities to be selected within BahamasSimCLIM; and the inclusion of climate variability and extremes;.
    - Decide upon the outputs of the model runs that should be used as indicators of impact;
    - Obtain crop and water impacts under the set of baseline and climate change scenarios; and
    - Processing and analysing the results of the simulations.

The training workshop involved presentations on specific topics covering the various aspects of climate change assessment and group exercises. Each participant had a laptop supplied by

[33] BahamasSimCLIM is a tool for generating climate change and sea-level rise projections using the various SRES emission scenarios. The tool has an open structure which allows it to be populated with the country-specific data and is linked to the several biophysical models for conducting integrated assessments. BahamasSimCLIM uses ensemble of 21 GCM patterns for generating climate change and sea-level rise projections for The Bahamas. More information on this tool and its applications can be obtained from http://www.climsystems.com/.

their respective government offices. Each laptop had a BahamasSimCLIM system, site licenses, model components, site specific data, and an instruction manual installed. Two resource people were available to help facilitate the training and respond to queries and comments raised by the participants.

The training was based on the *SimCLIM Essentials for The Bahamas: Training Book I*, an instruction booklet which allows for a step-by–step process of navigating through the software. Apart from navigating through instructions on the main component sessions were centred on the following: creating synthetic scenarios; generating scenarios and showing changes from baseline conditions; creating site-specific climate change scenarios; creating sea-level rise scenarios and running an impact model including a model for rain water collection/use. Other specific tools include a climate data browser and an extreme event analysis.

The training allowed for the following: the creation and/or generation of climate change and sea-level rise scenarios; familiarization of the participants with the interpretation of results; appropriate use of global circulation models and the use of the IPCC Special Report on Emission Scenarios (SRES) for scenarios on greenhouse gas emissions.

Another important aspect of the training was the ability and/or capacity to input country-specific or site-specific data to The BahamasSimCLIM system. This enabled The Bahamas experts to populate the model with Bahamas-specific site data prior to, during and after the SNC process. Participants also learnt that this tool will help The Bahamas design and implement climate change-related projects as a planning tool for project design, development and implementation.

Sectors that are important to climate change vulnerability and adaptation assessment work in The Bahamas include agriculture, water resources, forests, coastal resources, human health, energy, fisheries and disaster preparedness.

4.3 Evidence of Climate Change in The Bahamas and Projection to 2100

Recent analysis of the temperature record in The Bahamas shows that average annual temperatures have been steadily increasing over the last 30 years (1971-2000) and this trend is likely to continue in the foreseeable future (McSweeney, et al. 2009). The observation record of temperature in The Bahamas has shown that the mean annual temperature has increased by about 0.5^{o}C since 1960, at an average of 0.11^{o}C per decade (McSweeney, et al. 2009). The rate of increase is most rapid in the warmest seasons (JJA) and SON) at 0.13^{o}C and 0.15^{o}C per decade respectively. As for rainfall, observational record shows that the mean rainfall over The Bahamas has not changed significantly since 1960. The general trend for The Bahamas shows an increasing temperature from 1960-2006 (Figure 21). Figure 21 also provides projected trends up to 2100 under A2, A1B and B1 emissions scenarios (McSweeney, et al. 2009).

Trends in Annual and Seasonal Mean Temperature for the Recent, Past and Projected Future Under A2, A1B and B1 Emission Scenarios

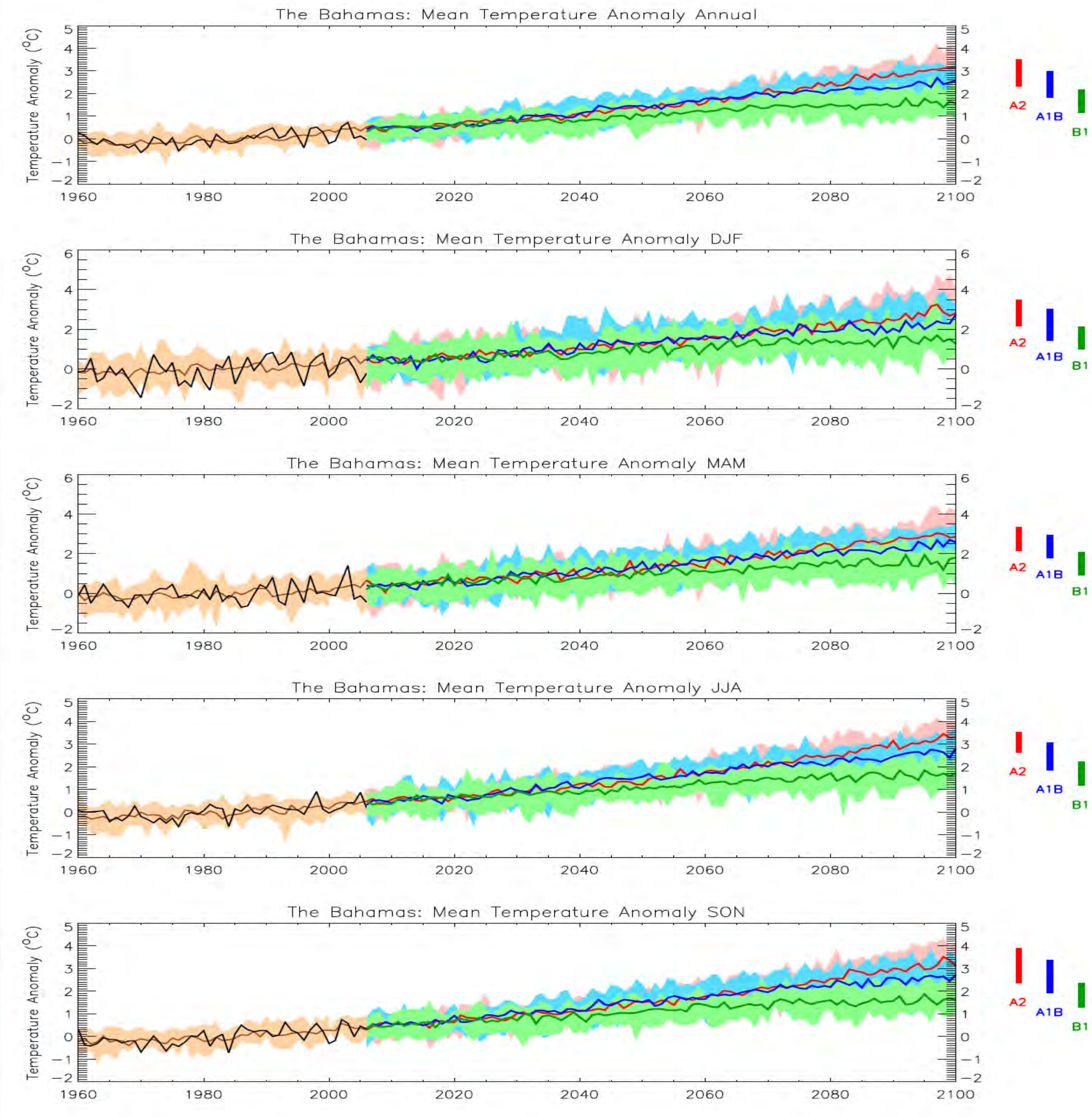


Figure 21: Trends in annual and seasonal mean temperature for the recent, past and projected future under A2, A1B and B1 emission scenarios. All values shown are anomalies, relative to the 1970-1999 mean climates. Black curves show the mean of observed data from 1960 to 2006, Brown curves show the median (solid line) and range (shading) of model simulations of recent climate across an ensemble of 15 models. Coloured lines from 2006 onwards show the median (solid line) and range (shading) of the ensemble projections of climate under three emissions scenarios. Coloured bars on the right-hand side of the projections summarise the range of mean 2090-2100 climates simulated by the 15 models for each emissions scenario (reproduced from McSweeney, et. al. 2009).

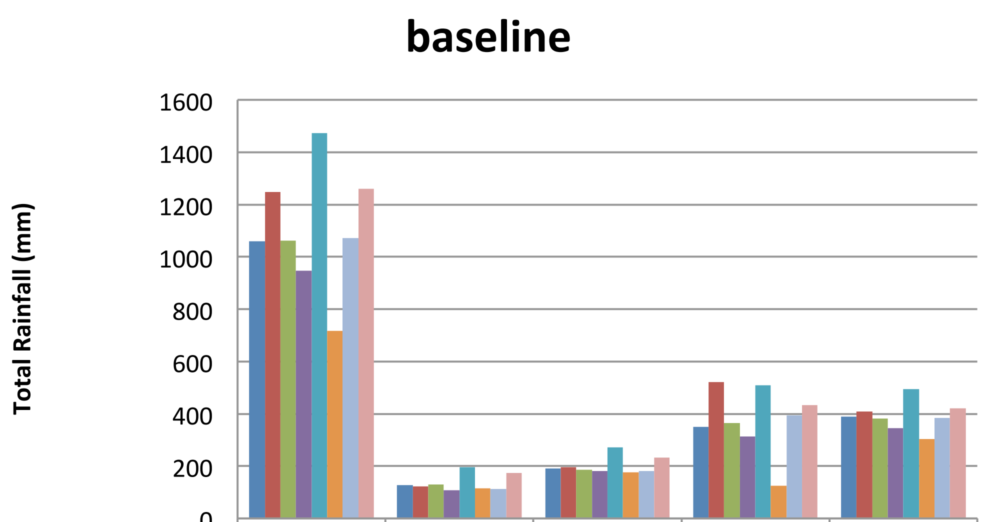
4.4 Climate Change and Sea Level Rise Projections

Projections of future changes in climate are from a baseline, the average over the period 1961-1990. For sea-level rise projections the baseline is 1990. The SimCLIM software (Warrick 2009) which uses the results of the GCMs in the IPCC intermodal comparison database was used to generate the calculations. Where possible, ensemble results were used.

4.4.1 Precipitation

The baseline precipitation for the entire The Bahamas and seven of its islands is given in the table below (yearly total, as well as seasonal sums, all in millimetres).

Seasonal Rainfall in The Bahamas



	YR	DJF	MAM	JJA	SON
Bahamas	1059	128	192	351	388
New Providence	1248	123	196	521	408
Eleuthera	1063	129	187	364	383
Exuma	948	109	180	313	346
Grand Bahamas	1472	196	272	510	494
Inagua	717	114	176	124	303
Andros	1072	113	180	394	385
Abaco	1260	174	232	433	421

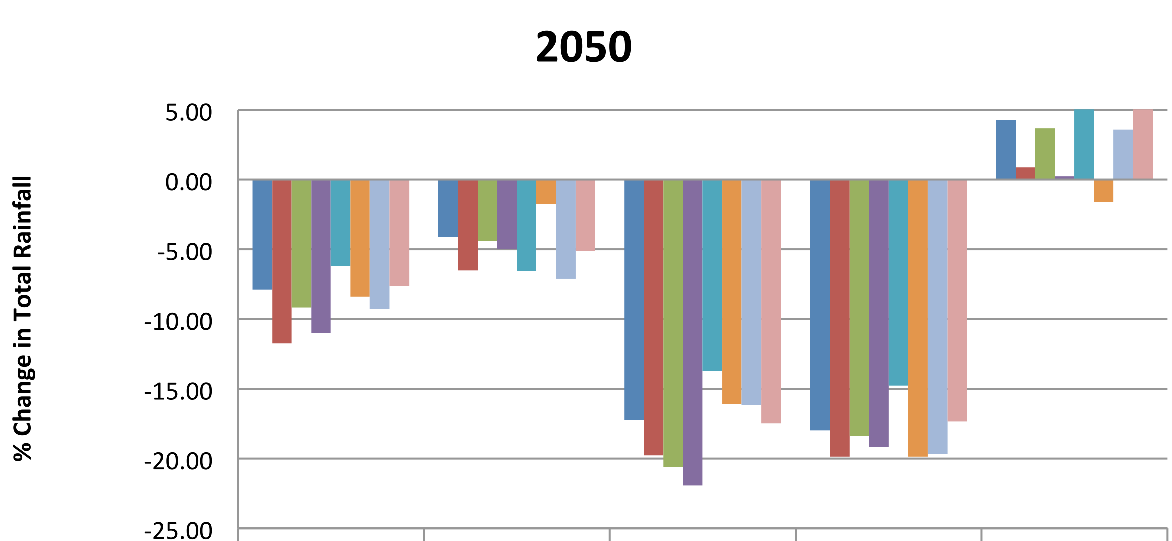
Table 20: Annual seasonal rainfall in The Bahamas

The "wettest" island (Grand Bahama) gets twice the amount of rain (1472 mm) of the "driest" island (Inagua, 717 mm) annually, but for the June/July/August season, it is four times more (510 mm vs. 124 mm). Thus, more rain falls in the northwest (Grand Bahama, Eleuthera, and Abaco), Central (Andros, New Providence) and less in the southeast (Exuma, Inagua).

Decreases in summer rainfall in all islands are expected with significant decreases in Exuma, Eleuthera and New Providence. During the winter Inagua will remain “driest” while all other islands to the northwest will experience an increase in rainfall by 2050. The northwest Bahamas will be wet while the southeast Bahamas will experience dry conditions.

Using the median result of a 21-GCM ensemble, the A1FI emission scenario, with high climate sensitivity rainfall changes (%) likely to be expected by 2050 will mean a decrease in rainfall by as much as 10% for annual precipitation, and 20% in some seasons for most islands (Table 21 below). Winter will be drier in Inagua while all islands to the northwest will have an increase in precipitation.

Results of the 21-GCM Ensemble for The Bahamas 2050



	YR	DJF	MAM	JJA	SON
Bahamas	-7.88	-4.12	-17.26	-17.99	4.25
New Providence	-11.76	-6.50	-19.79	-19.85	0.86
Eleuthera	-9.17	-4.38	-20.60	-18.41	3.67
Exuma	-11.00	-5.02	-21.92	-19.18	0.21
Grand Bahamas	-6.20	-6.58	-13.71	-14.79	6.92
Inagua	-8.38	-1.74	-16.12	-19.85	-1.62
Andros	-9.28	-7.09	-16.15	-19.68	3.57
Abaco	-7.63	-5.12	-17.47	-17.34	6.77

Table 21: Results of the 21-GCM Ensemble for The Bahamas 2050

Spatially, the distribution and change (%) in rainfall is expected to decrease by 10-20% by 2050. Most islands will decrease by 10% in annual rainfall and up to 20% decrease in some seasons due to climate change. For instance New Providence, Eleuthera and Exuma islands would experience up to 20% reduction in rainfall during the dry and wet seasons (March-August) by 2050.

Even within each island the rainfall changes will be significant. For instance in New Providence annual rainfall ranges from 1200-1400mm in New Providence; with less in the east than in the west of the island. The west is a highly developed and densely populated area, and less rainfall is likely to compromise future water supply. This will put additional pressure with increased risk of fires. The figure below shows precipitation for New Providence with a decrease of 11.3-12.1% thus indicating a west-east gradient (Figure 22 (b)). The average rainfall ranges from 1,204.1 mm to 1,367.5 mm (based on 1961-1990 record). There is a clear distinction between the eastern areas which receive less rainfall (by as much as 11% less) than in the western section of the island (Figure 22 (a)).

The change in rainfall for The Bahamas would decrease by as much as 5-11% in most islands. Drier regions such as the southeast (e.g. Inagua) will become drier while the wet regions in the northwest will experience a decrease in rainfall, but not as much as the southeast region. Decreases in rainfall will mean less recharge of the groundwater. Additionally, the seasonal differences will be greater ranging from a 6-20% decrease. Water resources on drier islands is the southeast will be highly compromised. Figure 23 shows the spatial distribution of rainfall in the entire Bahamas archipelago.

Precipitation Rates of New Providence

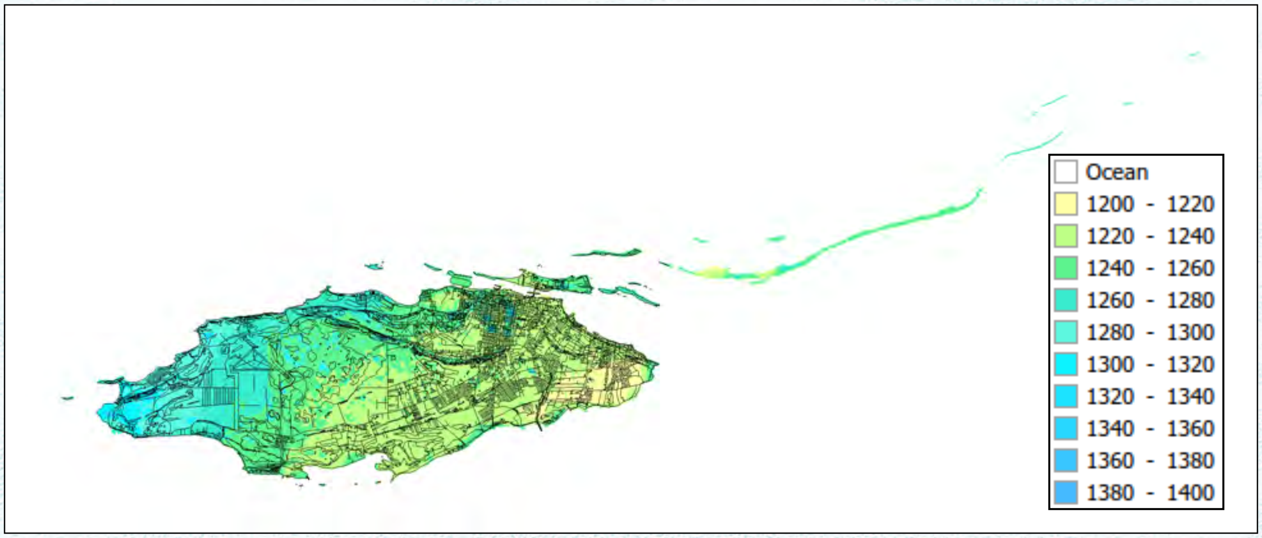


Figure 22 (a): Baseline precipitation New Providence (mm/yr)

Change in Precipitation in The Bahamas (1)

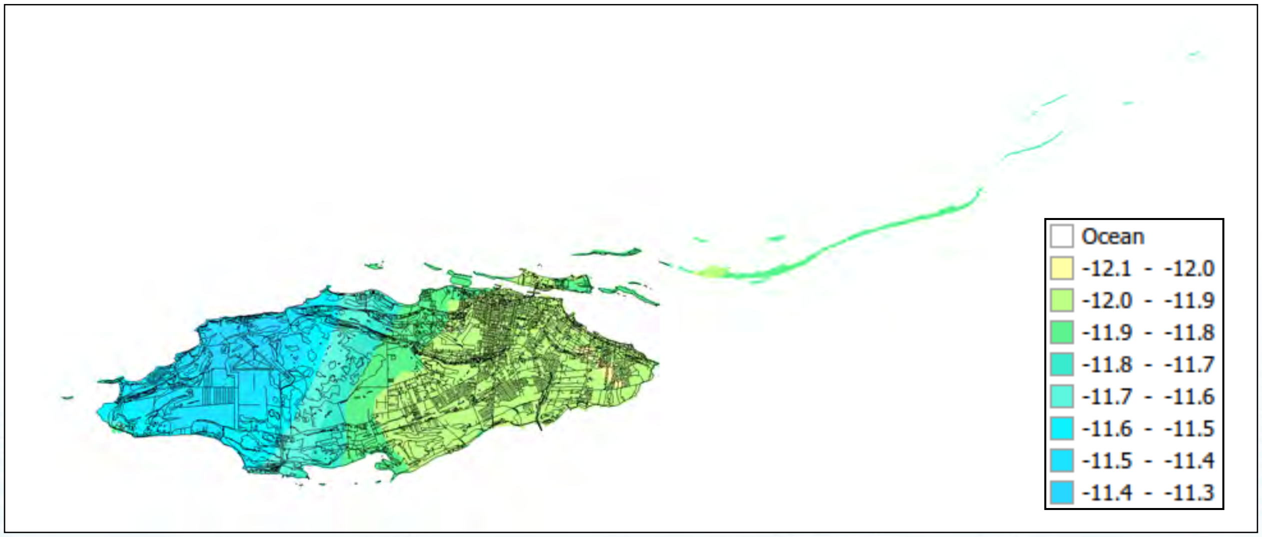


Figure 22 (b): Precipitation New Providence (A1F, high, 2050, 21-GCM ensemble) (decrease of 11.3-12.1%)

Change in Precipitation in The Bahamas (2)

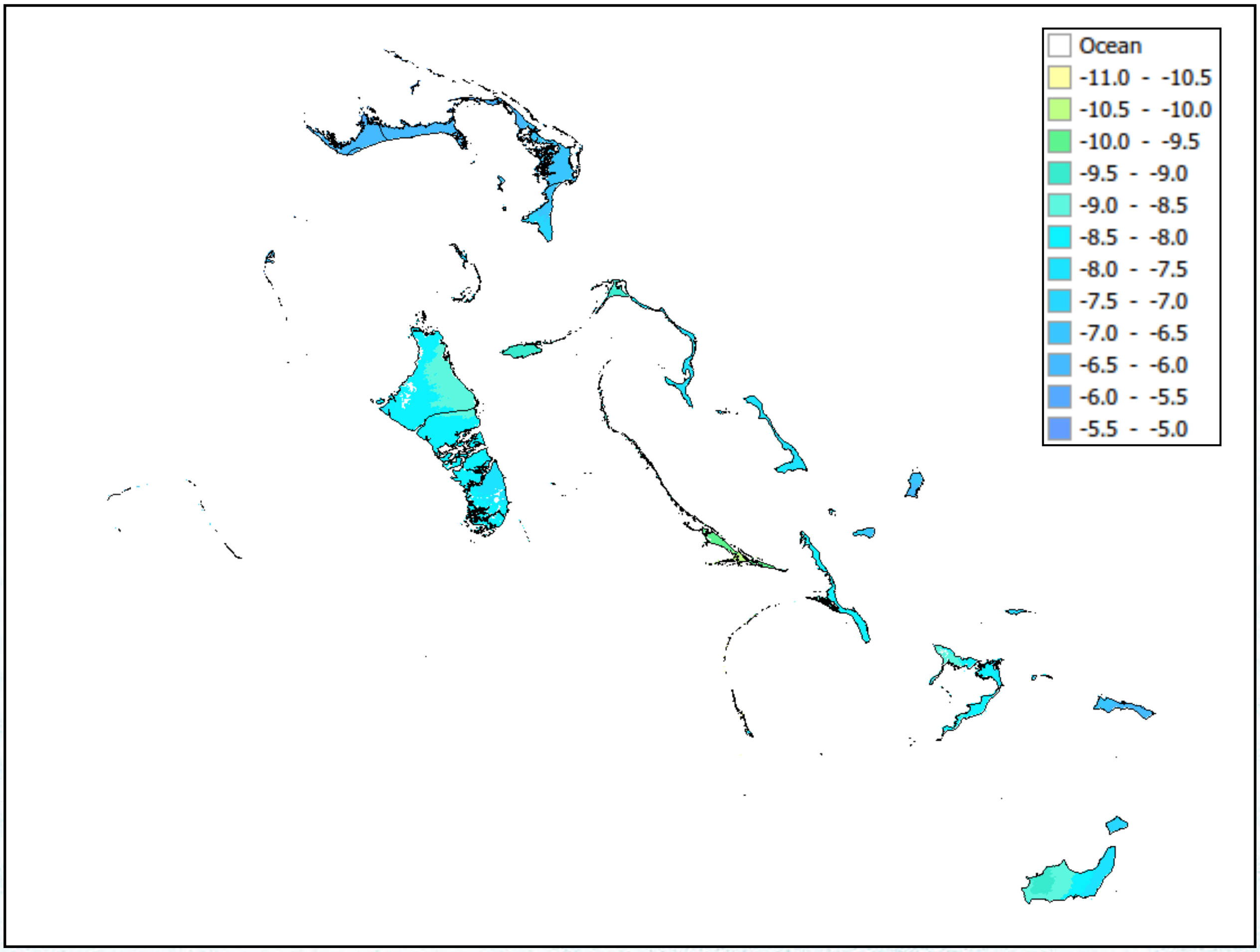


Figure 23: Change in precipitation for The Bahamas (A1FI, high, 2050)

Current climate variability was assessed through historic observations which are available for Nassau Airport (New Providence) (Figure 24). The total annual rainfall is shown to be highly variable ranging from less than 500 mm to 2500 mm per year.

Total Rainfall from Nassau Aiport, New Providence 1977-2009.

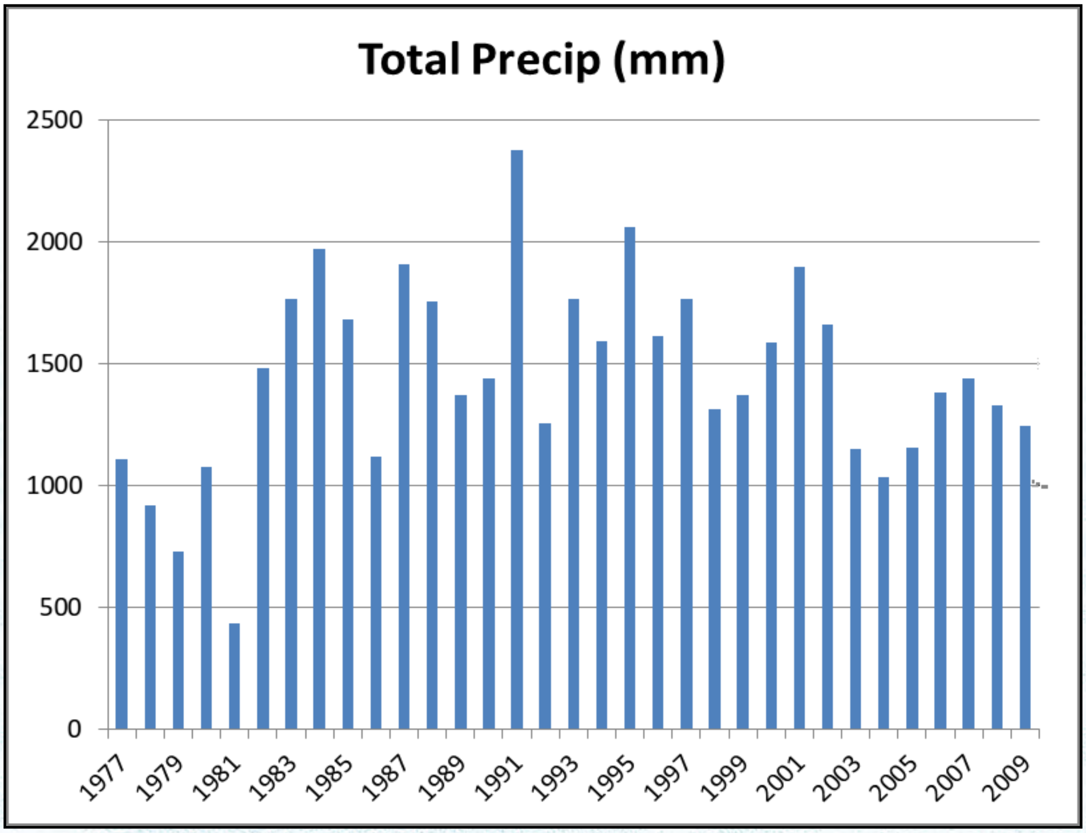


Figure 24: Total rainfall from Nassau Aiport, New Providence 1977-2009.

Seasonal variablity is also pronounced and this can have considerable implications for structuring adaptation plans for various rainfall impacted infrastructure and socio-economic activities.

The precipitation data can be analysed for both high (flood risk) and low (droughts), extreme events, current climate and climate change. By using the extreme value analysis tool, it was possible to calculate return periods for certain extreme rainfall events. Thus, Figure 25 shows that the most extreme rainfall event at Nassau Airport (481 mm of rain in one day) has a return period[34] of once in almost 60 (58.07) years and a 1:100 year event is almost 560 mm.

[34] A return period also known as a recurrence interval is an estimate of the interval of time between events like an extreme rainfall or extreme event of certain intensity or size. It is usually required for risk analysis (i.e. whether a project should be allowed to go forward in a zone of a certain risk and also to design structures so that they are capable of withstanding an event of a certain return period.

4.4.1 High Extreme Precipitation

Most Extreme Rainfall Record at Nassau International Airport

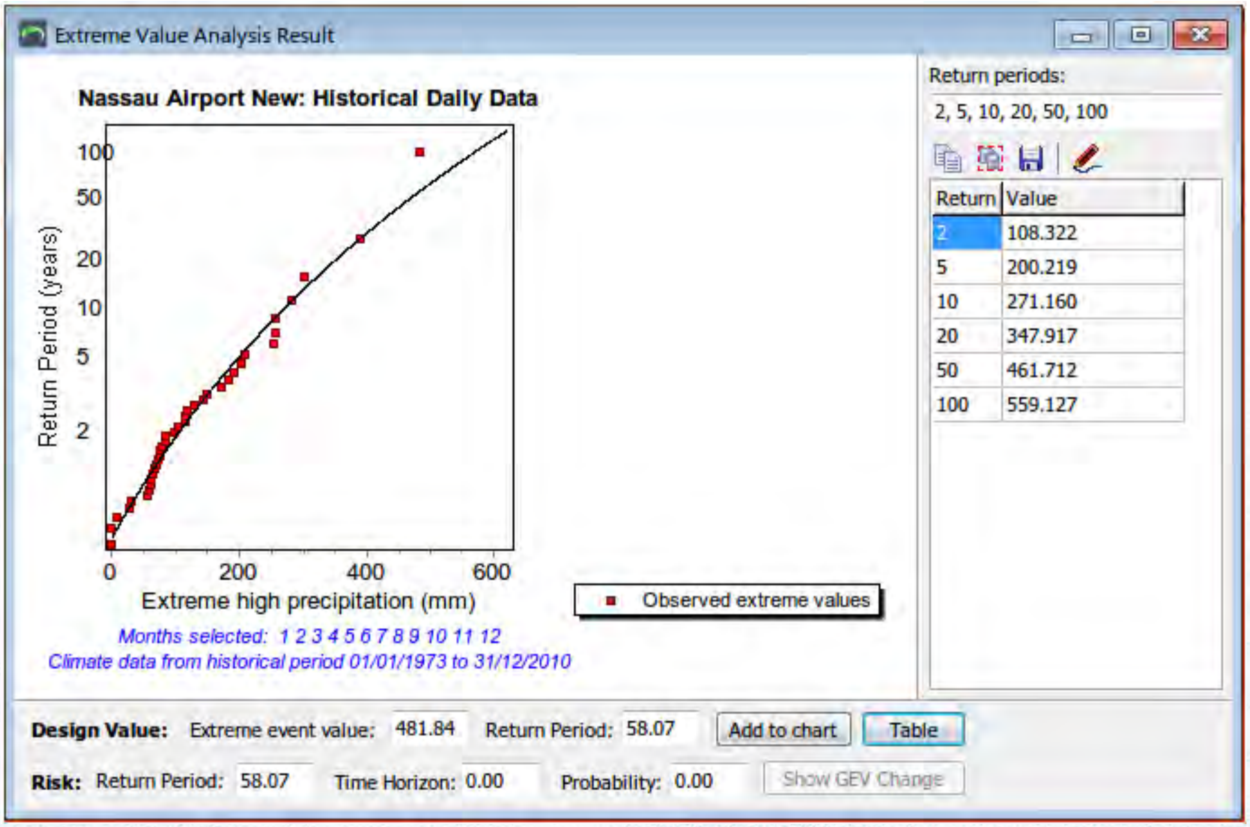


Figure 25: Most Extreme Rainfall Event at Nassau International Airport

As indicated in the projections for rainfall for 2050 and as shown above by the extreme event analysis, The Bahamas will experience a decrease in precipitation. This suggests that future extreme high events would be less severe. However, when daily outputs of 12 GCMs are applied, the analysis shows that by 2050 (with A1FI-high), the return period for the current most extreme event will have dropped to 42 years (from 58), while the 1:100 year event increases to 622 mm (from 560 mm) (Figure 26). This would mean that such events would become more severe and more intense.

This is important for flood-related infrastructure that will be built or renovated. The message from the more nuanced application of a daily GCM pattern extreme event analysis tool is that while the overall climate of The Bahamas is likely to become drier with time, extreme rainfall events will become more frequent and there will be greater one-day rainfall totals than historically experienced.

Daily Rainfall Record at Nassau International Airport

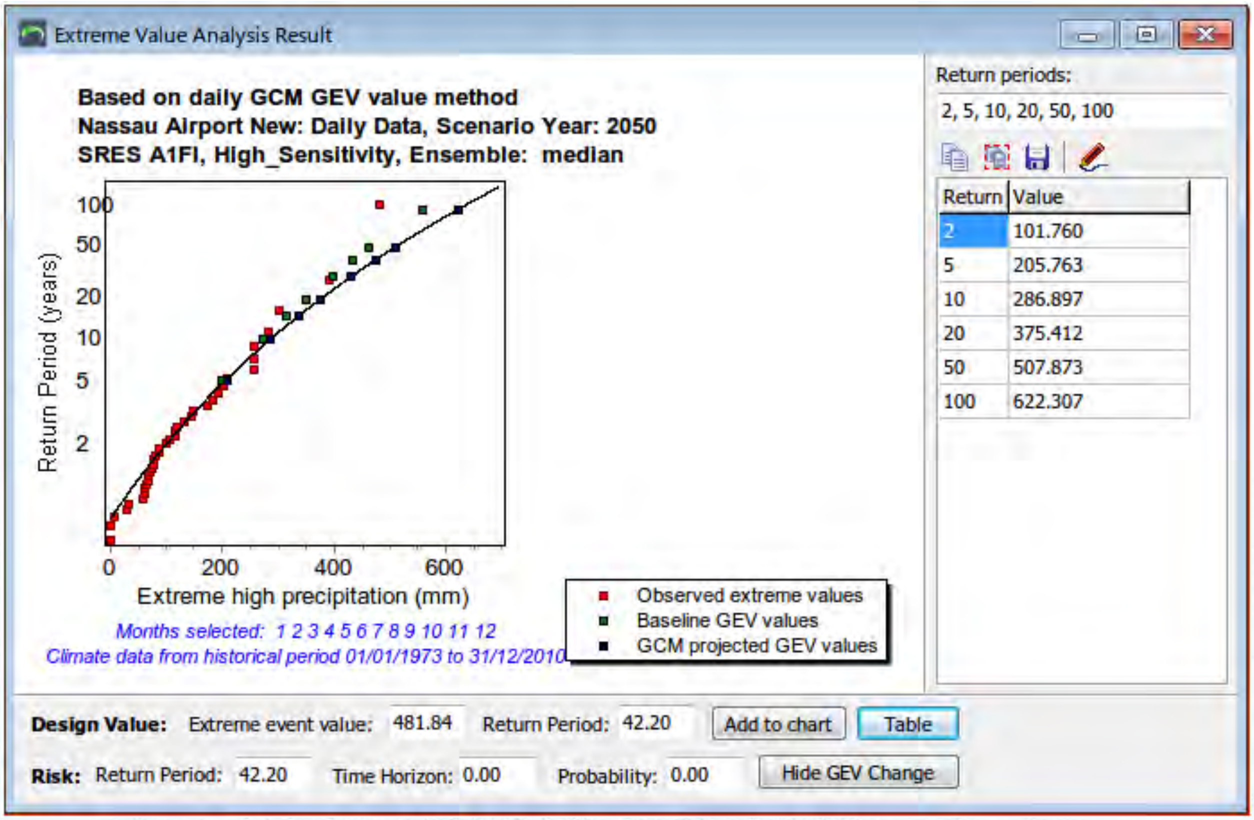


Figure 26: Daily rainfall (high extreme rainfall) under SRES A1FI High based on 12-GCM Ensemble for 2050.

4.4.2 Low Extreme Precipitation

For low extreme rainfall, a low amount of rain in a given period is calculated as an extreme event. In this case a 90-day period (three months) was chosen. Using the example for Nassau Airport, for every 10 years at least one three-month period will have less than 24 mm of rain (extreme low rainfall). However, by 2050, using the A1FI-high scenario and a 21-GCM ensemble, this will have dropped to 20 mm of rain (Figure 27). While the driest period (DJF) only shows a decrease of up to 7%, this analysis shows that for extreme droughts, the decrease in rainfall is closer to 17%. Again, the implication of this change is that droughts will become more severe. This will lead to higher temperatures and greater difficulties to secure energy efficient and potable water supplies. Increased temperature, coupled with an increased demand for water results in higher evaporation rates and less intermittent rainfall within the drought period.

Daily Rainfall Under SRES A1FI High

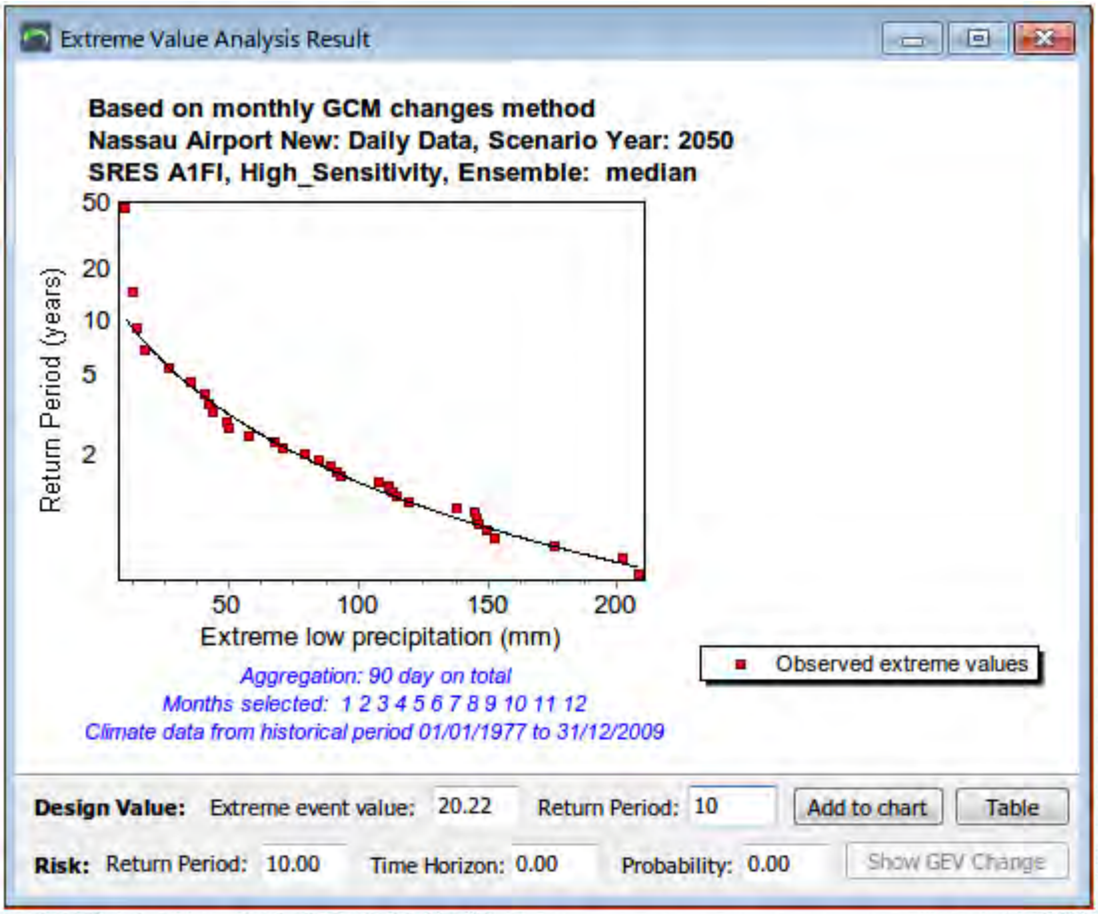


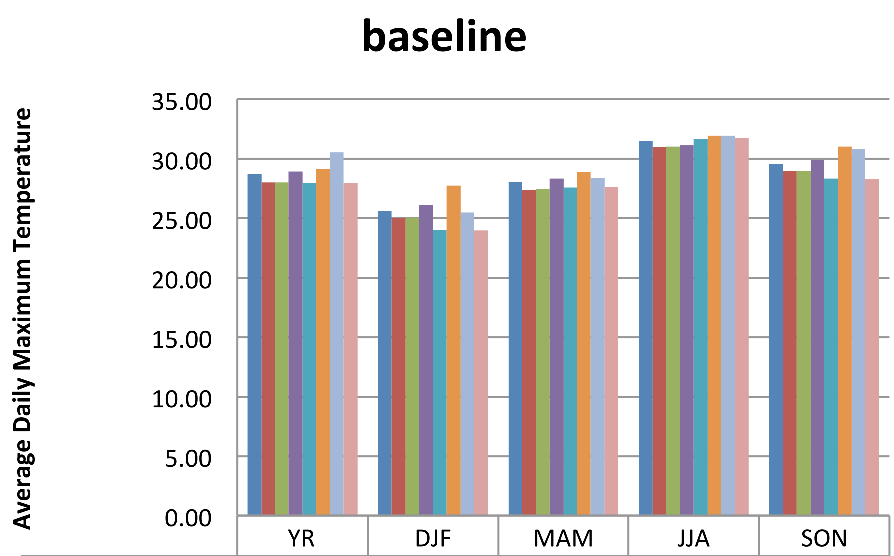
Figure 27: Daily rainfall (low extreme rainfall) under SRES A1FI High based on 12-GCM Ensemble for 2050.

4.4.3 TEMPERATURE

4.4.3.1 Extreme (High) Temperature

The baseline for daily maximum temperature for The Bahamas and seven of its islands is shown in Table 22. Maximum daily temperatures range from 27^{o}C to 31^{o}C for most islands with an average maximum temperature of 28.70^{o}C for the entire Bahamas. Analysis of extreme or maximum temperatures shows a 5^{o}C change from winter (DJF) and summer months (JJA).

Daily Maximum Temperatures for The Bahamas, 1960-2006

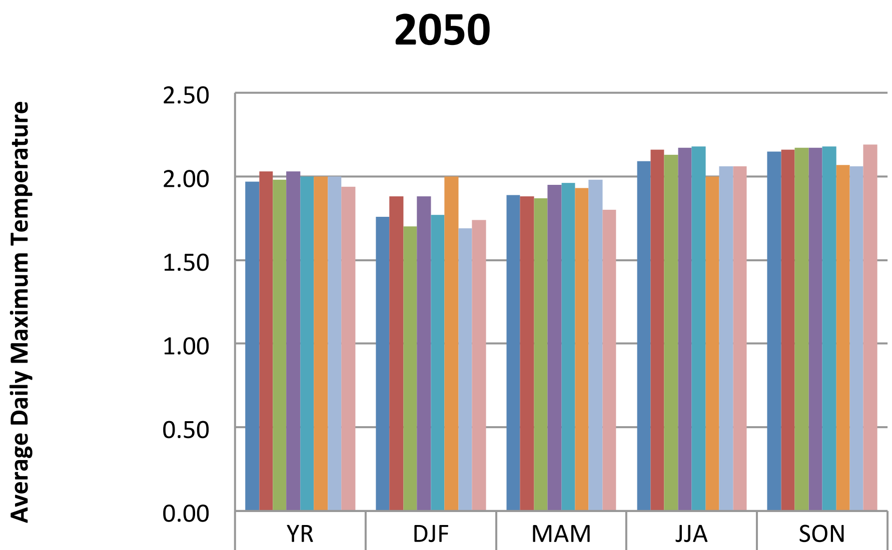


	YR	DJF	MAM	JJA	SON
Bahamas	28.70	25.61	28.08	31.49	29.58
New Providence	28.01	24.97	27.37	30.97	28.97
Eleuthera	28.02	25.05	27.47	31.00	28.99
Exuma	28.91	26.11	28.34	31.15	29.90
Grand Bahamas	27.97	24.02	27.57	31.69	28.31
Inagua	29.11	27.72	28.86	31.93	31.00
Andros	30.54	25.49	28.37	31.93	30.83
Abaco	27.95	23.99	27.61	31.70	28.27

Table 22: Average daily maximum temperatures for The Bahamas, 1960-2006.

However, projecting maximum temperature for 2050 using a 21-GCM ensemble the A1FI emission scenario and a high climate sensitivity, daily maximum temperatures are expected. It is projected that maximum temperature for The Bahamas will increase by 1.97°C, and the maximum temperature increase for the Family Islands will be 1-2°C. The winter months will be less than 2°C, and the summer months will experience the average daily maximum temperature increase of over 2°C. The drier islands in the southeast will experience higher temperatures during the winter months (DFJ) than the central and northwest regions. The range of daily average maximum temperature increase in The Bahamas is expected to be up to 2°C. This compares favourably with the expected global average daily temperature increase of 2.7°C. The lower increase in The Bahamas is due to the moderating effect of the surrounding waters.

Increase in Average Daily Maximum Temperature Under A1FI



	YR	DJF	MAM	JJA	SON
Bahamas	1.97	1.76	1.89	2.09	2.15
New Providence	2.03	1.88	1.88	2.16	2.16
Eleuthera	1.98	1.70	1.87	2.13	2.17
Exuma	2.03	1.88	1.95	2.17	2.17
Grand Bahamas	2.00	1.77	1.96	2.18	2.18
Inagua	2.00	2.00	1.93	2.00	2.07
Andros	2.00	1.69	1.98	2.06	2.06
Abaco	1.94	1.74	1.80	2.06	2.19

Table 23: Increase in Average Daily Maximum Temperature under A1FI, High Sensitivity, 2050

4.4.3.2 Baseline Average Daily Maximum Temperature, New Providence

Using the example of spatial distribution for average daily maximum temperature in New Providence, there was an increase in temperature of 0.2°C - 0.9°C from the baseline (1960-2006) which is consistent with the increase over the entire Bahamas (See Table 23). Thus, even under current climate, current atmospheric and oceanic conditions subtle differences in temperature and rainfall can be experienced depending on the geography of the island and the positioning of the prevailing trade winds. It is likely that these subtle differences could be amplified under future climate change.

Daily Maximum Temperature Projected for New Providence in 2050

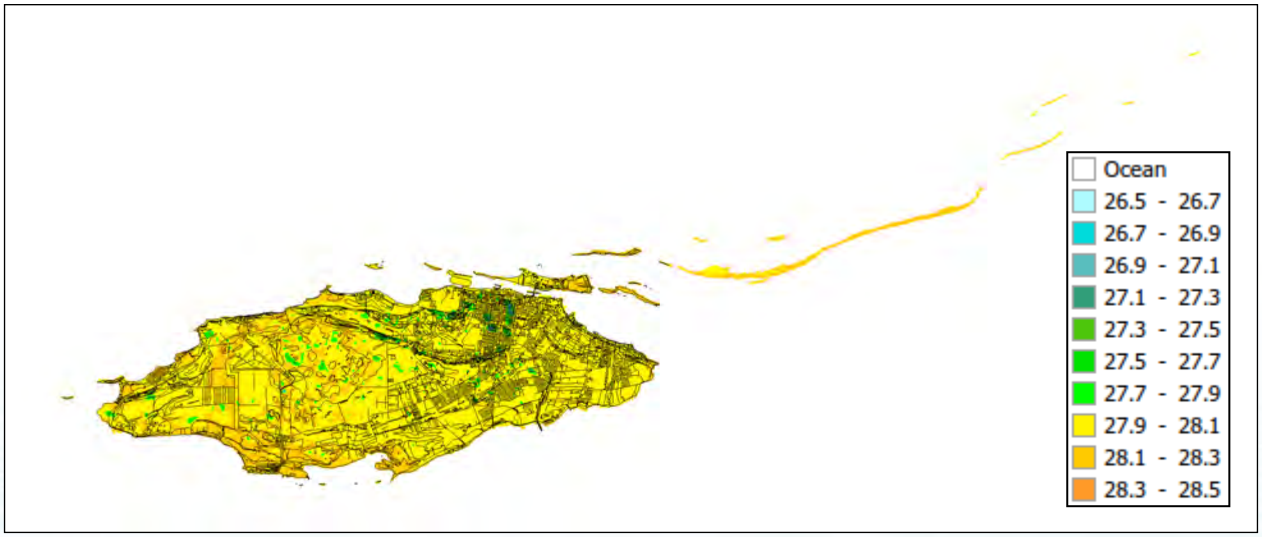


Figure 28: Average daily maximum temperature projected for 2050, New Providence.

Using the A1FI high scenario for 2050 and the 21-GCM ensemble, the projected temperature increase is spatially uniform over the island of New Providence (2.0^{o}C), ranging from 26.50^{o}C to 28.50^{o}C (Figure 28). However, the increase in average daily maximum temperature for The Bahamas ranges from 1.91^{o}C to 2.11^{o}C (Figure 29). The daily maximum temperature is highest in the northernmost island of Grand Bahama and in the southernmost island of Inagua (average over 2.0^{o}C). An increase of 1.93^{o}C to 1.97^{o}C in the central part of The Bahamas is expected. Interestingly, the largest island of Andros will have a temperature differential ranging from 1.91^{o}C in the north to 1.99^{o}C in the south. In Grand Bahamas, temperatures range from less than 2.0^{o}C in the west to over 2.0^{o}C in the east. The northern part of Andros and the western part of Grand Bahama are highly developed areas with most of the socio-economic infrastructure and activities located there. For most other islands the temperature increase will be fairly uniform. The implications of increase in daily temperatures are likely to be serious.

Daily Maximum Temperature Projected for The Bahamas in 2050

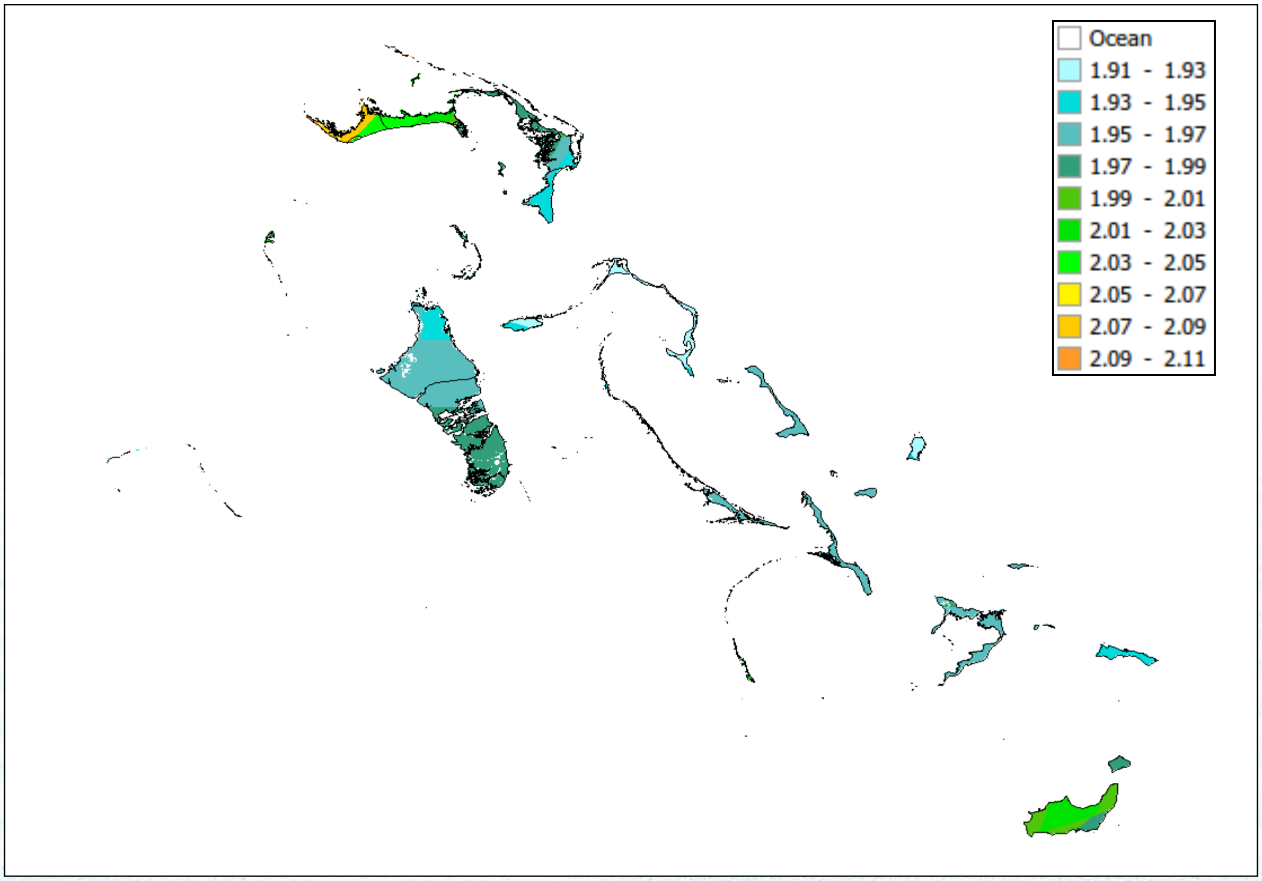


Figure 29: Average Daily Maximum Temperature for The Bahamas under A1FI for 2050

Observational records at Nassau Airport show a steady increase in average daily maximum temperature between 1974 and 2008 (34 years) (Figure 30).

Daily Maximum Temperature at Nassau International Airport, New Providence 1974-2008

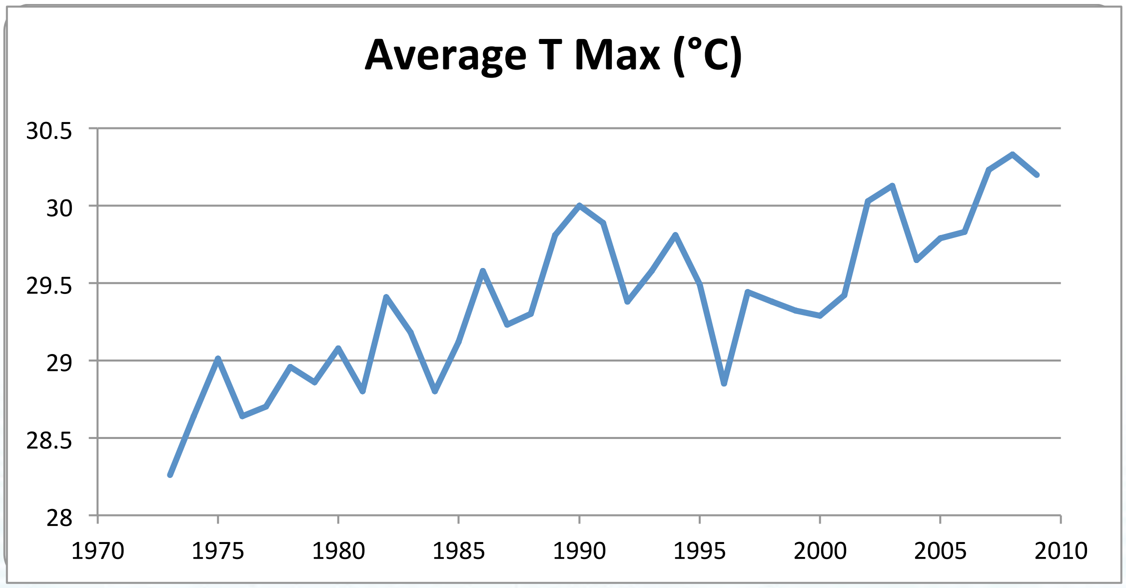


Figure 30: Average daily maximum temperature at Nassau Airport, New Providence 1974-2008

The use of extreme value analysis shows that the highest temperature extreme of 39.22°C has a return period of 74.31 years. Under the A1FI-high scenario, using a 21-GCM ensemble for 2050, the frequency will increase to 9.92 years. Thus, extreme temperatures are likely to occur more frequently by 2050 (Figure 31).

Extreme Value Analysis of Average Daily Temperature for Nassau International Airport

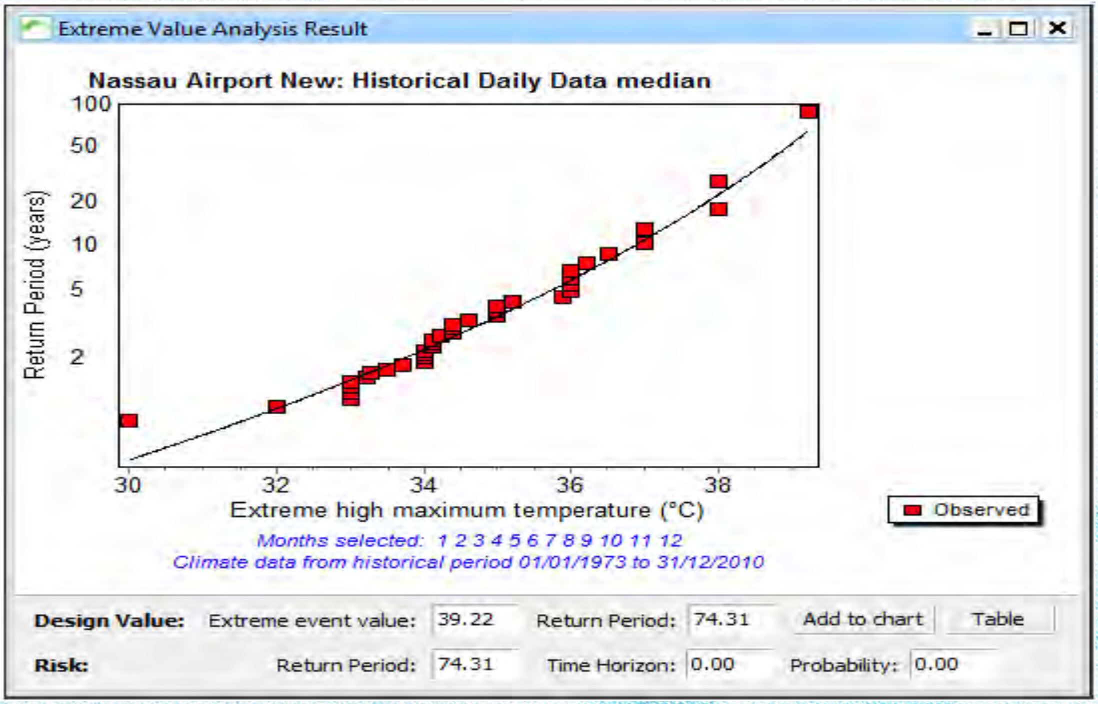


Figure 31: Results of extreme value analysis of average daily temperature for Nassau International Airport

As with extreme value analysis, the trends for maximum and minimum temperatures can be analysed.

Trends for Maximum and Minimum Temperatures at Nassau International Airport Between 1973-2010

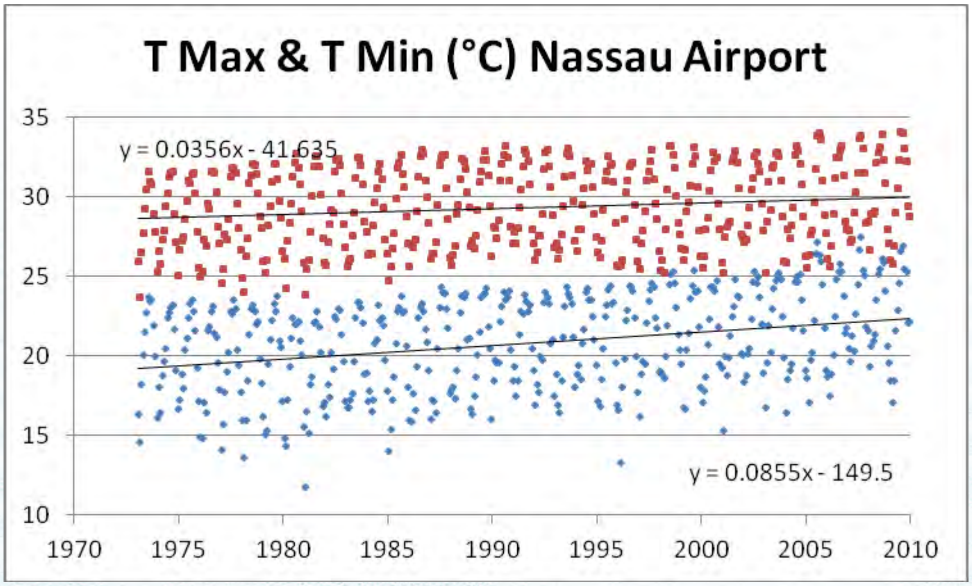


Figure 32: Trends for maximum (red) and minimum (blue) temperatures.

Figure 32 shows that minimum temperature (TMin) has risen at a rate of 0.05^{o}C/yr faster than maximum temperature (TMax). The total increase for TMin was 3.24^{o}C while the total for TMax was 1.35^{o}C over almost 38 years. The increase in TMin is consistent with a faster rate of increase in night time temperatures than day-time temperatures globally (Meehl, et al. 2009).

4.4.4 Sea Level Rise

With respect to sea level rise, the analysis here uses historical hourly data from Settlement Point, Grand Bahama to uncover a trend. Although there are four tide gauge measurements available in The Bahamas, only Settlement Point has a good data set. By recursively fitting the data-points to a trend line assesses the rate of sea level rise in order to determine if the estimate converges. This analysis shows that relative (compared to a baseline that is exposed to vertical land movement) sea level rise at Settlement Point, Grand Bahama is between 0 and 0.5 mm/yr. Additionally, from the SONEL database (Santamaria-Gomez and Bouin, 2009) with vertical land movement data, the value of -0.7 mm/yr (land sinking) is estimated. Thus, sea-level rise is slower than the vertical land movement (i.e. sinking/subsidence) indicating that the impact of thermal expansion causing sea-level rise is minimal for Grand Bahama.

Sea Level Rise Recursive Estimate at Settlement Point, Grand Bahama

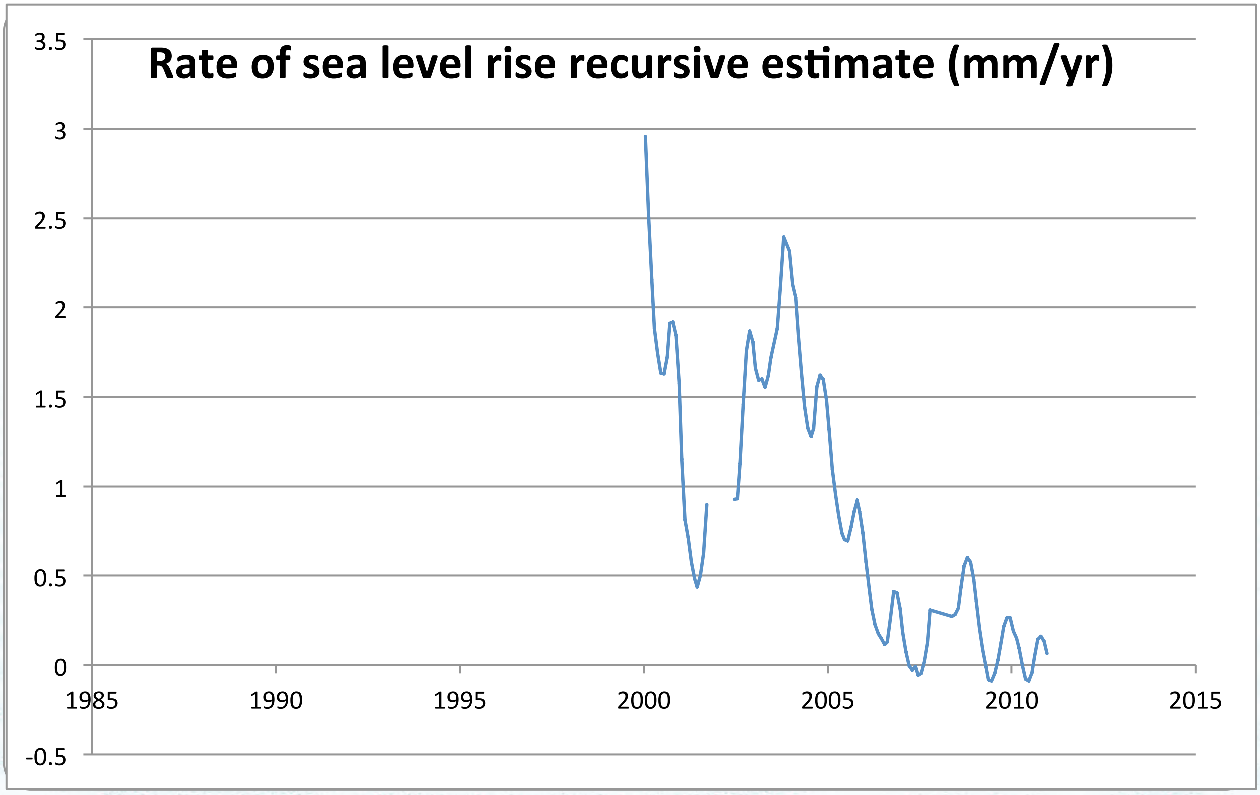


Figure 33: Sea level rise recursive estimate at Settlement Point, Grand Bahama (mm/yr).

While the historical evidence as presented above shows that sea-level rise is occurring at a slower rate than vertical land movement, it still indicates that sea level is rising at a rate of 0.2 mm/yr (the difference between vertical land movement and thermal expansion). Based on the 13-GCM Ensemble using the A1FI scenario, the sea-level is projected to rise by 2100 in The Bahamas (Figure 34).

Sea Level Rise Projections (AIFI), 2100 (local, 13 GCMs)

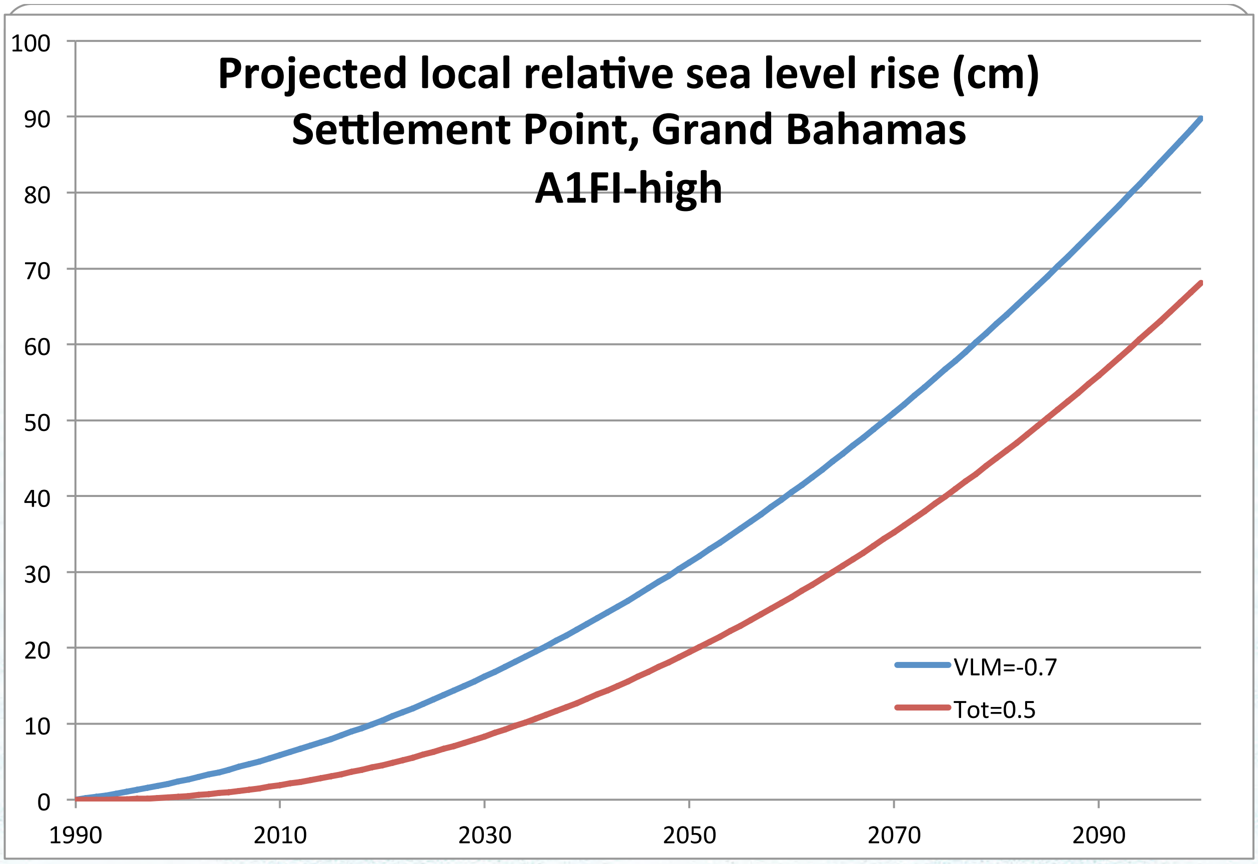


Figure 34: Sea-level rise projections (AIFI), 2100 (local, 13 GCMs). The blue line shows vertical land movement (VLM) and the red line shows total sea-level rise (Tot). The y-axis is in millimetres.

The graph above shows that by 2030 the sea level will have rise by 9.0mm, 20mm by 2050, and near 70mm by 2100. The increasing rate of sea-level rise in Grand Bahama is consistent with the global sea-level trend. However, the projection does not show the effects of local variations, and the impacts of climate-related extreme events which are likely to exacerbate the negative impacts of sea-level rise.

4.4.5 Impacts of Climate Change

The foregoing analysis of climate change in The Bahamas provides a basis for taking action as early and urgently as possible to either cope with and/or adapt to imminent changes that are likely to be expected over the coming decades. The historical analysis of rainfall and temperature strongly indicate that the average annual temperatures have increased over the last 30 years (1971-2000), and this trend is likely to continue in the near future. The mean annual temperature has increased by about 0.5^{o}C since 1960, at an average of 0.11^{o}C per decade, with the rate of increase most rapid in the warmest seasons. As for rainfall, observational record shows that the mean rainfall over The Bahamas has not changed significantly since 1960. However, since 1974 Grand Bahama has been experiencing twice the amount of rain as the island of Inagua. Spatially, more rain falls in the northwest (Grand Bahama, Eleuthera, and Abaco), Central (Andros, New Providence) and less in the southeast (Exuma, Inagua).

Projections of future climate change show that the average daily maximum temperature is likely to increase by 2.0^{o}C in The Bahamas by 2050. The highest increase is projected in the northernmost island of Grand Bahama and in the southernmost island of Inagua (average over 2.0^{o}C). However, an increase of 1.93^{o}C to 1.97^{o}C is expected in the central part of The Bahamas.

The annual rainfall is likely to decrease by as much as 10% while for some seasons a 20% reduction is expected in most islands. Winter will be drier in Inagua while all islands to the northwest will have a slight increase in rainfall.

4.5 IMPACT ASSESSMENT AND KEY VULNERABILITIES

The impact and vulnerability assessment involved both top-down and bottom-up approaches. The top-down approach involved the use of information generated by the GCM-based climate change and sea-level rise scenarios, while the bottom-up approach involved consultations with relevant stakeholders and literature survey on the impacts of climate change in The Bahamas.

4.5.1 Vulnerability Analysis Key Vulnerabilities

The key vulnerabilities in The Bahamas are water resources, forests, human health, agriculture, human settlement, disaster management, energy, tourism and coastal zones. The key vulnerabilities were identified through consultative processes via expert workshops and synthesis reports[35] prepared by relevant experts. A synthesis report for each sector outlined the following: (i) the key characteristics/activities that may have direct or indirect influence on how climate change and sea-level rise have affected the sector; and (ii) how it is being dealt with or addressed in the future.

4.5.2 Storm Surge

Sea Lake and Overland Surges from Hurricanes (SLOSH) modeling as outlined below, provides the extent of vulnerability of The Bahamas to storm surge. Under the worst case climate change scenarios, and with variable intensity of hurricanes, the surge height overland in many of the islands will be up to 26ft (7m) which would render most parts of the island under water.

[35] Synthesis reports were prepared for water resources, energy, forests, human settlements and infrastructure, agriculture and tourism.

SLOSH Modeling in The Bahamas (text provided by Russell 2010). SLOSH: Sea Lake and Overland Surges from Hurricanes is a computerized model developed by Jelesnianski and Taylor (year). Rolle et al completed an atlas for the Northern and Central Bahamas including New Providence and its vicinity. The model was used with GIS information to assess vulnerable areas of The Bahamas. SLOSH is best for defining the maximum potential surge for a location. It should be used as a tool of possibility and not absolute prediction. No computer model is perfectly accurate, so there is some room of uncertainty.

SLOSH was used to run hurricane scenarios for category 1 through to 5 using the MOM functions. More specifically, scenarios were run for every island in the SLOSH grid to show what the growing intensity would be from a category 1 to 5 hurricanes. Outputs from SLOSH show that coastal areas would be heavily impacted by storm surge. Specifically, the southern coastal area of New Providence would experience severe flooding by a category 5 hurricane, and could receive a maximum of 18ft of storm surge - Eleuthera 24 ft and Exuma 26ft. Each grid cell has an accuracy of ± 20% based on the high water mark (HWM). For example, if one grid cell has a surge of 10 feet, it is accurate between 8ft and 12ft. These results show catastrophic impacts that can cause loss of life, property and a shift in local topography. Therefore, it is imperative that new measures of mitigation and adaptation be put in place to protect and prevent the coastal communities and their environments.

The scenarios have proven that adaptation needs to be implemented to protect against hurricane surges. All of the islands of The Bahamas are at risk of being severely impacted by surges from hurricanes along the coast. Therefore, more adaptation should be put in place in these areas. Some adaptive measures that can be used are as follows: rebuild natural buffer zones along the coast i.e. sand dunes and mangroves; restore the natural environment along the coast; manage coral reefs including the creation of artificial reefs that break incoming surge; restrict development along the coast; improve the building codes with construction of silted houses or retrofitted older buildings in coastal areas; and recap early warning systems (MET-office capability).

Vulnerability SLOSH mapping has been completed for the islands of New Providence, Eleuthera, South Berry Islands, The Exumas, Long Island, Cat Island, Rum Cay and San Salvador. SLOSH output shows that areas along the coast will be exposed to extreme surge from hurricanes. However, the extremity of coastal surge depends significantly on the topography of each island. Flatter narrower islands (e.g. South Berry Islands, New Providence, Eleuthera) show surge values anywhere from 16 to 23 ft ± 5%, whereas islands with higher elevation (e.g. Cat Island, Rum Cay, San Salvador, Long Island) show surge values from 2.5 to 17 ft ± 5%. Climate Change increments demonstrate high extreme values of 16.6 – 23.6 ft ± 5% and low extreme values from 3.1 – 17.6 ± %.

The storm surge values are expected to increase based on the IPCC Fourth Assessment Report (2007), which crystallizes that in the future hurricanes are expected to increase in intensity.

An assessment of all available literature was conducted to examine the adverse impacts of climate change. Stakeholder consultations through focus group meetings and workshops were also held with national experts from the government, non-government, academic and educational organisations to conduct vulnerability analysis. A number of key questions[36] were used to guide the analysis of climate change impacts and vulnerability in The Bahamas.

The Bahamas is highly vulnerable to climate change and sea-level rise due to its physical geographical characteristics. It is a low-lying archipelagic island country with 98% of its population living at or within 10ft (3m) of mean sea level. Most socio-economic activities and infrastructure development is located on the coast. Vulnerability is exacerbated by its geographic spread spanning 800mi (1,300 kilometers) in a northwesterly to southeasterly direction.

The vulnerability of The Bahamas is reinforced by a recent study of a comparative analysis of the impacts of sea-level rise and storm surges in developing countries (Dasgupta, et al. 2009). The analysis reveals that relative exposure of coastal populations will be high for The Bahamas (73.02%), with coastal GDP loss most severe (65.7%). Thus, the urban extant along the coast will be highly vulnerable to inundation from storm surges in The Bahamas (94.12%) while its coastal wetlands will be subject to 71.4% inundation risk from storm surges. This makes The Bahamas highly vulnerable to impacts of climate change and sea-level rise. Of the top ten countries most at risk to storm surges, The Bahamas is ranked first (highly vulnerable) with respect to its coastal population, loss of GDP and coastal urban areas.

4.5.3 Water Resources

The Bahamas depends almost entirely on groundwater resources, which are extremely vulnerable in the low-lying limestone islands. This vulnerability is caused by several factors:

a) Overexploitation of the water lens. This activity causes freshwater to be replaced by seawater. Salt water upcones beneath an overpumped well making it unfit for potable use. Nearly all small islands provide evidence of this in the form of abandoned or saline well fields.
b) Development of canals and waterways for boat access and the increased value of lots. Cutting canals facilitate fresh and saline water mixing, and can cause the total loss of a valuable resource. In Grand Bahama, for example, one canal system was cut right across the centre of the island where there was once a 40 ft. thick freshwater lens resulting in the direct loss of 7.5 billion gallons of freshwater held in storage and the enforced abandonment of an important wellfield (Cant et al. 1990).

[36] The questions are: (i) how would you describe The Bahamas in terms of its vulnerability to climate change? (ii) what are the key vulnerabilities?; (iii) what actions, existing or planned are being taken to address/manage key vulnerabilities?; and (iv) what are the needs and priorities for climate change adaptation?

c) Seawater inundation in low-lying limestone islands. This disturbance is caused by storm surges, or rising sea levels. Any form of saline inundation will damage a groundwater resource. When the water table continues to rise, close to or above the land surface, it results in complete evapotranspiration that will, in due course, destroy the resource. Storm surges from Hurricanes Frances and Jeanne in 2004 had major effects on the water resources of Grand Bahama. Hurricane Frances also impacted the water resources on the island of Andros. In effect, the country's two major well fields located in the centre of two of the largest Bahamian islands (W6 in Grand Bahama and the Barging Wellfield in North Andros), were inundated by several feet of seawater which caused the freshwater supplies to become brackish. Parts of the Andros wellfield still have high salinities t because saline intrusion was facilitated by the design of the conduit system used for water abstraction. Further there is abundant evidence in Grand Bahama and Andros of previous events that caused saltwater damage to the environment, but few of these, if any, are recorded anywhere.

d) Pollution threatens the water resources in The Bahamas. The islands are made up of limestone, and suitable disposal sites are scarce. Sink holes, swamps, and marshes are often used as dump sites, but these are probably the worst of all possible options. Islands of this type, have widely scattered, undeveloped communities that do not have mains sewerage. The use of septic tanks, and similar means of disposal results in widespread problems. Domestic wastes and effluents are discharged directly to the water table. Seasonal flooding is a frequent problem in low-lying islands, which affect areas with septic tanks. Other accumulations of waste affect the local water resources.

Of all the threats to water resources identified and outlined above, the most significant of all is that of the rising water table. The centre of New Providence is the lowest area (Lake Killarney and environs) on the island. So as this area becomes wetter the main freshwater lenses on the island are impacted, and important facilities such as the Lynden Pindling International Airport will be affected.

Since all the major freshwater lenses in The Bahamas are generally in the flatter low-lying areas, they are all threatened by rising water tables. For example, Cat Island has good groundwater resource areas that are not being considered appropriate as water supply sources because of flooding problems. This will apply to more and more areas in the future.

Whatever changes there may be in future rainfall patterns, they will have significant impacts on the groundwater resources of The Bahamas. For example, The Bahamas faces a future of 10-20% less rainfall by 2050. This will cause serious shortages in water supply on most low-lying islands. Unless changes are made to conserve and enhance efficiency in water resource management, water shortages will have dire economic (higher tariffs) and social (compromised livelihoods) consequences for the populations of low-lying limestone islands. Additionally, a Category 5 hurricane is likely to generate surges up to 20ft above sea level which would have a devastating effect on any island in The Bahamas.

The water resources are also going to be affected by the sea-level rise in the future. The sea-level rise projection using A1B scenario with A1FI high sensitivity indicates a 20cm rise by 2050.

This outcome will affect groundwater resources either through seawater intrusions into the freshwater lens or by up-coming due to overexploitation and seawater inundation.

4.5.4 Human Health

With an increased temperature of 2°C by 2050 in The Bahamas, it is possible that the human health of the population will be compromised. A temperature increase of 1.5°C to 2.0°C is evident for all highly populated islands of The Bahamas, and would most likely contribute to increases in vector-borne (e.g. dengue and malaria), water-borne and communicable diseases. Costs associated with treating these diseases will also increase. Signs of vector-borne diseases such as dengue are already present in The Bahamas but little is known about its introduction. Increasing temperature with little rainfall could increase dengue incidences and place additional pressure on public health resources.

Increased temperatures would result in increased incidence of respiratory and cardiovascular problems that will affect the lifestyle of the aging Bahamian population. Other health-related issues include increased risk of heat stroke particularly for the field personnel; diarrheal diseases; rodent population; and mosquitoes, including the mosquito vector for dengue and malaria.

4.5.5 Human Settlement and Infrastructure

New Providence has always been the central point of The Bahamas due to its central location within the group of islands. Since The Bahamas is a tourism destination, it provides an aesthetic setting for hotel resorts. There are several types of landscapes. Some are the result of soil topography and climate, which forms a natural setting and others are artificially conditioned and altered from planning and management of resources.

The most prominent type of landscape is rock covered by a thin layer of soil, where forests, palmetto, coconut palm trees and shrub pine are grown. Parts of The Bahamas, particularly New Providence, show decades of human alteration. Road passageways have been cut through the hills where limestone rock is directly exposed to the weather.

The main challenge of human settlement and infrastructure development is the clearing of pine forests for the development of housing and agriculture. Clearance of pine forests will affect water sources and public services. For example, there is no freshwater flowing on the island of New Providence, so the capital city, Nassau relies heavily on reverse osmosis for its water supply. With increasing population, land and infrastructure development makes the preservation of the pine forests and well fields more difficult. As the population continues to increase, groundwater sources become developed with little prospects of increased volumes.

Climate change and sea level rise will have adverse consequences on the growth of cities in The Bahamas. Land development in New Providence is extensive and closely associated with the physiographic conditions. For example, the natural harbor along the northern waterfront consistently attracts developers to initiate major developments. Therefore, much of downtown Nassau has a wide range of predominantly commercial uses such as shops, banks, high scale hotels and residential buildings. These amenities are also extended along Cable Beach and as far as Lyford Cay, (which is only a few meters above sea level).)

4.5.6 Agriculture

Agricultural production in The Bahamas focuses on four main areas: crops, poultry, livestock, and dairy. Poultry, winter vegetables and citrus fruits are the mainstay of the agricultural sector, which is concentrated in The Abacos. Exports consist mainly of grapefruits, limes, okra, papaya, pineapples and avocado. Other food crops include bananas, oranges and mangoes.

An estimated 5,000 acres of agricultural land in The Bahamas is used for citrus production. In 1993, about 14 million pounds of poultry meat was produced and valued at $15.3 million. Production of 4.15 million dozen eggs was valued at $4.85 million, and agricultural exports were estimated at 18,794 tons. Agricultural exports included honeydew, citrus, cantaloupe, watermelon and squash. The Ministry of Agriculture (Incorporation) Act of 1993 allows the Minister to authorize a lease of land for periods up to two consecutive 21-year periods. Under this policy, the government has earmarked 36,148 acres of Crown Land for agricultural use: - 13,869 acres in Andros, 11,737 acres in The Abacos and 10,542 acres in Grand Bahama. The Department of Agriculture encourages farmers to expand sweet potatoes, bananas, onions, Irish potatoes and pigeon peas acreage. The Department uses the taxes collected by the Government to subsidize the work of the farmers. This relieves farmers from the cost of acquiring a loan with the bank. The Bahamas currently has a limited capacity to grow food. However, climate change will exacerbate the problems associated with food production. Climate-related extremes such as storm surge and sea level rise would result in the loss of arable land, which can limit the capacity to produce crops. The expected changes in mean annual temperature are unlikely to have a major impact on Bahamian agriculture until the latter part of the century. However, the warming projected coupled with the CO_2 fertilization effect may increase plant growth in the short term. Extreme high temperatures and an increase in global average temperature can damage food crops thus affecting food production and yield.

The other major impact of climate change on food production in The Bahamas is the occurrence and intensity of hurricanes. Hurricanes can cause significant damage to food crops either by inundation or by salt spray. Information on the adverse impacts of hurricanes on food crops and production is scanty in The Bahamas. Despite this drawback, the government is encouraging farmers in the The Abacos, Grand Bahama and northern Andros to market their own products. Farms in these areas now represent more than two-thirds of all produce sold. In the south, where there is less rainfall, low population, poorer soil and underdeveloped infrastructure, farmers benefit from more Government support. A Disease Insect Surveillance Unit monitors the importation of fruit and vegetables into The Bahamas, to reduce the risk of pests and diseases.

4.5.7 Coastal Zones

Much of the coastline of The Bahamas, particularly in the built-up areas, is protected by seawalls. However, such infrastructure and investment is under serious threat from climate change and sea level rise including extreme events such as storm surge associated with hurricanes. Construction of harbour facilities like that at Gunpoint, Ragged Island, is necessary for getting supplies quickly and safely to the island after hurricanes or other storm events.

Globally, sea level rise is a result of melting icecaps and glaciers, and thermal expansion. The Bahamas as The Bahamas is considered the most vulnerable country to sea level rise so sea level rise is a major concern. Some 80% of the landmass is within 5 ft (1.5m) of sea level (Draft National Environmental Policy for the Commonwealth of The Bahamas). Consequently, sea level rise will have a significant impact on most hotel accommodations, marinas and cruise ship ports located in coastal areas.

Sea level rise can also have an impact on the quantity and quality of our ground water resources due to saltwater intrusion. Perhaps the most significant impact on the coastline in The Bahamas is caused by hurricane or storm generated storm surge. With the intensification of storm surges in The Bahamas, the following areas are expected to be impacted: 94.1% of The Bahamas urban coastal areas; 73% of coastal population; 71% of coastal wetlands and 65.7% of coastal GDP (S. Dasgupta, et al. 2009). Storm surges are also responsible for coastal and beach erosion.

In 2005 Hurricane Wilma passed within 150 miles (240km) of Grand Bahama, but produced storm surges as high as 20ft (7m) resulting in $100M damage and loss.

4.5.8 Tourism

Coral bleaching would not only affect the fisheries sector, which represents 5% of GDP, but also the important dive market. The Bahamas is the third most popular destination for the 43 m US dive market, 30% share. The industry supports the jobs of approximately 900 divers, and contributes 49,000 room nights annually to the accommodation sector (Bahama Dive Association). Coral bleaching can reduce the reef's ability to act as a natural defense system against storm surge, exposing our beaches to erosion. It can also have a negative impact on tourism, which contributed $365m to the economy in one year.

Vector and water-borne diseases can have an adverse impact on the tourism sector, as experienced during the summer of 2006, when the island of Exuma reported an outbreak of malaria. This resulted in a travel warning by the Center for Disease Control. Dr. Baldwin Carey, Director of Public Health, suggested that the geography of the area made it especially easy for a large influx of illegal immigrants into The Bahamas, which also contributed to the outbreak of this disease. More than 25 hurricanes impacted the region between 1970 and 2000. While the period 1990 – 1999 seem to have been the most active with some 25 hurricanes impacting the region, years 2000-2006 registered more than five category five hurricanes. The Bahamas lost 10% of its GDP due to two hurricanes (Frances and Jeanne) and a cost of USD 551m. The total loss in actual infrastructure damage resulting from Hurricanes Frances, Jeanne and Ivan was an estimated $5b for the five countries. However not calculated in the numbers is the subsequent decline in business due to the disruption in tourism arrivals during the recovery and reconstruction period. Additionally, destinations that are frequently hit by hurricanes or severe weather events suffer from the perception in the market that they are unsafe.

4.5.9 Forests

Presently, there is no information available on the potential impacts of climate change on Bahamian forests. It had been documented in other countries that the climatic variables directly influence plants and trees as a result of the increasing concentration of CO in the atmosphere. Research will have to be conducted to determine the physiological effects, as well as, the correlation of forest health, fires, storm surges, hurricanes impacts, sea-level rise and soil salinisation levels.

With the expected increase in temperature coupled with the CO_2 fertilisation effect forest growth may increase. However, this is likely to be compromised by the effects of intense hurricanes, which usually destroy large tracts of forests in The Bahamas.

4.5.10 Biodiversity

Impacts of climate change on biodiversity include - sea level rise, saltwater intrusion, coastal erosion; ocean acidification, coral bleaching, droughts, floods, fires, storm surge, hurricanes, ENSO, vector and water-borne diseases and invasive species.

4.5.11 Energy

The Energy Sector is vulnerable to changes in climate, extreme weather events and sea level rise. There are direct and indirect effects of climate change on the energy sector for The Bahamas. Other impacts include those normally associated with climate change.

Direct impacts are those that affect processes related to energy production and power generation. This also includes transportation, energy resource availability (effects of weather on shipment of energy sources), electricity generation and transmission and distribution systems.

Indirect impacts are those whose effects on other sectors have consequential impacts on the energy sector, either through competition for resources, changes in power requirements, or increases in demand. Energy, a basic commodity, is used in the production of virtually all other economic goods and services. Changes in other sectors usually have consequential effects for energy.

The indirect impacts of climate change on energy, through its effects on the residential, commercial, and transportation sectors in The Bahamas, can exceed the direct effects. For this reason they cannot be ignored in any assessment of the impacts of climate.

Salt water intrusion causes increased corrosion of electrical generating and transmission assets. The Bahamas is essentially a coastal country and is highly susceptible to the effects of corrosion on metallic structures. Salt water intrusion also causes electrical shortage events on insulators which lead to outages and loss of revenue. Coastal erosion has great impact on the facilities of The Bahamas Electricity Corporation (BEC) as most of the power generating facility is located near coasts in order to facilitate the inter-island transport of fuel. Erosion of the coast impacts the maintenance and safe handling of fuel. Hurricanes, droughts, floods, fires and storm surge also pose a serious threat to infrastructure of the energy sector.

Elevated temperatures generally reduce cooling and generating efficiencies at thermal power plants. Conversely, higher technical losses could be experienced on the transmission and distribution systems. In addition to this, there is the potential for reducing the life spans of system components, should the thermal limits be exceeded. Increased 'line losses' from electrical transmission and distribution systems results from elevated average temperatures and increased occurrence of blackouts caused by line sagging during heat waves. This situation is exacerbated by the increased internal resistance heating attributable to increased power flow to meet higher electricity demand for space cooling and refrigeration.

Sea level changes are a particular concern as assets of the Energy sector are typically located near the coast to facilitate shipping. Sea level rise also threatens siting options for the sector. Such impact is experienced by low-lying land during extreme weather events. The land area of The Bahamas is essentially coastal and extremely vulnerable. Any change in the frequency and intensity that make these events more prolific or more intense, will negatively impact the energy sector. Power lines, fuel pipelines, fuel stock, shipping routes and generation equipment are all vulnerable, exposed and severely affected.

4.6 ADAPTATION MEASURES, STRATEGIES AND OPTIONS

The vulnerability analysis thus far suggests that many of the issues, constraints, gaps and difficulties relating to climate change are not necessarily new. However, they will become worse if no actions are taken to address them. From the foregoing evidence of climate change, it is more than likely that temperature will increase by at least 2^oC in the coming decades (by 2050) in The Bahamas. This will place additional pressure on the population, human systems and natural ecosystems that provide goods and services to sustain livelihoods. Some islands will become wetter and others will become drier with more frequent extreme events in The Bahamas.

In recognition of the ongoing problems associated with sustainable development, and the greater potential for worst problems under climate change, the Government of The Bahamas developed a National Policy for the Adaptation to Climate Change (NPACC) in 2005. The NPACC sets out the goals and objectives, principles and directives for adaptation planning and action in The Bahamas. The NPACC also identifies the key vulnerable sectors to which resources would be directed to address climate change issues and concerns. The vulnerable sectors include: agriculture; coastal and marine resources; energy; the financial and insurance sector; forestry; human health; terrestrial biodiversity; tourism; transportation; and water resources. For each of these sectors, key issues relating to climate change adaptation and key actions to address each adaptation action were identified. The analysis of available information on each of the key vulnerable sectors identified indicates that only a handful of actions have been implemented including the development of policy actions for energy and forestry.

A number of factors characterize The Bahamas, which should be taken into account for the planning, development and implementation of climate change adaptation:

- The Commonwealth of The Bahamas stretches over 1,400km of ocean.
- Replication of adaptation on every inhabited island of The Bahamas would be highly resource intensive and in many cases, the cost would be prohibitive;
- From a disaster perspective, a small population can be isolated very quickly, and it is very expensive to reach them send assistance; and
- In terms of biodiversity, some islands have unique or endemic species that could be wiped out quickly by sea level rise or changes in climate.

Additionally, a number of key issues have been identified which are critical for managing climate change risks and climate change adaptation: (i) information and awareness; (ii) education and training; (iii) integration of climate change adaptation into management, planning and budgetary processes; and (iv) cooperation and collaboration.

The adaptation measures, strategies and options identified were aided and informed by the data generated through (i) vulnerability assessment; (ii) sectoral reports produced by national experts; and (iii) several expert and training workshops conducted over the course of the V&A assessment process.

The measures, strategies and options focused on the question of how to address the issues and concerns relating to the impacts of climate change and sea-level rise. In the first discussion a list of potential impacts was created, that takes into account impacts per one of eight sectors for each of the four climate change effects. In the second discussion, this list was completed with suggested adaptation options. The resulting impacts and adaptation matrices (showing potential relevant impacts and adaptations per sector) for the four major climate change effects follow below.

4.6.1 Water Resources

The reality is that there is nothing that can be done in The Bahamas to stop –(i) rising sea levels (ii) associated threat of higher water tables; or (iii) the possible increasing severity of storms that might impact the area. These are global issues that have to be addressed. Adapting to the threats and taking measures to mitigate these threats is something that can be done locally. From a Bahamian perspective, policies and measures need to be adopted or taken that will help to protect the nation’s freshwater resources and related environmental concerns:

a) Enactment of laws and regulations where needed. Water Management Consultants 2003 report outlines these needs in detail;
b) Prevention of further development in low-lying areas that will be prone to flooding, now, or in the future;
c) Discouragement of the excavation of canals and waterways and any excavations below the water table where these are unnecessary;
d) Control rock and sand mining activities so that they are restricted to approved locations only;
e) Protection of beach ridge, coastal dune formations, mangroves and similar coastal features;
f) Adopting appropriate physical planning policies that will protect infrastructure from storm surges and rising water tables; and
g) Encouraging young Bahamians to seek careers in fields like Environmental Engineering, and Hydrology, and providing the necessary courses and training programs locally.

Clearly, it would very beneficial to future planning if there were accurate projections for sea level rise over the next one hundred years or so. All international efforts to improve such projections have to be supported by The Bahamas. This must include any such research that can be done in The Bahamas where the impacts of subtle changes in the environment are quickly reflected. One such project, now in the early implementation stage, is the Groundwater Resources Assessment under the Pressures of Humanity and Climate Change (GRAPHIC) initiative structured under the UNESCO-IHP program. A case study for this program is approved for the North Andros area. It includes the Barging Scheme Wellfield that has been impacted by a storm surge, and provides an ideal site for modeling environmental changes that might occur as sea level rises and climatic conditions change. The US Army Corps of Engineers have shown interest in being involved in this project, and appear willing to make significant investments in it. If it proceeds as planned, there will be scope for future expansion to map out all the water resource environments in Andros, including the inaccessible western areas, using newly developed aerial methods. Seeing exactly what changes take place over time will provide knowledge that can be applied elsewhere in The Bahamas, and in similar island environments in the world. This will aid appropriate long term planning.

With accurate sea level projections and more knowledge of future changes in climate, it is anticipated that there will be a better understanding of how groundwater conditions will change. It should become feasible to plan how long a specific water resource area can be used to provide a supply, plan for its use and final abandonment, and plan to develop alternate supply options for the future. It may be possible to protect a specific facility by elevating foundations, but this is not practicable for Bahamian groundwater resources.

If it is accepted that the sea level will continue to rise, then it must be assumed that the water supply capabilities of Bahamian natural resources will diminish. Alternative sources must be considered and the most obvious of these must be desalination. This is already accepted technology, but involves high energy usage and is costly. Alternate energy options have to be given more attention in finding ways to provide potable water at acceptable prices. Wind and solar power have been applied in the past, but more studies need to be done to see what they can offer for the future. Two other research areas of particular relevance to The Bahamas would be that of Ocean Thermal Energy Conversion (OTEC) and current power. The Bahamas has a reverse geothermal energy profile, and it may be possible to obtain the necessary cold water for OTEC use directly from deep wells. This would be a lot cheaper than obtaining cold sea water from long distance pipelines into the sea. Tidal movements across the banks create very strong reliable currents in many areas. These have flow rates that can produce enough energy to operate small reverse osmosis plants. Research needs to be carried out to see how both of these untested technologies might be used to provide the freshwater that The Bahamas will need in the future.

4.6.2 Forests

Presently, there is no information available on the potential impacts of climate change on Bahamian forests. However, it had been documented in other countries that climatic variables directly influence plants and trees as a result of the increasing concentration of carbon dioxide (CO_2) in the atmosphere. Research will have to be conducted to determine the physiological effects and the correlation of forest health to fires, storm surges, hurricanes impacts, sea-level rise and soil salinisation levels.

In order to meaningfully address the present state of affairs in the public forestry sector, the following realistic and fundamental actions are prescribed for adoption; by the Forestry Office:

i) Enact comprehensive forestry legislation, ensuring congruency with international standards and protocols;
j) Establish institutional arrangements for forestry (Forestry Unit) to effectively and efficiently undertake the mandate for sustainable forest resource management. This institution should be adequately resourced with a complement of qualified staff and a sustained budget. It should be guided by the provisions of the National Forest Policy, Forestry Law and Regulations;
k) Review and evaluate the existing forest management plans for the sustainable management of all types of forests, on Crown Lands;
l) Plan and implement a comprehensive public education and awareness program on all aspects of forestry development and conservation in partnership and concert with relevant stakeholder agencies in The Bahamas (e.g. The Bahamas National Trust, The Nature Conservancy, BEST Commission, The Ministry of Agriculture and Marine Resources, etc). The primary objective should be to sensitize the general populace on the goals and objectives of the newly constituted forestry institution, as mandated by policy and legislation;
m) Institute a program to allow for the sustainable utilization of the natural pine forest resources;
n) Actively participate on the Committee on Forestry (COFO) of the FAO, the Latin American and Caribbean Forestry Committee (LACFC) of the FAO, the Standing Committee on Commonwealth Forestry based in the United Kingdom, the Commonwealth Forestry Association and the Caribbean Foresters Association. This is

essential in seeking partnerships, co-operation and collaboration on matters pertaining to global forestry initiatives that impact The Bahamas.

o) Develop a program to recruit and train Bahamian students from high schools, who show a keen interest in forestry and conservation.
p) Provide In–Service Training Awards or Scholarships to deserving candidates for training in forestry sciences & conservation. This is paramount to allow for succession planning in the profession. Further, Forestry Resources Management and Conservation should be included on the list of areas subject to full scholarship through the Ministry of Education's Scholarship/Loan program.

4.6.3 Tourism

In response to the impact of climate change, variability and extreme events on the tourism sector the Ministry of Tourism will continue to engage in the following activities:

h) Raise the awareness of Awareness-raising of policy makers and other relevant stakeholders through workshops and symposiums to increase awareness and an appreciation of the impact of climate change on tourism and related sectors;
i) Pursue vulnerability assessments in collaboration with the Caribbean Community Center for Climate Change, Oxford University Center for the Environment and the Department of Meteorology. So far, the island of Eleuthera was surveyed to determine the vulnerability of the island and its residents to sea level rise.

j) Introduce the Foundation for Environmental Education Blue Flag certification program to marinas to assist them in developing programs that will protect the marine ecosystem;

k) Develop a hurricane preparedness and evacuation plan to assist the tourism sector to respond to and recover from any hurricane or extreme weather events in cooperation and collaboration with its partners in the public and private sectors; and

l) Assist communities through the Coastal Awareness Committee in protecting their beaches and shoreline by restoring dunes with planting sea oats, sea grapes and other native flora.

The high level of vulnerability to climate change, sea-level rise and storm surge which is exacerbated by coastal erosion and saltwater intrusion in the ground water resources, has created an urgent need to protect the vital resources on which that the tourism industry depends. Protection can be achieved with the implementation of the following steps:

a) Develop funding mechanisms and technical know-how for communities to build and re-vegetate sand dunes that will protect vulnerable areas against storm surges;
b) Educate the general public concerning the role wetlands play in the protection of our coast from storm surges and as an important habitat for fisheries and wildlife;
c) Solicit the support and buy-in from local stakeholders and the travel public that there is a need to educate persons on climate change and its impact; and
d) Establish an ICZM Unit to manage our coastal assets

4.6.4 Financial, technical and human resources

The financial, technical and human resources required are as follows:

a) the development of a national tourism plan that would include and address the issue of climate change and adaptation strategy;
b) trained personnel to monitor climate change impacts on coastal resources;
c) training of additional Department of Meteorology personnel and procurement of equipment to assist in mapping coastal areas throughout The Bahamas vulnerable to sea level rise;
d) training of additional technicians in the use of the SLOSH model to be able to assist in the forecast of hurricane landfall. This is important in helping tourism to safely evacuate guests off the island;
e) the Establishment of an integrated coastal zone management unit to effectively manage our coastal resources;
f) Workshops to bring awareness of climate change and its impacts to a broader number of stakeholders in the tourism industry; and
g) Assist communities to build and re-vegetate sand dunes to protect against sea level rise.

The table below (Table 22) provides a list of key impacts of climate change and possible adaptation measures. This was developed at a national workshop in May 2010, where representatives from government departments and civil society were in attendance.

Adverse Impacts and Adaptation Matrix

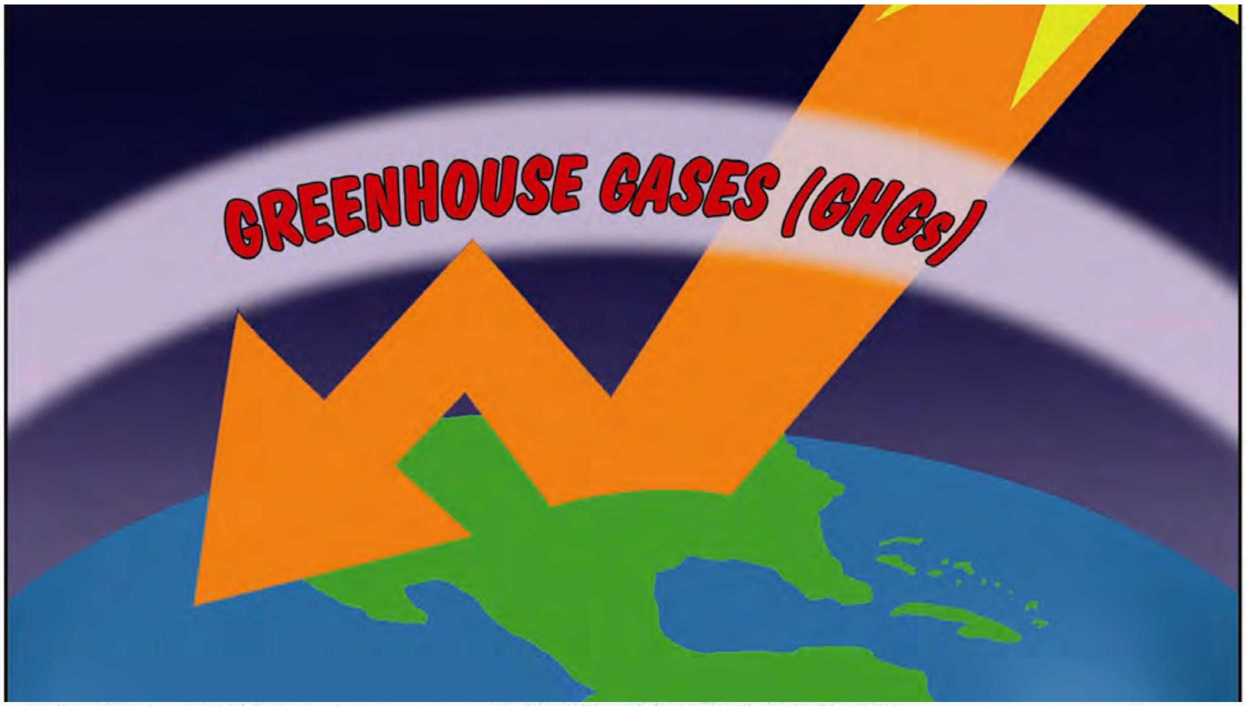
Increasing temperature	Adverse Impacts	Possible Adaptation Measures
Water Resources	Increase in evapotranspiration Fresh water lens drops/shrinkage Private wells affected Increased demand for water	Regulate use of water Education and awareness on conservation measures (government funded programs) Water catchment systems (i.e. Tanks) Maximize hotel-contribution (i.e. Supply, recycling) "green" incentives
Coastal Zones	Increase in sea surface temperature affects marine resources (e.g. sensitive to coral species leading to bleaching) Sea surface temperature increase intensity of tropical cyclone activity	Better building codes; retrofitting older building; early warning systems (MET-office capability) Protect (natural) buffer zones along the coast (i.e. sand dunes) Restricting development along the coast (zoning) Restore natural environment Coral reef management
Agriculture	Potential for increased incidence of pests Plants/crops sensitive to increasing temperature SST affecting fish species distribution	Crop rotation/seasonal crops; new ("climate") crops; reduce existing slash & burn practices; Native plants (multi-purpose: less water demanding; protection; so not only for agriculture) Natural remedies against pest
Forest	High evapotranspiration Potential high risk of forest fires Loss of native animal and plant species.	Forest legislation and enforcement; restrict burning; protect areas (20% land promise'); control "other threats" (i.e. development)
Tourism	SST increase =>fish distribution (migration) Loss of marine diversity Loss of attractiveness ("green") =>decrease in tourist arrivals (because of loss of attractiveness)	Other adaptation options will maintain/improve attractiveness Protect: marine reserves Tourist education (i.e. behaviour, type of sun-block (water-soluble), anchors); Change "tourist promotion strategy" (sun-sand-see => …)
Human Health	Respiratory/ Heart Heat stroke Vector borne diseases e.g. dengue, malaria, Food borne illness (food-poisoning)	Education; Integrated approach to vector-borne diseases (ie. stop breeding opportunities); Preventable diseases Act also dietary shifts
Settlements / Infrastructure	Road improvement needed to counter temp. increase ("road melt") Impact: uncomfortable homes Adaptation: House construction design ("Home Insulation")	Road improvements Setbacks 'Climate proofing' infrastructure Integrating alternative energy technologies in buildings Adapted house designs

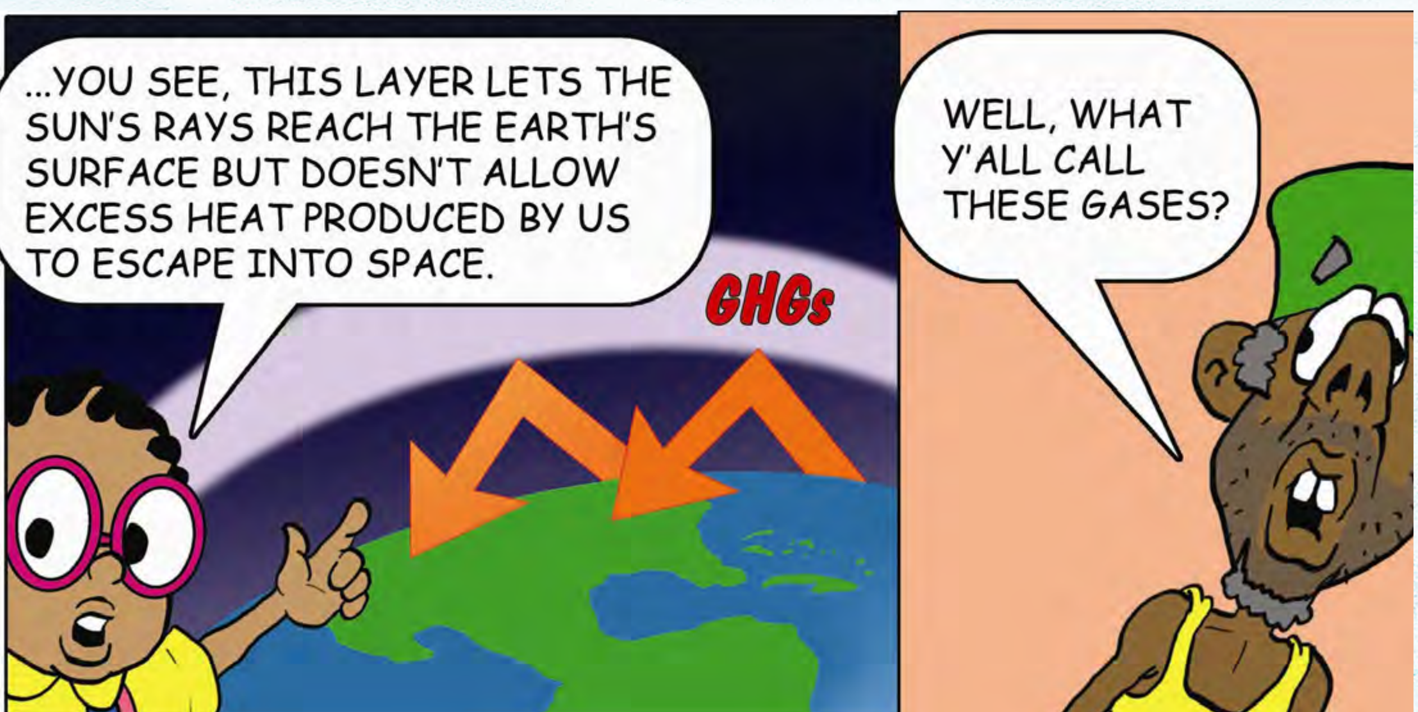
Energy	More demand for energy (e.g. air-conditioning) Increased fuel cost Decreases ability to generate energy (because of temp. constraints)	More use of renewable energy sources Alternative technologies Emission regulations/enforcement (e.g. Cars) wrt. Urban heating

Decreasing Rainfall	Adverse Impacts	Possible Adaptation Measures
Water Resources	Causes drop in groundwater table Affects the availability of water in private wells	(See temperature increase adaptation)
Coastal Zones	Salt intrusion; loss of near coast plants - specific mangroves erosion because of vegetation loss (dune plants, mangroves)	Replanting of plants Building sea walls
Agriculture	Drought; Lower cultivation; Affect size and quality of crop yield.	Irrigation (drip/improved technology); drought/salt tolerant plants; smaller scale activities; diversification (might need population preference shifts) See adaptation for temperature increase
Forest	(Shrinks forest reserve) Drought Forest Fires	More cleanups (carbide dumps); See temperature increase adaptation
Tourism	Impact on environmental quality less vegetation (loss of attractiveness) Incidence of more forest fires (pressure on water resources) Increase of air pollution	Save ‘water' initiatives; (showers, laundry) Awareness-raising; recycling & waste water-treatment/reuse
Human Health	More dust: adapt: Car Emissions Regulations; Water security => hygiene affected	
Settlements / Infrastructure	Utility water demand increase	Upgrade the network to deal with the increase in demand
Energy	More water barged or Reverse Osmosis or water production (all adaptation) permanently increase energy use (as an impact on Energy sector) Can be mitigated through “more water conservation methods”	Conserve water; conserve energy from other demands

Ocean Acidification	Adverse Impacts	Possible Adaptation Measures
Coastal Zones	-Less protection from coral reefs	See "sea level rise/coastal zones"
Agriculture and Fisheries	Affects fishing grounds Affects fish stock Ph affects organic composition of the marine life (through coral reef condition).	Remove/mitigate other pressures on fish
Tourism	Coral reefs impacted Loss in native species More invasive Native marine food source sport fishing / diving less attractive	Remove/mitigate other pressures on coral reef
Human Health	Food security (coral reef health): Reduced marine food source (protein source) More invasive pests Biodiversity loss	Education; Dietary shifts
Energy	Loss of economic stability (i.e. from tourism) impacts energy usage	None possible

Sea Level Rise	Adverse Impacts	Possible Adaptation Measures
Water Resources	Increase of salt intrusion Salt intrusion can affect well fields	Regulate water extractions from ground water (recharge areas); reroute storm water (not to sea, but to recharge areas)
Coastal Zones	Coastal erosion; Loss of beaches and land Affects mangrove vegetation: changes location	Sea walls; enrich sand dunes, mangroves, coral reef management
Agriculture	Changes chemistry of soil, which adversely affects crop production.	See "water resources/sea level rise"; crop change; fix chemistry (?)
Forest	Affects chemistry of soil – eg. Pine forest; Displaces brackish mangroves + wetlands	Replant; sea grapes; coconut/palm trees
Tourism	Loss of beach areas Coastal inundation Coastal zone erosion Dune and sand loss	Change attraction; improve coastal management; beach nourishment; dune (re-planting; setbacks
Human Health	Salt water intrusions Decrease in fresh water supply Waterborne disease due to ground water pollution	See "water resources/sea level rise"
Settlements / Infrastructure	Subsidence Impact: increased risk of flooded docks Impact: increased flood risk; Sewage system Cemeteries flooded (close to coast!; especially outer islands) Flooding of roads => change road layouts Utilities mostly on the coasts: increased flood risk and salt spray will impact insurance	Adaptation: Increase in dock height Adaptation: Improved drainage systems Adaptation: Building code upgrade Adaptation: Building code upgrade Change road lay-out Relocation; protection (nb: Vapor/moisture barriers for floors/walls)
Energy	Persons move inland (new houses) More sea wall construction More dam constructions = constructions necessary to adapt to loss of coastal area = 1 time more energy	Relocate utilities (part of refurbishing schemes) Construction of sea walls /dams


GREENHOUSE GASES (GHGs)


...YOU SEE, THIS LAYER LETS THE SUN'S RAYS REACH THE EARTH'S SURFACE BUT DOESN'T ALLOW EXCESS HEAT PRODUCED BY US TO ESCAPE INTO SPACE.
GHGs
WELL, WHAT Y'ALL CALL THESE GASES?

CHAPTER 5: OTHER INFORMATION CONSIDERED RELEVANT FOR THE ACHIEVEMENT OF THE OBJECTIVES OF THE CONVENTION

5.1 INTRODUCTION

5.1.1 Integration of Climate Change into National Policies

The Bahamas has a National Policy for the Adaptation to Climate Change. The National Policy identifies Government as the major facilitator of the implementation of the policy directives. It also provides a framework for advancing the capacity and capability of The Bahamas to effectively adapt to climate change impacts, and contributes significantly to the conservation and preservation of The Bahamas' natural resources for present and future generations of Bahamians.

Policy goals and objectives involve the following steps:

- Develop plans, processes and strategies to adapt to climate change and to avoid, minimize or mitigate the negative impacts of climate change on ecosystems, biological resources, land, water, economic activities, human settlements, and infrastructure;
- Encourage efficient use of energy and renewable energy while reducing dependency on imported fossil fuels;
- Conduct systematic research and observation on climate change;
- Explore and access mitigation and adaptation technologies;
- Enact legislative and regulatory instruments to promote effective implementation of this policy;
- Set up appropriate institutional systems and management mechanisms to ensure effective planning and responses to climate change; and
- Devise appropriate economic incentives to encourage public and private sector investment in adaptation measures.

Integration of such a policy and other aspects of climate change would vary across agencies.

5.2 Department of Meteorology

The Department of Meteorology has no existing policies. They operate with focus given to the National Emergency Management Agency (NEMA) Plan of Action. The Department is involved in the Global Climate System (GCOS) program, and is looking at being involved in the Global Earth Observation System of Systems (GEOSS).

The priorities of the department include improving Family Island stations to garner information on temperature and evapotranspiration. They are engaged in a coupon insurance scheme with Ministry of Agriculture and Marine Resources to assist farmers who may lose funds from impacts of tropical cyclones.

Climate change is not specifically considered in agency planning, but work with NEMA is related to climate change in terms of the early warning system. Impacts will include an increase in the intensity of storms that will be measured by the modification of instruments. Presently instruments are only designed to measure a certain wind speed (up to 120 miles) and will not work beyond that measurement. The Department will need additional instruments to read up to 200 mph. Changes in technology, such as utilization of air quality measurements are required to aid effective monitoring.

Information needs include GIS data to help monitor the decrease in vegetation. More research is needed to determine the impacts certain events will have on agencies and present statistics.

5.3 Bahamas Environment, Science and Technology (BEST) Commission

BEST has been the lead agency on development of national policies related to climate change, invasive species, wetlands and marinas. Policies planned for the future include those related to issues such as land-based sources of marine pollution and persistent organic pollutants.

Programs include the Integrated Watershed and Coastal Area Management project and the GEF Sustainability of Marine Protected Areas Full-Sized Project.

BEST's priorities include improving national policy development and legislation for the environment, and helping the country to pursue initiatives that would facilitate adaptation to climate change. BEST officers do consider climate change in planning. They encourage developers to go after greener alternatives such as minimal land clearing to preserve carbon sinks.

5.4 Bahamas Electricity Corporation (BEC)

The policies of BEC involve making a contribution to the national energy policy and participation in the National Climate Change Committee. Planned policies include exploring renewable energy options.

One of the priorities of BEC is the reduction of the amount of electrical power produced from fossil fuels (this will lead to reduction in fuel costs).

BEC is the largest emitter of GHG. BEC is charged with providing power to all Bahamians, and it is a challenge to provide power in the Family Islands at the same cost as the more populated and developed island of New Providence.

Climate change is not considered in agency planning. There is no imperative to address this issue. If BEC was to seriously consider impacts of emissions, it would change the way it uses energy to generate power. It would be helpful to view a Government agency's report on BEC's emissions. Information on mitigation of measures to reduce emissions would be useful. The information can be produced in any format as long as it is on Government letterhead. (Air conditioning load is the largest load they have; BEC uses less power when it is cooler. BEC emissions will increase the hotter it gets.)

A draft national energy policy has been developed, but is not yet approved by the Government. BEC looks at energy production from a financial perspective, not an economical one. The power company is looking at solar, wind, waste-to-energy, Ocean Thermal Energy Conversion and plasma energy generation as alternatives.

5.5 Water and Sewerage Corporation (WSC)

Policies of the Water and Sewerage Corporation include working with the World Health Organization and abiding by their standards. They also work with Global Water Partnership and Caribbean Water and Wastewater Association. WSC has financial and customer service policies. Planned policies include an Integrated Water Resources Management Plan which they are presently pursuing. The agency is trying to develop a master strategy for the water and sewerage service sector.

Priorities include developing adequate service standards throughout the country. This is very difficult to do without vast economic resources.

Agency issues include providing the populace with potable water and collecting their waste effluents. The latter is not being done adequately anywhere in the country.

5.6 Ministry of Education

Education policies include educating as many as possible on climate change. Climate change is incorporated in the national secondary school curriculum with more details provided at Grades 10 through 12. While climate change is not specifically referenced in the national primary school curriculum, aspects of it are addressed in science and social studies. Topics such as earth's atmosphere, hurricanes and how they happen and other climate phenomenon may include these aspects.

5.7 The College of The Bahamas

The College of the Bahamas (COB) has educational policies and programs for science, science majors and teachers.

Issues include strategic planning associated with trying to have campuses all over the country. What is the carbon footprint of teachers and students having to move around? Is COB's growth being done in a sustainable manner? COB is transitioning to a university. Therefore, it will take a larger role in research and be more involved in national issues.

COB now has a Small Island Sustainability programme, which includes a curriculum, related to climate change. The programme looks at other aspects of sustainable development including alternative means of crop production and renewable energy technologies.

5.8 Department of Lands and Surveys

The LUPAP (land use policy and administration project) is an attempt to create a base map of all the islands of The Bahamas starting with Grand Bahama, New Providence and Abaco. It would be a land parcels map including all the surveys that have been done in the country.

Sea level change may impact LUPAP. GIS maps or statistics would be best formatted for relaying information.

5.9 Department of Agriculture

The Department of Agriculture has no specific policies, but is looking to develop policies on land use and tenure, water use and management, and pesticide use. They are having discussions to review the availability of land for farmers especially those in low-lying areas. The Department wants to have some land conveyed to move farmers to higher ground and is meeting with the Office of the Prime Minister and Department of Lands and Surveys on this matter.

The Department is encouraging farmers to use greenhouses to start seedlings and grow crops with improved seed varieties. The Department is also encouraging the use of drip irrigation instead of rain fed agriculture. Slash and burn is still a practice amongst subsistence farmers. The Department does have a system of land clearing available to farmers at a cost, but some farmers prefer not to use it.

The Department wants to implement agricultural coupon insurance, which is agreeable with the majority of farmers. However, the high premium farmers would have to pay is an obstacle, but the Department is working to eliminate this concern.

Some of the issues for the Department of Agriculture include animal and plant health, food security and production, wildlife conservation and research, import control, and rural planning. Climate change will affect all aspects of agriculture, including marketing or transporting produce to different islands. Land use and clearing, land availability, wildlife management, genetic selection related to pest control and resistance will also be impacted.

5.10 Department of Environmental Health Services (DEHS)

It was noted that the Environmental Health Services Act speaks to the issue of burning and makes it illegal to emit any pollutant into the environment.

5.11 Ministry of Finance

Existing policies include a reduction in duty on solar panel and other equipment related to solar energy. She noted that the issue of climate change is on the agenda for Finance Ministers.

5.12 Bahamas National Trust (BNT)

Existing policies do not include climate change, but the BNT is planning to review them to see how they can include this issue. Its priorities are biodiversity and wetland conservation.

5.13 Ministry of Tourism

The Ministry of Tourism has no existing policies, but it does support the national climate change policy. The organization has a programme that involves coastal awareness. Priorities include doing whatever is eco-friendly, conserving the natural resources of The Bahamas and making tourism thrive. Wherever possible, the Ministry tries to influence touristic developments to be eco-friendly like building on the coast. Sustainable tourism guidelines exist, and are provided to developers when new developments are presented to the Ministry for comment.

5.14 Environmentally Sound Technologies – Transfer and Access

The Initial National Communication (INC) of The Bahamas presented to the UNFCCC in 2001 identified a number of potential projects and activities that The Bahamas could implement to contribute positively to its response to climate change. Areas and sectors covered include agriculture, energy (including renewable), health, transportation, water conservation, land use and forestry and tourism. The technologies and practices required for the above can also contribute to economic and social development for The Bahamas. To achieve sustainable development objectives, it is crucial to have the following: (i) technologies for mitigation such as in energy and transportation; (ii) adaptation technologies in the areas of water conservation; (iii) improvement and sustainability of agricultural and livestock production; (iv) reduced incidences of malaria and upper respiratory diseases; and (v) the management and conservation of biodiversity, including forestry..

Technology for implementation of activities in the above-mentioned areas and sectors vary in appropriateness and cost. In order to use scarce and valuable resources, as efficiently as possible, there is a need to conduct an assessment of available technology and cost of transfer and adaptation. This is also consistent with decision 4/CP.4 of the UNFCCC requiring non-Annex I countries to submit their technology needs for addressing climate change in a prioritized manner.

The Bahamas National Climate Change Committee (NCCC), chaired by the BEST Commission of the Ministry of the Environment, with the support of the United Nations Development Program requires the services of a consultant, an institution or consortium to conduct an assessment of the available technologies that could support economic development while meeting the climate change obligations and responses of The Bahamas. The Bahamas intends to pursue GEF Enabling Activities funding in order to complete a technology needs assessment within the GEF-5 cycle.

5.15 Climate Change Research and Systematic Observations

The Bahamas is a part of WMO and the Global Climate Observing System (GCOS).

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 in locations across The Bahamas by numerous private and untrained individuals, on both land and at sea. These records were often incomplete with numerous gaps.

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, with necessary instructions.

Annual tours were arranged to inspect and maintain the instruments. The information collected was disseminated in accordance with international standards and practices to well inhabited islands.

The formation of the British Caribbean Meteorological Service in 1951 resulted in the formulation of a more systematic manner of making observations. Hydro meteorological and climatological observations became the responsibility of The Bahamas Department of Meteorology on its creation in 1973, while under the Ministry of Tourism.

Systematic observations are made from a network of 21 automatic weather observing stations on 15 well inhabited islands. These stations provided data continuously at frequent intervals and for observation time. Parameters measured include wind direction and speed, precipitation, air temperature and solar radiation. The network forms part of the Global Climate Observing System and the Global Earth Observation.

A cooperative upper air observing station with the United States has been maintained since 1978. The unit provides upper-air analyses and products to users who are monitoring or conducting research in climate change, for short or long periods of time.

A Doppler weather radar, satellite data from the National Oceanic Atmospheric Administration (NOAA) and a lightning detection network are tools that are used for the early warning system of The Bahamas.

The impact of radiation on health is measured with a UV-B 501 biometer. Measurements have been made since 1999. The data will be used for plant, marine, climatological ozone or other biological impact studies that require continuous field measurements over long periods of time.

5.16 Hydrological Observations

A data well waverider buoy for the study of waves is used in marine forecasting. The data from the buoy also provides useful information for coastal management and planning.

Sea level is monitored by three tidal gauges installed in Nassau Harbour, Lee Stocking Island and Inagua. The tidal gauges were granted under the Caribbean: Planning for Adaptation to Climate Change (CPACC) Project of the Organization of American States (OAS). Data strings for Inagua and Lee Stocking Island have been shortened due to monitoring disruptions caused by tropical cyclones. A tidal gauge has been maintained and 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.

Additional observations have been made by the Perry Institute for Marine Sciences, at Lee Stocking Island in the Exuma Cays, to 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.

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.

Constraints and gaps related to RSO include the need for personnel, observation stations in remote Family Islands, development of a rainfall network and telecommunications infrastructure to support a system.

5.17 Research Programmes

Research programmes are widely ranged and encompass regional and international initiatives, with meteorological and socio-economic elements.

Two stations are equipped with meteorological sensors to monitor precipitable water (PW). The project is part of the COSMIC program recently funded by the National Science Foundation to expand SuomiNet into the Caribbean. SuomiNet is an international network of GPS receivers, configured and managed to generate near real-time estimates of precipitable water vapor in the atmosphere, total electron content in the ionosphere, and other meteorological and geodetic information. The objective of this expansion is to improve the forecasts of hurricane track and intensity using continuous observations of integrated water vapor. We will install and operate a network of up to 15 GPS stations in the Caribbean. They will all be equipped with meteorological sensors and the data will be analyzed to retrieve precipitable water vapor (PW). The derived PW data will then be assimilated into the Weather Research and Forecasting (WRF) model to evaluate what impact they have on hurricane forecasts.

Seasonal Forecasts are made by the Caribbean Institute for Meteorology and Hydrology (CIMH) and the products used by the Department of Meteorology to warn of drought.

Research activities coordinated by The Bahamas Meteorological Service include PRECIS modeling at a scale of 25km resolution using two Global Climate Models (GCMs) to downscale to regional level to be able to interpret outputs that would show changes in climate. BahamasSimClim model is used to give more site specific outputs.

Vulnerability mapping using the Sea Lake and Overland Surges from Hurricanes (SLOSH) model has been completed for the islands of New Providence, Eleuthera, South Berry Islands, the Exumas, Long Island, Cat Island, Rum Cay and San Salvador. The outputs show surge values of 16 to 23 feet in the flatter, narrower islands (New Providence, Berry Islands and Eleuthera).

5.18 Regional Research

The Caribbean Community Climate Change Centre (CCCCC), in collaboration with the Oxford University Centre for Environment (OUCE), has been implementing a pilot phase of one component of a more holistic proposal, CARIBSAVE. CARIBSAVE addresses the vulnerability of the regional tourism sector to climate change, and seeks to develop adaptation/mitigation responses to build a more climate resilient tourism sector in the region. The component being addressed, on a pilot scale in Negril in Jamaica and Eleuthera, in The Bahamas seeks to develop a Destinational Climate Change Risk Map that will form the basis of integrating climate risks into the sectoral (tourism in this instance) planning process.

In June 1999, the Government of The Bahamas, through the National Climate Change Committee (NCCC) of the BEST Commission, contracted 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 GEF FSP on Sustainability of Marine Protected Areas in The Bahamas involves a research project on how increasing resilience of coral reefs to climate change can be improved by restoring mangrove areas adjacent to reef areas. This project is scheduled for completion in 2013.

5.19 El Nino-Southern Oscillation

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.

5.20 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.

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; and
- possible health impacts, to date, as indicated by hospital admissions data are incidences of malaria, respiratory disease and heat stress.

A comparison with nearby countries and similar regions will be attempted if data is 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.

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; and
- 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.

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 the 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 Geographic Information Systems (GIS) data generated by this model be used. 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.

5.21 Education, Training and Public Awareness

The Bahamas Environment, Science and Technology (or BEST) Commission manages the implementation of multilateral environment agreements in The Bahamas, including the UNFCCC. The National Climate Change Committee (or NCCC), under the auspices of the BEST Commission, has tasked a public education and outreach subcommittee (or PEO subcommittee) with drafting and implementing a public education and outreach strategy on climate change in The Bahamas.

The PEO subcommittee has adopted a strategy document on public education and outreach with a three-year duration. The strategy adopts the overall goal of informing the various stakeholder groups on the effects and threats of climate change for The Bahamas. It also encourages public action and involvement in national mitigation and adaptation efforts to promote sustainable development and poverty reduction.

The strategy document sets out various stakeholder groups to be targeted, in order of priority, as follows:

- youth and education through school level general educational materials, student competitions and teacher workshops;
- the media through workshops;
- civil society (including the private sector and community groups) through targeted meetings and workshops; and
- politicians and the public sector through targeted workshops.

5.22 Education

The national primary school level curriculum currently includes general environmental education components, but no specific content on climate change. The national secondary school level curriculum currently includes specific components on climate change. Based on meetings with the Ministry of Education, the subcommittee has determined that by providing educational materials and workshops for teachers, climate change can be more effectively integrated into both the primary and secondary level school curriculum. To this end, the first short term project of the PEO subcommittee is to develop a nationally appropriate comic booklet on climate change as an educational tool. Workshops have been held with the subject officers, the writing unit of the Ministry of Education, a selection of teachers, and the Coastal Awareness Committee to review the draft comic booklet. Further funding will be required to print the booklet in large numbers for schools.

The national higher education institution, The College of The Bahamas, launched a new programme in Small Island Sustainability (SIS) in September of 2009. The SIS programme offers a Bachelors of Arts in Small Island Sustainability with a focus in either policy studies or eco-tourism and development. It also offers a Bachelors of Science in Small Island Sustainability with a focus in either environmental and ecosystems management or integrated sustainable development planning. Although there is presently no specialization in climate change available in the SIS programme, the required courses for students in the SIS programme include climate change content. The SIS programme held a series of public town hall meetings at The College of The Bahamas in 2009-2011 on various environmental issues such as geotourism, sustainable development and environmental governance.

Current climate change education (school and college level) challenges include a lack of -

- educational materials;
- familiarity with the subject matter;
- methodological courses in primary and secondary schools;
- advanced training for qualified people.

5.23 Media

There has been an increase in public awareness through both the national and international media. On a national level, a climate change workshop for media and policy makers was held on May 3, 2010. This segment was part of a workshop prepared for the Second National Communication. A new show, The Bahamas Naturally, airs monthly and focuses on the eco-systems of The Bahamas.

There are no specialist environmental journals or newspapers, and there is limited national scholarship on the issue.

5.24 Non-governmental Organizations

The Bahamas National Trust (BNT) developed many educational programs and collateral material that aid in teaching the effects of climate change in the ecosystems of The Bahamas. One such resource is the Treasures in the Sea Teacher Resource Manual around which a Teacher Professional Development workshop is built. The workshop focuses on issues of pollution, marine life and reef health, specifically, coral bleaching and ocean acidification. Another vital aspect of the BNT education program is the Wondrous Wetland Workshop and teacher’s resource that highlights the importance of mangroves in acting as barriers for hurricanes and storm surges.

In 2010 during its annual summer camp, the BNT designated a full day for conducting climate change lessons and activities. Other aspects of the camp featured various topics that relate to climate change. These include topics such as Reduce, Reuse, Recycle, Water Conservation, Pollution and various ecosystems that would have a direct negative impact from climate change. The Discovery Club, the BNT's youth environmental program, has a weather badge where climate change is among the topics discussed over a 6 week period. The BNT hopes to continue to integrate climate change in its education programs in order to facilitate a better understanding of climate change - its causes and effects.

The Bahamas Reef Environmental Education Foundation (BREEF) conducts an annual summer Marine Conservation Teacher Training Workshop at the Gerace Research Center on San Salvador. The objective of the workshop is to provide Bahamian primary and secondary level educators with hands-on experiences in the marine environment that they could subsequently share with their students. To date, approximately 280 Bahamian educators have participated in the workshops. Since 2008, the workshop has contained a component on climate change education. In 2010, the workshop will produce a series of Public Service Announcements under the theme "Conservation makes Cent$," linking environmental issues with economic development. One of the public service announcements will focus on climate change in The Bahamas.

The National Coastal Awareness Committee is a group of stakeholders from the private and public sectors formed to heighten awareness of the importance of protecting and preserving the coastline of The Bahamas. Its members are: the Ministry of Tourism, Bahamas Reef Environmental Education Foundation, the BEST Commission, Bahamas Hotel Association, Bahamas National Trust, the College of The Bahamas, Department of Environmental Health Services, Department of Marine Resources, Stuart Cove's Dive Bahamas, Dolphin Encounters Ltd., the Nature Conservancy and the Ministry of Education. The Committee has launched the National Coastal Awareness 2011 School Competitions. These include a design competition to produce a climate change banner for students Grades 7-9, and a public service announcement competition on climate change for high school students Grades 10-12 and high school graduates up to age 25.

The Fifth National Exhibition of the National Gallery of The Bahamas will take place under the theme 'The Carbon Footprint: Bahamian Artists' 21st Century Response to the Environment.' The themed national exhibit is designed to explore ideas and narratives from a selection of Bahamian artists on issues relating to the 21st century global question on carbon footprint and climate change. The exhibition is scheduled to open in August 2010 and end in January 2011.

5.25 Public Sector

Public addresses by senior government officials have included the impacts of climate change and government's effort to build capacity, and to report on the national involvement in the UNFCCC process. Additionally, experiences with tropical cyclones, public debate and the increased national and international media attention to climate change continues to be used to increase awareness on the subject.

Specific workshops on climate change have been held to train experts in preparation for the Second National Communication, namely long-range alternative energy planning system from 15th - 18th March 2010, and BahamasSimCLIM from 3rd – 7th May 2010. Both workshops focused on using and inputting data into climate modeling systems.

A strategy on public education and outreach on climate change in The Bahamas was recently adopted.

5.26 Public Participation and Access

The Bahamas is not a signatory to the Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters. However, the government plans to enact a Freedom of Information Act, and recently enacted a Planning and Sub-division Act 2010, which includes components involving public participation on planning decisions.

5.27 Sub-regional, Regional and International Cooperation

The PEO subcommittee recently entered into conversations with the University of South Florida to participate in a project for the development of a regional partnership on climate change. the project will include the identification of best practices in climate change education and the piloting of innovative climate change education practices.

The PEO subcommittee has also made contact with the Caribbean Community Climate Change Centre in Belize.

5.28 Gaps, Needs and Priorities

Educational materials combined with workshops for teachers on climate change are required at every level throughout the national education system. A lack of familiarity with the subject matter, combined with a lack of educational materials, means that the subject matter is not fully integrated in the national curriculum as taught.

In addition, there is a lack of:

- national data collection and distribution initiatives;
- policy interactions; and
- prioritization of climate change at the institutional and executive level which further reduces the efficacy of any educational and outreach impetus.

In order to address these gaps and needs, further funding will be required to implement the public education and outreach strategy.

5.29 Capacity Building

The intergovernmental negotiation process that ultimately led 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 received approval from 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 county 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 rise in sea level, increases in sea surface temperatures and changes in wind and ocean currents. The vulnerability of coastal resources, human settlements and infrastructure to sea level rise underscores the urgent need for an integrated framework to address these issues. The scarcity of reliable data, 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 on 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.

5.30 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. This dialogue resulted in 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 and is 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. The CPACC project is 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 a cost-effective means for adaptation planning, data collection, sharing of information skills, and project benefits.

5.31 Need, Options and Priorities

There have been a number of workshops held to enhance capacity. The Department of Meteorology is currently conducting flood plain mapping with the aid of The Bahamas National Geographical Information Service (BNGIS). The data has been integrated in the SLOSH model. It will be analyzed and transformed by NOAA, which is donating time and equipment to the process.

CHAPTER 6: CONSTRAINTS, GAPS AND RELATED FINANCIAL, TECHNICAL AND CAPACITY NEEDS

One of the principles of The Bahamas National Policy for Adaptation to Climate Change is to develop national human and institutional capacity in all aspects of climate change research, response and planning. Procuring and allocating adequate financial and other resources to ensure that climate change issues are effectively addressed is also a policy principle. Specific actions recommended by the policy include:

- continue, expand and strengthen coastal monitoring and data collection so as to facilitate decision-making;
- develop the basis for sound decision-making by further developing the capacity to undertake research into relevant climate change processes which may affect coastal human settlements;
- implement fiscal and financial measures in order to achieve equitable distribution of the economic burden between stakeholders;
- encourage the financial and insurance sectors to develop mechanisms aimed at assisting human settlements affected by climate change; and
- undertake a comprehensive assessment of human settlements and related infrastructure at risk from the effects of climate change, using risk mapping, and incorporation of the findings into the National Land Use Management Plan, and into the planning processes of the National Emergency Management Agency (NEMA) of the Cabinet Office.

6.1 Financial and Technical Resources

Financial and technical resources dedicated to climate change and addressing its impacts are significantly limited in The Bahamas. Agencies that have other tasks as their priority functions, such as Department of Meteorology, Department of Agriculture, Water and Sewerage Corporation and Bahamas Electricity Corporation, can only commit few resources to climate change.

The 2005 National Capacity Needs Self-Assessment (NCSA) Report confirmed that "current levels of government funding are insufficient to adequately support the implementation of four international environmental conventions" including the UNFCCC. The NCSA report outlined the following additional staffing needs to build capacity for improved environmental management and addressing climate change:

- 7 forecasters for the Department of Meteorology;
- 68 technical staff members for the BEST Commission (now under the Ministry of the Environment);
- 3 staff members for the Water Resources Management Unit of the Water and Sewerage Corporation;
- 400 staff members for the Department of Environmental Health Services; and
- 15 staff members for the Department of Marine Resources.

A lack of financial resources at the systemic and institutional levels was identified as a key obstacle to staff training. Furthermore, permission for involvement in training, in particular international workshops, are most often granted at the ministerial level, and not at the institutional level, where training needs are best assessed. As a result, the process of approving staff involvement in training can be very onerous and lengthy. In some instances, approval is granted after key dates for registration and payments have elapsed, thus effectively eliminating the opportunity for the staff to participate in training.

Since many of the government institutions are understaffed, and individuals are often responsible for a multiplicity of tasks, managers have expressed a reluctance to "lose" staff time through training. Managers have indicated that in some cases staffing levels are so low that they require the full complement of their staff in order to meet the most basic responsibilities of their departments. There is also a lack of learning plans and a specific environmental management training program.

The inability to effectively participate in training results in the following lost opportunities:

- to improve skills through exposure to new technologies, procedures, research, etc.;
- for networking with professional peers; and
- for gaining recognition by sharing expertise through presentation of and participation in training activities both locally and internationally.

The 2005 National Environmental Management and Action Plan (NEMAP) recommended that stable additional financial resources be made available for training. The assessment of training needs and approval for training should be completed at the institutional level and not at the ministerial level. Immediate managers and supervisors are best placed to assess the training needs of their staff. It is also recommended that learning plans be developed and a competency-based environmental management training program be developed and implemented about a two-year period. This will include the development of a training module and pilot test. E-Learning could be utilized to reduce cost. The estimated cost per module is between $US 25,000 – 40,000, thus 6-8 modules will cost about $US 150,000 – 250,000 per year or $US 300,000 – 500,000 for two years. An additional $US 50,000 or so will be required for maintenance and delivery of the training modules.

Government contribution to the preparation of the second national communication and activities relating to the implementation of the Convention

Project Proposals – Emissions Reduction and Sink Enhancement

Under GEF-5, The Bahamas intends to pursue funding for the following projects related to emissions reduction and sink enhancement:

Transformation of the public transport system through low-carbon technologies - This project would involve completion of a comparative study of the public bus transport system before and after the introduction of low-carbon technologies. It will require building on the reform of this sector, which is currently underway. It will involve policy, legislative and institutional reform to facilitate the introduction of these technologies and capacity building for staff involved in operation and maintenance of the system.

Energy efficiency market penetration in the tourism sector - Approval of the National Energy Policy would facilitate implementation of this project in the largest economic sector in The Bahamas. The project would involve the introduction of energy efficient technologies and systems into major and small hotels throughout The Bahamas. It includes training and certification for line staff in monitoring and maintenance of these systems. The project would also have a public education and outreach component.

Renewable energy (RE) technologies - Possible technologies may include waste-to-energy, biodiesel for vehicles and Ocean Thermal Energy Conversion (OTEC). Changes to facilitate the introduction of RE technologies may include modifications to the Building Code. These will need to be framed in the context of the new electricity sector framework proposed under the IDB energy projects.

6.2 Adaptation Projects

The GEF Full-Sized Project on Sustainability of Marine Protected Areas in The Bahamas includes a pilot project entitled "Incorporating Climate Change and Mangrove Restoration into Conservation Planning." The demonstration project has implications for the entire Bahamas, but is specifically focused on the Exuma Cays Land and Sea Park (ECLSP). The project is being led by the Northern Caribbean Office of The Nature Conservancy in conjunction with the University of Queensland.

Coral reefs in The Bahamas were seriously damaged by coral bleaching in 1998 when sea temperatures rose to anomalously high levels. With sea temperature continuing to rise throughout this century, coral bleaching events are likely to become regular problems. Added to the bleaching threat to corals are the routine disturbances from hurricanes. However, recent work funded by the GEF Coral Reef Targeted Research Project and Living Oceans Foundation has shown that sea temperatures warm predictably in parts of The Bahamas. The research, led by the University of Exeter, clearly shows that some reefs will experience more intense climatic disturbance than others.

The first part of this pilot project will use a combination of historical sea surface temperature records, historical hurricane tracks (as far back as the year 1851), and climate models to locate those reefs of The Bahamas that are likely to have the greatest resistance and resilience to climate change. These predictions will be made possible by using a validated ecological model of Bahamian reefs that was developed by the University of Exeter and published in the journal *Nature*. The model will be calibrated locally by undertaking field studies of different levels of algal growth across the Bahamian archipelago. Other parameters will be obtained from existing satellite imagery (habitat maps, hurricane tracks, and sea surface temperature patterns). The final output will be a map of expected reef futures under a 'business-as-usual' approach to conservation. This will be complemented with another map that shows the potential impact on reef health of implementing marine reserves in each part of The Bahamas. These maps will then be combined with state-of-the-art information on patterns of larval dispersal across The Bahamas, provided by the University of Miami, to identify priority sites for conservation from a biophysical perspective. This information will assist the strategic planning of new marine reserves and provide simple tools to local stakeholders that can be used to help them select local sites for conservation.

Reefs with prolific mangrove access have a greater supply of several commercially important fishes and increased levels of grazing that are thought to improve the reef's recovery from hurricanes and bleaching events. Priority sites for mangrove reforestation will be identified using a computer algorithm to determine which sites, if restored, would offer the greatest value to the reef ecosystem, as a whole. Such an algorithm has been developed by the University of Exeter. The pilot will include a historical analysis of sites that have lost mangrove forest, thereby identifying those former mangrove sites that would offer the greatest value to reef fisheries if restored. Restoration activities will occur in the Exuma Cays Land and Sea Park as a demonstration to be scaled up at other sites in the future. Modeling will be complemented by field data collection for identification of critical areas of mangrove seeds and mangrove restoration sites. There will also be resilience monitoring for mangroves restored and development of threat abatement strategies for critical areas identified within ECLSP.

Key indicators of the project will be the following:

- maps of climate change impacts on coral reefs in The Bahamas;
- maps indicating potential impact of implementing marine reserves on reef health;
- number of sites identified as being relatively resistant to future climate change;
- number of management plans that take account of climate change impacts on reefs;
- number of sites identified for mangrove reforestation;
- production of map of mangrove contribution to reef fisheries;
- quantification of the loss of mangroves in The Bahamas over the last 20 years;
- amount of mangrove reforested; and
- health of mangroves reforested following restoration.

6.3 Technology Transfer

The Technology Needs Assessment that is scheduled to occur within the next 3 years will provide the basis for technology transfer to The Bahamas.

6.4 Other Capacity Building Needs

The NCSA Report also identified the need for the following:

- Regulations related to climate change and estimated the cost of drafting such regulations as US$15,000;
- Environmental Impact Assessment guidelines with respect to extractive processing, energy industries, industrial operations and manufacturing which should have considerations for climate change as an integral part. The estimated cost for developing the guidelines was in excess of US$63,000; and
- Funding for a fully staffed Ministry of the Environment of 274 persons with necessary infrastructure and equipment needs of US$6.2 Million.

ANNEX I: LIST OF SCIENTIFIC NAMES OF MARINE AND TERRESTRIAL FAUNA AND FLORA

LIST OF SCIENTIFIC NAMES OF MARINE AND TERRESTRIAL FAUNA AND FLORA		
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*
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 terrapin*
	Green turtle	*Chelonia midas*
	Hawksbill turtle	*Eretmochelys imbricata*
	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*
	Bull shark	
	Caribbean reef shark	
Native and naturalized plants	Black mangrove	*Avicennia germinans*
	Buttonwood	*Conocarpus erectus*
	Caribbean pine	*Pinus caribea*
	Horseflesh	*Lysiloma sabicu*
	Lignum vitae	*Guaicum sanctum*
	Mahogany	*Swietenia mahagoni*
	Poisonwood	*Metopium toxiferum*
	Red mangrove	*Rhizophora mangle*

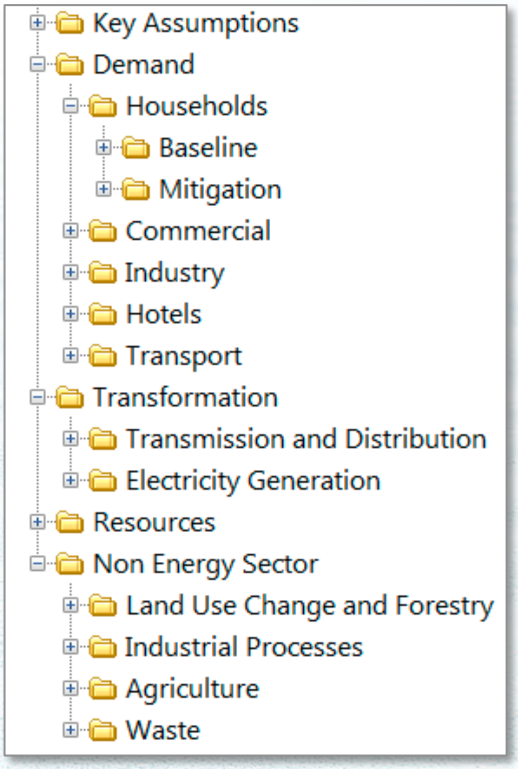
	Turtle grass	*Thalassia* sp.
	White mangrove	*Laguncularia racemosa*
	Wild fig	*Ficus* spp.
	Wild tamarind	*Lysiloma latisiliquum*
Introduced crop species	Avocado	*Persea americana*
	Beans	*Phaseolus* spp.
	Breadfruit	*Artocarpus communis*
	Cassava	*Manihot esculenta*
	Corn	*Zea mais*
	Guava	*Psidium 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*
	Watermelon	*Citrullus vulgaris*

ANNEX II: ASSUMPTIONS FOR LEAP MODELING

2.1.1 Introduction

Included in this annex is an explanation of the structure and assumptions behind the baseline and mitigation scenarios used in the mitigation analysis for The Bahamas Second National Communication. The baseline and mitigation scenarios were modeled in LEAP: the Long-range Energy Alternatives Planning System, a widely-used software tool for energy policy analysis and climate change mitigation assessment.[37]

The baseline scenario was developed by the Stockholm Environment Institute (SEI)[38] with the help of Mr. Robert Hall from The Bahamas Electricity Company (BEC) and Ms. Chantel Nesbitt from the Grand Bahama Power Company (GBPC). The mitigation scenario was compiled by SEI using assumptions from the Fichtner Reports[39,40] and The Bahamas National Energy Policy report[41].



This data set includes a comprehensive picture of historical energy demand and supply in The Bahamas from 2000 to 2009 based mainly on the in-country data, but supplemented with international data sources as needed. The energy data includes information on energy use by fuel in each major demand sector (households, commercial, industry, hotels and transport). On the supply side the data sets include information on transmission and distribution losses in addition to electricity production.

The data set also includes one baseline scenario which tells a story of how The Bahamas energy system could develop over the time period of 2010 to 2030. In addition, the data set includes a comprehensive mitigation scenario which includes the various policies and measures reported in the mitigation chapter and documented in this annex.

Energy information is supplemented with the IPCC's standard Tier 1 emission factors to provide estimates of greenhouse gas emissions from the energy sector. The data sets also include simple estimates of non-energy sector GHG emissions taken from the 1990, 1994 and 2000 national inventories.

Energy consumption and production data are supplemented by macroeconomic and demographic data from The Bahamas Statistics Office and Central Bank.

2.1.2 Key Assumptions

Population

Current Accounts: Population estimates were collected from The Bahamas Department of Statistics. This data is based on historical national censuses for years 1990 and 2000, and based on preliminary census data for 2010. Data was interpolated between known data points. No digital copies of this data were available.

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[37] LEAP, distributed through www.energycommunity.org

[38] Stockholm Environment Institute, www.sei-international.org, 11 Curtis Ave. Somerville, MA 02144

[39] Fichtner, Explore Alternatives for BEC's Expansion Plan, Preliminary Report II, Strengthening the Energy Sector in The Bahamas, September 2010.

[40] Fichtner, Promoting Sustainable Energy in The Bahamas, Preliminary Report II, Strengthening the Energy Sector in The Bahamas, June 2010.

[41] National Energy Policy Committee, Second Report of the National Energy Policy Committee, The Bahamas National Energy Policy. Available online: http://www.best.bs/

Baseline Scenario: Population projections for years 2020 and 2030 also come from The Bahamas Department of Statistics. Data was interpolated between known data points. No digital copies of this data were available.

Mitigation Scenario: No changes have been made in the Mitigation Scenario. All data and expressions are inherited from the Baseline Scenario.

Population is used to calculate the key assumption in households.

Urban Population

Current Accounts: The percent of urban population data comes from the World Bank World Development Indicators (WDI 2010) database and is available for 1990-2007. This data was acquired from the World Bank's WDI online database.

Baseline Scenario: The baseline has no projections of this variable.

Mitigation Scenario: No changes have been made in the Mitigation Scenario. All data and expressions are inherited from the Baseline Scenario.

This variable is not used in LEAP's energy calculations in this data set.

Household Size

Current Accounts: Household size, or the average number of people per household in The Bahamas, is assumed to be 3.4, a representative number based on data from The Bahamas Department of Statistics.

Baseline Scenario: The baseline has no projections of this variable.

Mitigation Scenario: No changes have been made in the Mitigation Scenario. All data and expressions are inherited from the Baseline Scenario.

This variable is used to calculate the number of households in The Bahamas.

Households

Current Accounts: The total number of households in The Bahamas is calculated as the total population divided by the number of people per households.

Baseline Scenario: The baseline has no projections of these variables.

Mitigation Scenario: No changes have been made in the Mitigation Scenario. All data and expressions are inherited from the Baseline Scenario.

This variable is used as the activity level for the households demand sector.

GDP

Current Accounts: Historical GDP data in units of Million. In 2006 Bahamian Dollars were taken from The Bahamas central bank (raw data found in the "Bahamas Central Bank GDP data.xls" spreadsheet file in the worksheet titled "tab1"). Historical data was available from 1997 to 2007, and was extrapolated to 2009 using the historical growth rate (calculated from 1997 to 2007).

Baseline Scenario: Local GDP projections could not be found, so the baseline includes a simple growth forecast for GDP to 2030 based on a projection of historical growth from local GDP data.

Mitigation Scenario: No changes have been made in the Mitigation Scenario. All data and expressions are inherited from the Baseline Scenario.

This variable is used together with the value added key assumptions and calculated with the activity level for the commercial, industry, hotels and transport sectors.

Income

Current Accounts: In current accounts, the Income variable is calculated by dividing GDP by the population of the country in units of $/person.

Baseline Scenario: The baseline scenario assumes no change in the calculation used in current accounts.

Mitigation Scenario: No changes have been made in the Mitigation Scenario. All data and expressions are inherited from the Baseline Scenario.

This variable is not used in LEAP's energy calculations in this data set.

Electricity Correction Factor

Current Accounts: This variable is only used in the current accounts scenario. This factor corrects for the historical discrepancy between electricity generation and electricity consumption. In years 2000 through 2009, electric utility data reported that generation was approximately 1.25% higher than consumption. This is likely to be due to the difficulty of reporting exact consumption numbers. In order to recognize that the generation values are most accurate, we calculated a correction factor as the proportion of 2009 generation data to 2010 predicted consumption. This correction factor is multiplied by historical final energy intensities to ensure that historical generation matches consumption.

Baseline Scenario: All electricity final energy intensities are projected normally in the baseline scenario.

Mitigation Scenario: No changes have been made in the Mitigation Scenario. All data and expressions are inherited from the Baseline Scenario.

This variable is used to calculate final energy intensities for electricity consumption in the households, commercial industry and hotels sectors.

Value Added

Current Accounts: Historical value added data (i.e. percent of GDP by sector) for Industry, Commercial, Hotels and Transport sectors are taken from The Bahamas central bank (raw data found in the “Bahamas Central Bank GDP data.xls” spreadsheet file in the worksheet titled “tab4”). Industrial data includes value added from industry and construction. Commercial data includes value added from wholesale and retail activity, health services, education, public administration and defense, real estate, financial intermediaries, communications and storage. Historical data was available from 1997 to 2006, and was extrapolated to 2009 using the historical growth rate (calculated from 1997 to 2006).

Baseline Scenario: All value added variables are assumed to grow at their historical growth rate (calculated from 2000 to 2009) over the time period of 2010 to 2030. This assumes that total GDP for industry, hotels and transport increase over the 20-year time frame, but total GDP for commerce decreases.

Mitigation Scenario: No changes have been made in the Mitigation Scenario. All data and expressions are inherited from the Baseline Scenario.

This variable is used together with the GDP key assumption to calculate the activity level for the commercial, industry, hotels and transport sectors.

Transport

Current Accounts: Under the Transportation branches, you will find historical indicators for both passenger and freight air transport. This data comes from the World Bank World Development Indicators (WDI 2010) database and is available for 1990-2007.

Baseline Scenario: The baseline has no projections of these variables.

Mitigation Scenario: No changes have been made in the Mitigation Scenario. All data and expressions are inherited from the Baseline Scenario.

These variables are not used in LEAP's energy calculations in this data set.

2.1.3 Demand

Current Accounts: Demand data for current accounts was taken from varied sources. Electricity consumption data was provided by sales reports from each electric utility. The source of data for consumption of petroleum products is the Central Bank report on oil imports ("Value of Oil Imports for Local Consumption - Central Bank.pdf"). No local level data sources were found for fuel wood, natural gas or other fuels. Assumptions for each are explained in more detail below.

Electric utilities and oil imports are reported in units of total energy consumption, not energy intensity, which means that the LEAP data set calculates historical energy intensities in each sector for its Current Accounts data. In the household, commercial, industry, hotels and transport sectors these intensities are calculated for the sector as a whole.

All historical demand data can be found in the "Bahamas Consumption History 2000 to 2009.xlsx" spreadsheet.

Energy intensities are calculated using the following formula in each historical year:

EIy = Ey /Ay

Where:
EIy = Final Energy Intensity in year y
Ey = Total Energy in year y
Ay = Total Activity Level in year y.

Different activity levels are used in each sector to calculate energy intensities as shown in Table 1. For example in the industry sector the activity level is specified as the product of GDP and the percentage value added from the industry sector, both of which are stored as data in the Key Assumptions branches. The equation in LEAP is written as:

Key\GDP[Million Bahamian Dollars]*Key\Value Added\Industry[% of GDP]/100

Table 1: Activity Level Drivers Used in the dataset

Sector	Activity Level Variable
Households	Number of Households
Commercial	Commercial Value Added
Industry	Industry Value Added
Hotels	Hotels Value Added
Transport	Transport Value Added

Historical energy consumption data is stored in a user-defined variable (initially defined in the General: User Variables screen) labeled **Total Energy** with units of Millions of British Thermal Units (BTUs). Total energy and fuel share data are extracted from electric utility reports and petroleum imports data from the central bank. Oil import reports did not specify where fuels were used. Please see **Table 2** for a list of assumptions used for this analysis. Total Energy data is stored as the total for all sectors.

Table 2: Assumptions for Petroleum Product Consumption

Assumption	Source
Diesel - 1/8 used for road transport, 7/8 used for electricity generation	2000 GHG inventory assumptions
Kerosene - 1/12 used for local use (households) 7/12 used for air transport	2000 GHG inventory assumptions
LPG/Propane - all used in households	SEI
Residual Fuel Oil - all used for power generation	SEI
Motor Gasoline - all used for transport	SEI
Aviation Gasoline - all used for transport	SEI
Lubricants - all used for transport	SEI

In addition to total energy consumption, LEAP also stores data on the fuel shares (% shares of BTU) for each fuel consumed within these sectors. Fuel share data is also derived directly from electric utility reports and petroleum import records.

Energy intensities are simply calculated as the total energy consumption divided by total activity level for each sector using the following type of equation in LEAP:

Final Energy Intensity = Total Energy [Million BTU]/ Total Activity

NB: All electricity energy intensities are multiplied by the electricity correction factor, explained in the key assumptions section.

Baseline Scenario: In the baseline scenario, the Total Energy variable is not used. Instead we have made separate projections of the activity level, energy intensity and fuel share variables and LEAP will then automatically use these to calculate the energy consumption for each fuel in each sector in each year of the scenario. This calculation is shown below.

$FC_y = A_y * EI_y$

Where:
FC_y = Final Energy Consumption in year y.
Ay = Total Activity Level in year y.

EIy = Final Energy Intensity in year y

The changes in the baseline scenario Activity Level is defined in the respective key assumptions branch. For example, the formula for the activity level variable at the Households demand branch has no new equation for the total number of households, but growth can be seen under the Key Assumptions\Households branch.

In the households, commercial and transport sectors we have assumed the historical growth rate for final energy intensity over the time period for which there is historical data. In the industry and hotels sectors we assumed zero growth because of a lack of consistent trend in historical data.

In all sectors we have assumed that fuel shares have not changed in the baseline scenario, instead fuel shares remain constant at their 2009 value.

Mitigation Scenario: In the mitigation scenario, energy savings from different policies are modeled for each sector using the total energy variable. As with the Current Accounts historical data, energy intensities are calculated as the total energy divided by the total activity level. In the case of each demand-side mitigation option, an assumption was made about the potential electricity savings in the year 2030 Below is a list of mitigation options, and their respective electricity savings in 2030.

Households - Rooftop Solar Water Heating: Based on Component II of the Fichtner reports, it was assumed that 75 GWh of electric demand could be displaced by rooftop solar hot water heaters by 2030.[42] It was assumed that potential would ramp up gradually from 2010 to 2030.

Households – Solar PV: Fichtner documents that there is a total of 99 GWh of electricity potential from PV generation and that approximately 70% of this capacity lies in household generation.[43] Based on this research, it was assumed that 69.3 GWh of electricity savings could be expected in a mitigation scenario. It was assumed that potential would ramp up gradually from 2010 to 2030.

Households, Commercial, Industry, Hotels – Energy Efficiency: Component II of the Fichtner reports proposes that a combination of energy efficiency measures can yield 15% electricity savings by 2020 and 30% savings by 2030.[44] For the purposes of this mitigation scenario it was assumed that efficiency measures could reduce baseline electricity demands by 15% in 2020 and by 30% in 2030. This mitigation potential was assumed to ramp up gradually starting in 2010.

No transport mitigation measures were modeled due to a lack of data.

2.1.4 Transformation

Transmission and Distribution

Current Accounts: Electric transmission and distribution losses are assumed based GBPC system losses provided in the “GBPC SYSTEM LOSSES 03-10.ppt” document.

Baseline Scenario: The baseline assumes no change in electricity losses after 2009. This assumes T&D losses of 9.5% over the period of 2010 to 2030.

Mitigation Scenario: No changes have been made in the Mitigation Scenario. All data and expressions are inherited from the Baseline Scenario.

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[42] Fichtner, Explore Alternatives for BEC’s Expansion Plan, Preliminary Report II, Strengthening the Energy Sector in The Bahamas, September 2010. P. 4-1.
[43] Ibid. P. 4-1, 4-11.
[44] Ibid. P. 4-9.

Electricity Generation

The current representation of the electric generation module is based on electric utility capacity data that is dispatched in proportion to the available capacity. Electricity generation looks at five technologies based on the data provided by the BEC and GBPC utilities. Those technologies are as follows:

Diesel Steam Turbine, using no.2 diesel oil;

Diesel Gas Combustion Turbine, using no.2 diesel oil;

Diesel Gas Combined Cycle, using no.2 diesel oil;

Diesel Medium Speed Alternator, using no.2 diesel oil; and

Residual Fuel Oil Slow Speed Alternator, using no. 6 heavy fuel oil (or residual fuel oil, RFO).

In the mitigation scenario, new technologies are also considered. Those technologies are as follows:

Biomass;

Waste to Energy;

Solar PV;

Onshore Wind; and

Ocean Thermal Energy Conversion (OTEC).

Historical Generation data has been pieced together from both electric utilities. The final spreadsheet used for LEAP inputs is titled "Historical Generation Data.xlsx" which logged inputs from many individual source files, all documented in the previously mentioned file. To keep the file size down, none of the smaller files have been included in this analysis. A few things to note:

- BEC was unable to provide data for years 2000, 2001 and 2003. For the purposes of this analysis, historical generation from year 2003 was interpolated as the average of generation in 2002 and 2004. Data for years 2000 and 2001 were extrapolated assuming generation was proportional to electric consumption in those years.
- GBPC was unable to provide complete data for the year 2005. This data was interpolated as the average of generation in years 2004 and 2006.
- GBPC data was compiled from three separate utility sources, which may provide for inconsistencies. Data from 2000 to 2003 was taken from PRDREP reports, 2004 data was taken from the 2004 Production Report and 2006-2009 data was taken from the GADS database.
- The historical generation variable is only used in the current accounts scenario. Electricity generation starting in 2010 is calculated based on the variables below.

This variable is not used in baseline or mitigation scenarios.

Exogenous Capacity: Known current and future capacity was compiled both for GBPC and BEC through direct communication with Ms. Chantel Nesbit, Mr. Robert Hall and annual utility information. The final spreadsheet of input information to LEAP is "Electric Capacity Expansion import.xlsx."

Current Accounts: Current capacity was compiled for year 2009 with additional information from the following files:

Historical Capacity from GBPC : "Generator Name Plate – Rev 2.pptx"

Historical Capacity from BEC: "BEC Bahamas Generation Data.xls"

Baseline: Future additions and retirements from GBPC were assumed based on direct communication with Ms. Chantel Nesbit. Future additions for all of The Bahamas were assumed based on the following Ficthner Report: “Strengthening the Energy Sector in The Bahamas, Component II: Explore Alternatives for BEC's Expansion Plan.”

Mitigation: Component II of the Fichtner reports includes 2 mitigation scenarios. The mitigation scenario in LEAP is adapted from the second option from Fichtner – a plan including both energy efficiency and renewable energy supply options.[45] Fichtner provides a capacity expansion plan for this scenario for BEC only, which is used as a basis for the exogenous capacity variable in the mitigation scenario.[46] To supplement this plan, the following were also assumed:

- All Family Island and GBEC baseline plans remain the same in the mitigation scenario;
- 17MW of Solar PV capacity is achieved by 2030 at a rate of 1MW/year starting in year 2014;
- 20MW of Wind capacity is built in 2015;
- 60MW of Biomass capacity is added to the system. 20 MW are added in 2015, 20MW in 2020 and 20MW in 2025; and
- Refurbished thermal power plants were not modeled in LEAP as assumptions were not available to quantify those improvements.

The above assumptions ensure that the scenario is able to achieve 15% and 30% renewable generation by 2015 and 2030, respectively. These assumptions are documented further in the file “Electric Capacity Expansion import (w mitigation).xlsx.”

Endogenous Capacity: This is capacity added to meet a planning reserve margin in addition to capacity specified under the exogenous capacity variable. Neither the baseline nor the mitigation scenario requires any additional capacity to meet demand.

Dispatch Rules: Dispatch rules are only used in scenarios.

Current Accounts: In all historical years, power is dispatched according to the historical generation variable.

Baseline: All technologies are dispatched in proportion to available capacity. With this rule, processes are dispatched to try and meet electricity requirements. If the available capacity exceeds the amount needed to meet requirements, then each process will be dispatched in proportion to its available capacity (Capacity * Maximum Availability). For example, if two plants are defined and one is rated at twice the available capacity of the other, then they will run to produce outputs in a ratio of 2:1.

Please note that this assumption about dispatch causes a discrepancy in generation from residual fuel oil alternators between the years 2009 and 2010. For transparency of modeling approach, it was decided to dispatch in proportion to available capacity. The discrepancy represents that in historical years residual fuel oil alternators were dispatched at a higher rate than other technologies.

Mitigation: All thermal generation is dispatched in proportion to available capacity, the same as in the baseline scenario. New renewable generation is assumed to run to full capacity.

Maximum Availability values for thermal generation were taken from values provided by Mr. Robert Hall at BEC in the spreadsheet “Power Plant Availability BEC.xls” with the exception of the diesel steam turbine generator. Steam turbine availability was calculated from the GBPC GADS database spreadsheet "GenSummary2006-2010.xls" as an average of the two steam turbine units over the time period of 2006 to 2009. Steam turbine availability was calculated as follows:

Annual Availability [%] = Available Service Hours [hrs] / 8760 [hrs/yr] *100

[45] Fichtner, Explore Alternatives for BEC’s Expansion Plan, Preliminary Report II, Strengthening the Energy Sector in The Bahamas, September 2010. P. 4-7.
[46] Ibid. P. A-6, oil at $100/barrel.

Availability values for renewable generation were calculated based on available hours when given by Fichtner[47], and assumed based on SEI expertise when no data was available.

Table 3: Electric Generator Availability Assumptions

Technology	Availability [%]
Diesel Gas Turbine	90.4
Diesel Gas Combined Cycle	94.1
Diesel Gas Alternator Med Speed	86.2
RFO Alternator Slow Speed	78.9
Diesel Steam Turbine	63.2
Biomass	80.0
Waste to Energy	85.6
Solar PV	25.0
Wind	25.0
OTEC	80.0

No changes in availability were assumed for the baseline or mitigation scenarios. Note that performance parameters are included in current accounts for mitigation technologies. This does not mean that those technologies generate electricity in historical years or the baseline scenario.

Efficiency values for thermal generation were taken from values provided by Mr. Robert Hall at BEC in the spreadsheet “Power Plant Efficiency BEC.xls” with the exception of the diesel steam turbine generator. Steam turbine efficiency was calculated using the average monthly heat rates provided in PRDREP reports from GBPC.

Process Efficiency [%] = Conversion [3412 btu/kWh]/ Heat Rate [btu/kWh]

Renewable generation efficiencies were assumed based on SEI expertise.

[47] Fichtner, Explore Alternatives for BEC’s Expansion Plan, Preliminary Report II, Strengthening the Energy Sector in The Bahamas, September 2010. P. 4-9 – 4-10.

Table 4: Electric Generator Efficiency Assumptions

Technology	Efficiency [%]
Diesel Gas Turbine	25.6
Diesel Gas Combined Cycle	30.9
Diesel Gas Alternator Med Speed	33.2
RFO Alternator Slow Speed	39.5
Diesel Steam Turbine	21.4
Biomass	35.0
Waste to Energy	35.0
Solar PV	100.0
Wind	100.0
OTEC	35.0

No changes in efficiency were assumed for the baseline scenario.

Capacity Credit values represent the amount of rated capacity that contributes towards the reserve margin. This is an indicator of intermittent renewables and therefore only has significance for Wind and Solar PV in the mitigation scenario. All other technologies are assumed to have a capacity credit of 100%. Values in the mitigation scenario are listed below and are based on SEI expertise.

Table 5: Intermittent Electric Generator Capacity Credit Assumptions

Technology	Capacity Credit[%]
Solar PV	35.0
Wind	35.0

2.1.5 Resources

This model does not include a resource analysis.

2.1.6 Non-Energy Sector

The non-energy sector modeling is very simple. Data was provided for the following areas based on past Bahamian GHG inventories:

- Land Use Change and Forestry;
  - changes in forest and biomass stocks; and
  - abandonment of managed lands;

- Industrial Processes;
    - road surface paving;
- Agriculture;
    - enteric fermentation and manure management;
- Waste;
    - wastewater; and
    - sewage.

Current Accounts: Non-energy sector data was used from past Bahamian GHG inventories from IPCC spreadsheets. Data points were used from 1990, 1994 and 2000 and interpolated to provide data from 1990-2000.

Baseline Scenario: The baseline scenario assumes no change in the year 2000 values.

Mitigation Scenario: No changes have been made in the Mitigation Scenario. All data and expressions are inherited from the Baseline Scenario.

ANNEX III: COMPLETE LIST OF POLICY TARGETS AND OBJECTIVES

3.1 Policy Targets and Objectives

Short term Targets (1-5 years)[48]

- Complete data gap analysis;
- Complete phase-out of incandescent light bulbs and their replacement with reduced mercury compact fluorescent light bulbs (CFL);
- Investigate and implement waste-to-energy technology for New Providence;
- Investigate combined head and power and cogeneration technologies;
- Explore use of biofuels;
- Develop a common basis to measure and compare the average annual unit cost of each form of energy consumed by sector and geographic area ($/gallon, $/kWh, $/bbl);
- Develop a means to measure and track the annual national energy bill and the impact on the economy;
- Develop a regulatory framework to monitor and assess fossil fuel leakage, reduce losses of imported products and conserve resources of products imported for domestic consumption;
- Develop a means to measure the economic impact of the annual national expenditure on fossil sources of energy;;
- Initiate public buildings energy usage reduction strategies;
- Explore interconnections between islands to enhance efficiency and promote the potential for renewable energy;
- Assess the Commonwealth's wind potential as well as identify potential sites for pilot and or demonstration facilities;
- Assess the feasibility of compressed natural gas as a fuel source in The Bahamas;
- Develop a means to measure the economic impact of the annual national expenditure on renewable sources of energy; and
- Initiate energy efficiency activities in public and private utilities.

Medium-Term Targets (5-10 years)

- Increase the penetration of renewable energy sources in the Commonwealth to 15% of supplies;
- Deploy renewable energy technologies in several small communities, aiming towards >50% of power from renewable sources;
- Reduce dependence on imported fuel oils by: -
    - Increased building energy efficiency by introducing standards in public buildings for cooling public spaces, heating water, lighting and the deployment of the highest energy star ratings of equipment;
    - Increased use of solar hot water systems to 20 to 30% of all households;
    - Increased efficiency of cooling systems and increasing seasonal energy efficiency ratings (SEER);
    - Increased deployment and usage of energy efficient lighting systems and fenestration systems (windows) in public buildings;
    - Increased public awareness and education on renewable energy potential and usage; and
    - New requirements for all government financed homes and buildings to use, install, operate and maintain solar water systems;
- Develop pilot and demonstration systems for residential cooling using reverse thermal gradient in low cost housing estates;
- Initiate a pilot demonstration project for ocean thermal energy conversion potential starting with taking measurements at Clifton, New Providence and North Eleuthera;
- Assess wave and tide potential of The Bahamas, as well as, identify potential sites for pilot or demonstration facilities;
- Develop a means to estimate the average annual unit cost of renewable sources of energy;

[48] NEPC report p.27 (exact text)

- Develop filters to achieve the optimum level of local participation in any energy entity that should be pursued during a period of ownership transition.

Long-Term Targets (10-20 years)

- All installations of water heaters are solar water heaters
- Develop a programme to pursue cost-effective opportunities in reducing energy consumption
- Develop a programme to minimize greenhouse gas emissions
- Establish a funding mechanism, sources of energy use and constant technology innovations and the engagement of the private sector through private and public partnerships in the expansion, upgrade and renewal of energy services infrastructure; and
- Develop extended targets for changes in the energy mix based on extended unit cost and economic impact estimates by energy source, informed by local experiences and historical data.

Short-Term Objectives

- Energy Conservation
  - Develop and implement a public sector energy conservation programme and marketing campaign. This programme must be an aggressive campaign that includes a comprehensive energy audit of the various government agencies and holdings, with the goal of achieving energy-consumption reduction targets. This programme must be transparent and will require a marketing scheme to promote the programme, to lead both the private sector and the public by example, to encourage and influence private sector participation (starting with government vendors and service providers) and competition;
  - Develop and implement a consumer-oriented energy conservation campaign. Such a campaign should include consumer education on “wise” energy use and conservation (and consequently monetary saving) tips, and an outreach component to advise the public of its role in strengthening national self-sufficiency and energy security. In order to maintain enthusiasm and reinforce the importance of consumer energy conservation, the campaign also requires a marketing component that demonstrates the consumer savings achieved through the various tips promoted in the overall campaign;
  - Develop and execute an implementation strategy for the economic incentives announced in the 2008/09 budget cycle. This includes working with The Bahamas Customs Department to ensure customs officers are able to identify energy saving goods subject to tax-rate reduction or exemption. Consumers should also be advised of these goods. (This may be a component of the consumer-oriented energy conservation campaign).
- Energy production management
  - Review and establish a guideline for independent power producers; and
  - Explore the option of combining heat and power and cogeneration technologies to support the ongoing effort of capacity deferment.
- Assess renewable potential
  - Identify the data gaps, then formulate and implement solutions for closing the gaps and setting realistic targets; and
  - Investigate the potential exploitability of various renewable energy sources and technologies, including waste to energy, wave, tidal, wind, photovoltaic systems and solar water heating units.

Mid-Term Objectives

- Renewable energy implementation plan
  - Develop and implement a renewable energy programme. This programme should encourage the private sector to develop projects to produce electricity using renewable sources (e.g. solar, wind, ocean-thermal) for possible exploitation by The Bahamas Electricity Corporation. The programme can be used to establish targets for renewable electricity sales;
- Energy Commission

    - Establish a permanent energy commission, responsible for overseeing the implementation of select national energy initiatives, stemming from the national energy policy;
- Full data gaps
    - Identify data gaps, and then formulate and implement solutions for closing the gaps and setting realistic targets;
- Develop energy efficiency standards
    - Establish energy efficiency standards (e.g. building standards) for incorporation into the existing regulatory regimes. Stakeholder consultation on the proposed standards should be done, as well as, compliance promotion and enforcement.

Long-Term Objectives

- Reduce the rise in energy consumption and reduce use on a per capita basis
    - Develop and implement a programme to pursue cost-effective opportunities to reduce further energy consumption by various target sectors and individual consumers;
    - Develop and implement a programme to minimize greenhouse gas emissions; and
    - Establish funding mechanisms for identifying, implementing and promoting sustainable energy use and technology innovation that support efforts to achieve the targets outlined in the national energy action plan.

3.2 Transport Sector Policy Agenda

Short-Term Targets

- Introduce an integrated traffic management system and public transport system:
    - Reduce average commute times on New Providence by 20%;
    - Increase ridership of public transport to 10-20%;
    - Employ advanced energy efficient lighting systems in public spaces supported by signage and traffic management systems;
- Conduct a gap analysis to generate consistent datasets;
- Conduct national market and consumer research to secure data on pricing and other socioeconomic and market trends affecting the sector.

Mid-Term Targets

- Increase fuel efficiency for motor vehicles to 30-35 mpg for 70% of licensed vehicles through the application of incentives to import and use more efficient vehicles in private and public sector transport.

Short-Term Objectives

- Complete a study of the sector energy demand and consumption:
    - Identify the data gaps, and then formulate and implement solutions for closing the gaps and setting realistic targets; and
    - Investigate the potential exploitability of various options for improving the sector.

Mid-Term Objectives

- Fuel economy transport
    - Develop and implement a programme to increase the average fuel economy of vehicles. This program could include periodic vehicle emission testing as a part of the vehicle registration process, a ban on the import of vehicles older than five years, or improved enforcement of road traffic and safety legislation;
    - Improve the quality of diesel oils imported for local consumption to reduce particulate emissions in order to improve air quality in urban centers; and

- Develop and implement a national strategy for integrated traffic and transportation system management.

The Commonwealth Of The Bahamas