Third National Communication (TNC) of The Commonwealth of The Bahamas to the United Nations Framework Convention on Climate Change (UNFCCC)

March 2024

The Commonwealth of The Bahamas'

Third National Communication (TNC)

in fulfilment of its commitment under the

United Nations Framework Convention on Climate Change (UNFCCC)

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The climate crisis is an enormous threat to The Bahamas and other vulnerable Small Island Developing States (SIDS). If global emissions are not slowed, our country and many other nations will look different from the country we love today. Rising seas levels will cause our islands and other SIDS to disappear, drought will impact our food security, and warmer waters are likely to bring more catastrophic storms like Hurricane Dorian.

The Bahamas contributes less than 0.01% of global greenhouse gas (GHG) emissions, and despite this minimal contribution, our country has prioritized providing the domestic and international community with the required reports highlighted in the Paris Agreement, that adhere to TACCC principles, in an effort to demonstrate leadership and commitment to action to combat this global issue.

The realities of war, economic headwinds, the hangover from the pandemic, and competition among world powers, cannot be used as justification not to confront the imminent danger of the climate crisis.

At COP27, The Bahamas called on other nations to get real about tackling the climate crisis. We are not sitting still. The Bahamas has committed to the implementation of 41 mitigation actions, to achieve an economy-wide reduction of GHG emissions of 30% when compared to Business as Usual (BAU) by 2030. This is mirrored across our TNC, BUR1 and updated NDC. These actions will improve the lives and livelihoods of Bahamians. And we will continue our drive for innovation and ingenuity.

And while we continue to do our part to reduce GHG emissions, our country has growing adaptation financing needs. Climate change is not pausing its impacts on our nation's Agriculture, Natural Resources, Energy, Human Health, Human Settlements and Infrastructure, Tourism, Transport, Water Resources, and Disaster Management sectors. We need climate finance to flow now.

Our needs are clear. Review this TNC. And whoever you are, wherever you are, bring your climate solutions to The Bahamas. Help us convert our front-line vulnerabilities into cutting-edge solutions for all!

Hon. Philip Edward Davis, K.C., M.P,
Prime Minister and Minister of Finance
Commonwealth of The Bahamas

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Acronyms/Abbreviations

5Cs	Caribbean Community Climate Change Centre
AD	Activity Data
AFD	Agence Française de Développement
AFLOU	Agriculture, Forestry and Other Land Use
AGRRA	Atlantic and Gulf Rapid Reef Assessment
AIMS	Atlantic, Indian Ocean, Mediterranean, and South China Sea Region
AR5	IPCC Fifth Assessment Report
AWOS	Automatic Weather Observing Stations
BAHFSA	Bahamas Agricultural Health and Food Safety Authority
BAMSI	Bahamas Agriculture & Marine Science Institute
BAU	Business as Usual
BBSQ	Bahamas Bureau of Standards and Quality
BCCEC	Bahamas Chamber of Commerce & Employers Confederation
BDB	Bahamas Development Bank
BEST	Bahamas Environment Science and Technology Commission
BDM	Bahamas Department of Meteorology
BHTA	Bahamas Hotel and Tourism Association
BIS	Bahamas Information Services
BMA	Bahamas Maritime Authority
BNSI	Bahamas National Statistical Institute (formerly the Department of Statistics)
BNT	Bahamas National Trust
BPL	Bahamas Power and Light Company Limited
BPAF	Bahamas Protected Area Fund
BREEF	Bahamas Reef Environment Educational Foundation
BSD	Bahamian Dollar
BTR	Biennial Transparency Report
BTVI	Bahamas Technical and Vocational Institute
BUR1	First Biennial Update Report
C2EAU	Climate Change and Environmental Advisory Unit

CAAB	Civil Aviation Authority Bahamas
CCARRC	Climate Change Adaptation and Resilience Research Centre
CARES	Community and Renewable Energy Scheme
CARICOM	Caribbean Community
CARIFORUM	Caribbean Forum
CBB	Central Bank of The Bahamas
CBD	Convention of Biological Diversity
CCA	Climate Change Adaptation
CCARR	Climate Change Adaptation and Resilience Research Centre (University of The Bahamas)
CCCCCC	Caribbean Community Climate Change Centre
CCI	Caribbean Challenge Initiative
CCREEE	Caribbean Community for Renewable Energy and Energy Efficiency
CCRIF	Caribbean Catastrophe Risk Insurance Facility
CCT	Conditional Cash Transfer
CDEMA	Caribbean Disaster Emergency Management Agency
CDKN	Climate and Development Knowledge Network
CEOS	Committee on Earth Observation Satellites
CDB	Caribbean Development Bank
CFL	Compact Fluorescent Light
CGMS	Coordination Group for Meteorological Satellites
CMIP	Coupled Model Intercomparison Project
COP	Conference of the Parties
CORDEX	Coordinated Regional Climate Downscaling Experiment
COVID-19	Coronavirus disease of 2019
CREWS	Climate Risk Early Warning System
CRF	Common Reporting Format
CTF	Common Tabular Format
DDS	Decision Support System
DEHS	Department of Environmental Health Services

DEPP	Department of Environmental Planning & Protection (formerly the BEST Commission)
DFID	United Kingdom's Department for International Development
DMR	Department of Marine Resources
DOA	Department of Agriculture
DRA	Disaster Reconstruction Authority
DRM	Disaster Risk Management
DRMSIS	Disaster Risk Management Support Information System
DRR	Disaster Risk Reduction
ECVs	Essential Climate Variables
ECLAC	Economic Commission for Latin America and the Caribbean
EB	Energy Balance
EE	Energy Efficiency
EEMO	Energy Efficiency Management Office
EF	Emission Factor
EIA	Environmental Impact Assessment
EIB	European Investment Bank
ENSO	El Niño Southern Oscillation
ESCO	Energy Service Company
EST	Environmentally Sound Technologies
ETPA	Education, Training & Public Awareness
EU	European Union
EV	Electric Vehicle
EWS	Early Warning System
FAO	Food and Agriculture Organization of the United Nations
FNC	First National Communication
FOCOL	Freeport Oil Company/Sun Oil Limited
GBON	Global Basic Observing Network
GBPA	Grand Bahama Port Authority
GBPC	Grand Bahama Power Company
GCF	Green Climate Fund

GCOS	Global Climate Observing System
GDP	Gross Domestic Product
GEF	Global Environment Facility
GFDRR	Global Facility for Disaster Reduction and Recovery
GOB	Government of The Bahamas
GHG	Greenhouse Gas
GHGI	Greenhouse Gas Inventory
GHGMI	Greenhouse Gas Management Institute
GIZ	German Development Agency
GOOS	Global Ocean Observing System
GPI	Genuine Progress Indicator
GRB	Gender Responsive Budgeting
GWP	Global Warming Potential
IAI	Inter-American Institute for Global Change Research
IAMC	Integrated Assessment Modelling Consortium
IBC	International Business Companies
ICA	International Consultation and Analysis
ICZM	Integrated Coastal Zone Management
IDB	Inter-American Development Bank
IE	Included Elsewhere
IFAD	International Fund for Agricultural Development
IFC	International Finance Corporation
IFRC	International Federation of Red Cross and Red Crescent Societies
IICA	Inter-American Institute for Cooperation on Agriculture
IMO	International Maritime Organisation
INDC	Intended Nationally Determined Contribution
IOC	Intergovernmental Oceanographic Commission
IPCC	Inter-governmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
ISPS	International Ship and Port Facility Security
IUCN	International Union for Conservation of Nature (IUCN)

JICA	Japanese International Cooperation Agency
KBA	Key Bird Area
KCA	Key Category Analysis
KfW	German Development Bank
KPI	Key Performance Indicator
LAC	Latin America and Caribbean
LEAP	Low Emissions Analysis Platform
LED	Light-emitting diode
LEDS GP	Low Emission Development Strategies Global Partnership
LID	Low Impact Development
LPG	Liquefied petroleum gas
LULUCF	Land Use Land Use Change and Forestry
MAR	Managed Aquifer Recharge
MEAs	Multilateral Environmental Agreements
MOEH	Ministry of Environment & Housing
MOHW	Ministry of Health and Wellness
MOT	Ministry of Tourism
MOWU	Ministry of Works and Utilities
MPG	Modalities, Procedures and Guidelines
MRV	Measurement, Reporting and Verification
MRV Hub	Caribbean Cooperative MRV Hub
MSW	Municipal Solid Waste
NA	Not Applicable
NBSAP	National Biodiversity Strategy and Action Plan
NC	National Communication
NCV	Net Calorific Value
NCCC	National Climate Change Committee
NDC	Nationally Determined Contributions
NDP	National Development Plan
NE	Not Estimate
NEA	National Executing Agency

NEMA	National Emergency Management Agency
NGO	Non-Governmental Organization
NHI	National Health Insurance
NHSSP	National Health System Strategic Plan
NO	Not Occurring
NOAA	National Oceanic Atmospheric Administration
NPAC	National Project Advisory Committee
NPEP	New Providence Ecology Park
NPC	National Project Coordinator
NREL	National Renewable Energy Laboratory
OAS	Organization of American States
OLADE	Latin American Energy Organisation
OPM	Office of the Prime Minister
OTEC	Ocean Thermal Energy Conversion
PAHO	Pan American Health Organization
PEO	Public Education & Outreach
PM	Project Manager
PMU	Project Management Unit
POGO	Partnership for Observation of the Global Ocean
PV	Photovoltaic
QA	Quality Assurance
QC	Quality Control
RCP	Representative Concentration Pathways
RE	Renewable Energy
REDD-plus	Reducing Emissions from Deforestation and Forest Degradation plus enhancing forest carbon stocks
RER	Renewable Energy Rider
RET	Renewable Energy Technologies
RSO	Research and Systematic Observation
SASS	Smart and Strong Sisterhood
SEEA	System of Environmental Economic Accounting

SDG	Sustainable Development Goal
SDSS	Spatial decision support system
SEV	SEV Consulting Group
SGP	Small Grants Programme
SIDS	Small Island Developing States
SLOSH	Sea, lake and overland surges from hurricanes
SLR	Sea Level Rise
SMART	Specific, Measurable, Achievable, Relevant, Time-bound
SNC	Second National Communication
SOFF	Systematic Observations Financing Facility
SSP	Shared Socioeconomic Pathways
STeP	Science, Technology and Policy
SWH	Solar water heaters
TEG	Technical Expert Group
TNA	Technology Needs Assessment
TNC	Third National Communication
TOR	Terms of Reference
TOU	Time-of-use
UB	University of The Bahamas
UCL	University College London
UN	United Nations
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
UNITAR	United Nations Institute for Training and Research
UNWTO	World Tourism Organization
URCA	Utilities Regulation and Competition Authority

USAID	United States Agency for International Development
USD	United States Dollar
V&A	Vulnerability and Adaptation
VAT	Value Added Tax
WB	World Bank
WCRP	World Climate Research Program
WG Climate	Joint Working Group on Climate
WIGOS	WMO Integrated Global Observing System
WHO	World Health Organization
WMO	World Meteorological Organization
WSC	Water & Sewerage Corporation
YME	Young Marine Explorers

Units and Chemical Elements

Units

g	Gram
Gg	Gigagram
ha	Hectare
kg	Kilogram
km	Kilometre
km^2	Square Kilometre
kW	Kilowatt
kWh	Kilowatt-hour
m^2	Square metre
MW	Megawatt
MWh	Megawatt-hour
t	Tonne
TJ	Terajoule
W	Watt

Chemicals/Chemical Related Terms

BOD	Biological Oxygen Demand
CH_4	Methane
CO_2	Carbon dioxide
CO_2–eq	Carbon dioxide equivalent
EF	Emission Factor
HFCs	Hydrofluorocarbons
MCF	Methane correction factor
N_2O	Nitrous oxide
PFCs	Perfluorocarbons
SF_6	Sulphur hexafluoride

Executive Summary

a) National Circumstances

According to the Intergovernmental Panel on Climate Change (IPCC), global climate change impacts are evident, particularly for Small Island Developing States (SIDS) like The Bahamas, which was ranked third on the Climate Risk Index. Further, the Global Circulation Model (GCM) provides grime projected outlined of The Bahamas' vulnerability to temperature rise, changing precipitation patterns, and increased intensity of tropical storms the country may face throughout its archipelago. To address these concerns, The Bahamas has taken strong national and diplomatic approaches.

Located on the Western North Atlantic, The Bahamas' lowline coastal biogenic limestones rockland and oolitic sand landmass lies less than 1.5 meters above sea level on the Great and Small Bahama Banks. The subtropical summer months usually reach 90 degrees Fahrenheit, and the winter months typically reach 75 degrees Fahrenheit. The Bahamas' dry and wet seasons are distinct, with the seasonal effect of tropical cyclones having a pronounced effect on annual rainfalls across The Bahamas. Consequently, projections show a decline in rainfall in the Southeast Bahamas in contrast to the North and North Central Bahamas. The decreased rainfall, the sole natural means of recharging the aquifers, may affect the country's hydrogeology systems. The Bahamas will face several challenges with respect to its water security due to climate change impact.

The population of The Bahamas was estimated to be approximately 295,000 in 2000, compared comparison to the 2025 projection of 408,930, which is progressing at an annual rate of 0.92%. Most of the infrastructure and settlements of the islands are located along or near the coast, where they are particularly vulnerable to flooding and sea level rise that will have socioeconomic implications for residents and sectors, particularly the tourism sector.

The tourism sector is the primary driver of the Bahamian economy, accounts for approximately 50% of the GDP. Prior to Hurricane Dorian's landfall in 2019, more than

7.2 million visitors visited The Bahamas. Subsequently, due to the devastating impact of Hurricane Dorian on the islands of Grand Bahama and Abaco, along with the global onset of COVID-19, The Bahamas experienced a significant decline of 75% in 2020 in stopover visitors.

The energy sector of The Bahamas is heavily dependent on fossil fuels. The dependency on imported oil, almost 100%, has made energy production in The Bahamas vulnerable to global oil price fluctuations. The electricity and transport sectors are the country's primary users of fossil fuels. To address these concerns, the Government of The Bahamas has established and implemented The Bahamas National Energy Policy 2013 – 2033, which aims to achieve a diversified efficient energy sector, affordable energy supplies, and long-term energy security. In addition, The Bahamas' Government established the Ragged Island Microgrid and the Solar Car Park and is embarking on further efforts to expand renewable energy generation and electric vehicle utilization across the archipelago.

Water resources within The Bahamas vary between islands, and the supply-demand balance is highly dependent on population density. Having the highest population density, the island of New Providence has far less aquifer capacity and faces challenges with water quality and water resources. The water sector is identified as a national priority for climate change adaptation in the first and updated Nationally Determined Contribution (NDC).

Agriculture and fisheries are vital to The Bahamas Family Islands' socioeconomic security. The Agricultural sector land use is classified as arable land, permanent corps, permanent pasture, forestry, and others. Approximately 90% of the available agricultural land is owned by the government and leased to farmers. Major crops for export are grapefruit, limes, avocados, papaya, okras, and pineapples. Moreover, the fisheries sector contributes approximately US$80 million in foreign currency annually in export earnings. It provides full-time employment to 9,300 commercial fishers and thousands more jobs in recreational fisheries, vessel maintenance, fish processing, retail, and trade.

The Bahamas' financial sector accounts for about 15% of the GDP that consists of commercial banks, savings banks, trust companies, offshore banks, insurance companies, a development bank, a publicly controlled pension fund, a housing corporation, a public savings bank, private pension funds, cooperative societies and credit unions, including international business companies (IBC), mutual funds, and insurances services.

Generating more than 264,000 tons of municipal solid waste annually, the management of solid waste disposal varies throughout The Bahamas archipelago. Most Family Islands' solid waste disposal processes are underdeveloped compared to New Providence's solid waste and landfill management system carried out by the New Providence Ecology Park (NPEP). Notwithstanding, in 2011, The Bahamas established its first biodiesel production facility, Bahamas Waste Limited. The facility has the capacity to convert up to one million gallons of waste cooking oil into biodiesel. Currently, the facility is using a 50:50 blend of biodiesel to petroleum diesel in four vehicles in hopes of running its entire fleet on 100% biodiesel as production increases.

The Public Hospitals Authority oversees the quality of the three public hospitals in The Bahama. In contrast, the National Health Insurance (NHI) offers Bahamian residents access to primary health care, free at the point of service. Making a conscious effort to improve its healthcare system, the Government invested around 8% of its GDP into health care in 2018. In addition to improving the health care system and addressing climate change impact, the Government executed the "Developing a Climate Resilient Health System in The Bahamas" and the "EU/CARIFORUM Climate Change and Health Project".

Over the last decade, The Bahamas have experienced a significant impact in the form of frequent natural disasters. For example, in 2015, The Bahamas experienced Hurricane Joaquin, followed by Hurricane Matthew in 2016; the preceding year, the country experienced Hurricane Maria and Irma. In 2019, Hurricane Dorian (a Category 5 Hurricane) caused significant loss of life, evacuation of affected islands, climate migration, and damage to infrastructure and the economy, estimated to have caused over US$ 3 billion in loss and damages. The Internal Displacement Monitoring Centre (2020) estimated that 9,840 people were displaced due to Hurricane Dorian. Most persons displaced were from the islands of Abaco and Grand Bahama.

Initial discussions about institutional arrangements were held during a stakeholder workshop for the Project Identification Plan phase for the development of The Bahamas' First Biennial Update Report (BUR1). Through the development of the BUR1, these discussions have been further refined.

The BUR1 development was led by the Department of Environmental Planning and Protection (DEPP) and the National Climate Change Committee (NCCC). The Project Manager is a staff member of The Climate Change & Environmental Advisory Unit (CCEAU), a technical advisory arm of the Office of the Prime Minister (OPM). Consultants were engaged to complete the various chapters of the BUR1. And all chapter drafts were reviewed by the project team members and the NCCC. The NCCC members have also supported the process by providing information and data from their respective organizations and ensuring the chapters accurately reflect circumstances in The Bahamas and future plans for addressing climate change.

The following technical group was established to address future National Communications (NC) and other reports to the UNFCCC: Greenhouse Gas Inventory, Vulnerability & Adaptation Assessment, Mitigation Analysis, Environmentally Sound Technologies, Research & Systematic Observations, Education-Training & Public Awareness, Information & Networking Capacity-building.

b) National Greenhouse Gas (GHG) Inventories Summary

i) GHG inventory scope and approach

This chapter presents The Bahamas's national GHG inventory for the years 2001-2018, prepared in line with the IPCC 2006 Guidelines for national GHG inventories. The inventory scope covers the geographical borders of The Bahamas. Gases covered are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). While it is assumed that emissions from hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) are at least likely to occur, the necessary data to perform estimates for these gases were not available. The Bahamas intends to move towards covering these gases in future GHG inventory submissions.

The Global Warming Potential (GWP) values from the IPCC's 5th Assessment report[1] were used (see Table 1).

Table 1: Global warming potentials used

Gas	GWP
CO_2	1
CH_4 (biogenic origin)	28
CH_4 (fossil origin)	30
N_2O	265

ii) GHG inventory preparation

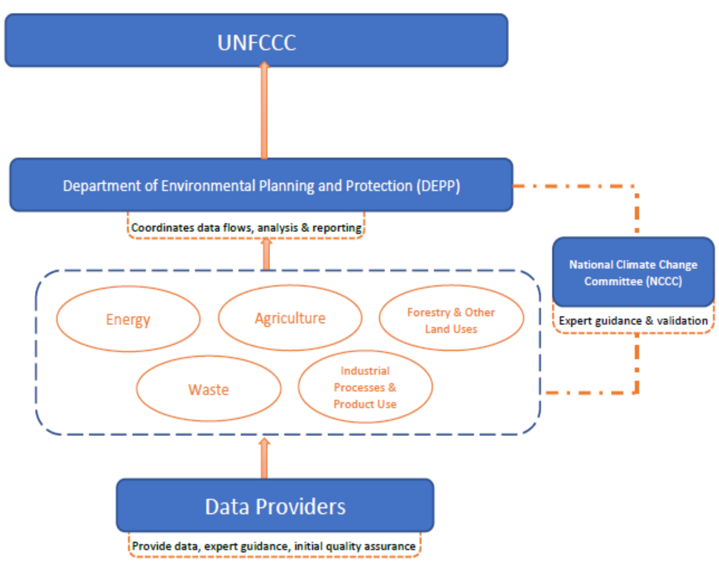
At present, The Bahamas National Climate Change Committee (NCCC) provides strategic level guidance on climate change related activities, policies, and plans, including the preparation of National Communications (NC), Biennial Update Reports (BUR),

[1] See Table 8.A.1, WG III, Chapter 8. Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestvedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura and H. Zhang, 2013: Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

National Greenhouse Gas Inventory Reports (NIR), among others. The NCCC is chaired and led by the Department of Environmental Planning and Protection (DEPP) (formerly BEST Commission) and consists of representatives from the government, private sector, non-governmental agencies and academic institutions.

The DEPP, apart from its role as the chair of the NCCC, is also the UNFCCC and Global Environmental Facility (GEF) operational focal point, and coordinates the preparation and presentation of all reporting requirements to the UNFCCC. The technical aspects of the preparation of this NIR were led by regional consultants in a collaborative fashion with national experts with an aim to build national capacity. This included both GHG inventory data collection, estimation, compilation, and quality control and assurance throughout the inventory compilation period. The institutions and roles of these actors involved are described in "Annex II - Institutions and Roles of those involved in the Preparation of The Bahamas' NIR". An illustration of these roles is shown below in Figure 1.

Figure 1: Institutional arrangements for the national GHG inventory preparation



iii) Quality assurance and quality control

The following quality control steps were undertaken initially by the inventory compiler, and secondarily internally reviewed by the Caribbean Cooperative MRV Hub GHG accounting experts not involved in the preparation of the NIR as a quality control check for each sector inventory. These quality control steps include:

- Check that assumptions and criteria for the selection of activity data and emission factors are documented.
- Check for transcription errors in data input and reference.
- Check for correct calculation of emissions and removals that utilize appropriate equations and steps based on the methods used.
- Check that parameters and emission and removal units are correctly recorded and that appropriate conversion factors are used.
- Check that estimates are complete, that all categories and all years from the base year (2001) to the current inventory year (2018).

In terms of quality assurance, national sector experts were involved in data collection and understanding sector specific assumptions for methods. Other line Ministry representatives and experts from non-governmental organizations and academia reviewed emissions estimates and methodological assumptions. Additional quality assurance reviews were performed by regional GHG Inventory experts who were not involved in the compilation of the NIR.

The documentation and archiving of emissions estimates, worksheets, activity data, expert judgement, and assumptions was completed by the inventory compilers, and shared with DEPP through a Dropbox folder, organized and used throughout all stages of the GHG inventory cycle. This was done to ensure transparency, national ownership of data and reports, and promote continuity of inventory preparation for subsequent cycles.

The final stage of the inventory preparation cycle included identification and documentation of further improvements. The identified improvements (cross-cutting as well as sectoral) relate to both the emissions inventory data and also the institutional arrangements and are detailed in Annex II. These will be taken into account as the Government of The Bahamas continues to develop its national inventory team and climate measurement, reporting, and verification (MRV) system.

iv) Key Categories

A key category assessment was carried out for The Bahamas' GHG inventory estimates for the time series 2001-2018.[2] Both the level and trend assessments under approach 1 according to Volume 1, Chapter 4 of the IPCC 2006 Guidelines were conducted.

Table 2 below presents the 13 key categories identified and indicates whether they have been identified by the level assessment (L) and/or the trend assessment (T).

The majority of key categories identified, were identified under both level and trend assessment. They include stationary as well as mobile fuel combustion activities in the energy sector, land-based categories in the AFOLU sector (all for CO_2) as well as solid waste disposal (for CH_4).

Table 2: Key categories identified

IPCC Category Code	IPCC Category Name	Gas	Key category related to Level (L) and/or Trend (T)
1.a.1.a.i	Electricity Generation	CO_2	L, T
1.A.2.m	Non-specified Industry	CO_2	L, T
1.A.3.b.i	Cars	CO_2	L, T
1.A.3.b.ii	Light-duty trucks	CO_2	L
1.A.3.b.iii	Heavy-duty trucks and buses	CO_2	L, T
1.A.4.a	Commercial/Institutional	CO_2	L, T

[2] The previous National GHG Inventory of The Bahamas was published as part of The Bahamas' Second National Communication in 2014. This GHG inventory did not include a key category assessment, it is therefore not possible to assess how key categories have changed over time.

3.B.1.a	Forest land Remaining Forest Land	CO_2	L, T
3.B.1.b	Land Converted to Forest Land	CO_2	L, T
3.B.2.b	Land Converted to Cropland	CO_2	L, T
3.B.3.b	Land Converted to Grassland	CO_2	L, T
3.B.4.b	Land Converted to Wetlands	CO_2	L, T
3.B.5.b	Land Converted to Settlements	CO_2	L, T
4.A	Solid Waste Disposal	CH_4	L

v) Source and sink category emission estimates and trends

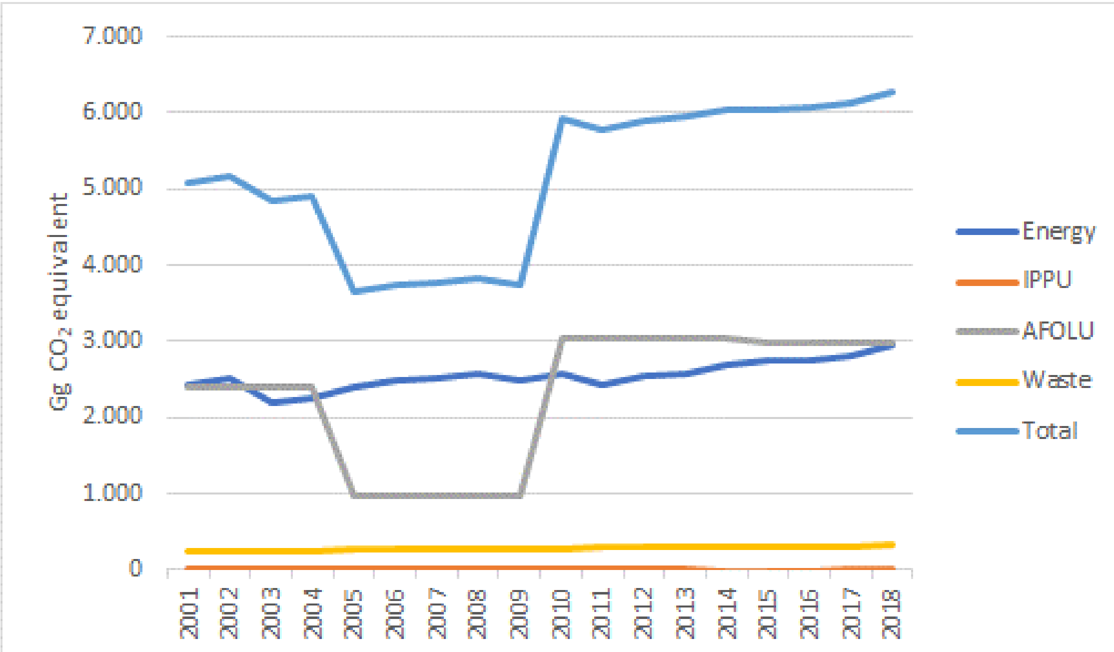
V.I Overview

Total GHG emissions in The Bahamas rose from 5,074.09 Gg CO_2-eq in 2001 to 6,264.39 Gg CO_2-eq in 2018, which equals an increase by 23.5 cent.[3] During the same time period GHG emissions from the waste sector rose by 30.6 per cent, from the AFOLU sector (including both emissions and removals) by 25.1 per cent, and from the energy sector by 21.1 per cent. IPPU sector emissions, to the extent estimated in this GHG inventory publication which covered only lubricant use[4], fell by 71.1 per cent. Total GHG emissions by sector are presented in Figure 2 (below). GHG estimates for 2001-2018 are presented in Table 2 (above). Developments of and drivers for sectoral and category-level trends are presented in the forthcoming sectoral chapters (3.7 - 3.10)

[3] The previous GHG inventory of the BAHAMAs published as part of The Bahamas Second National Communication in 2014 presented GHG emissions for the year 2000, amounting to 702.82 Gg CO_2-eq. when considering the gases CO_2, CH_4 and N_2O. These had been estimated using the IPCC Revised 1996 Guidelines for national GHG inventories and the GWPs from the IPCC's 2nd Assessment Report.

[4] Due to lack of data, GHG emissions from the use of HFCs and PFCs and of other potentially relevant sources could not be estimated. More information is provided in section 2 of this report.

Figure 2: Total GHG emissions by sector 2001-2018



The AFOLU and energy sectors dominate total national GHG emissions in The Bahamas, contributing 47.8 per cent and 47.1 per cent, respectively, to total emissions in 2018. The waste sector contributes 5.1 per cent and the IPPU sector was less than 0.1 per cent during the same year (see Figure 3 below).

Total CO_2 emissions amounted to 5909.18 Gg in 2018, representing 94.3 per cent of total GHG emissions. CH_4 amounted to 11.68 Gg in 2018, representing 5.2 per cent of the total and N2O to 0.12 Gg in 2018, representing 0.5 per cent of the total (see Figure 4 below).

Likely drivers to The Bahamas' GHG inventory emissions are the population and economic development. The increase in tourism has likely lead to an increase in demand on fuel and transportation, thus affecting energy sector emissions. GDP has increased by 56 per cent since 2001, the population by 27 per cent (see Figure 5 below).

Figure 3: Percent contribution of IPCC sectors to total GHG emissions in 2018

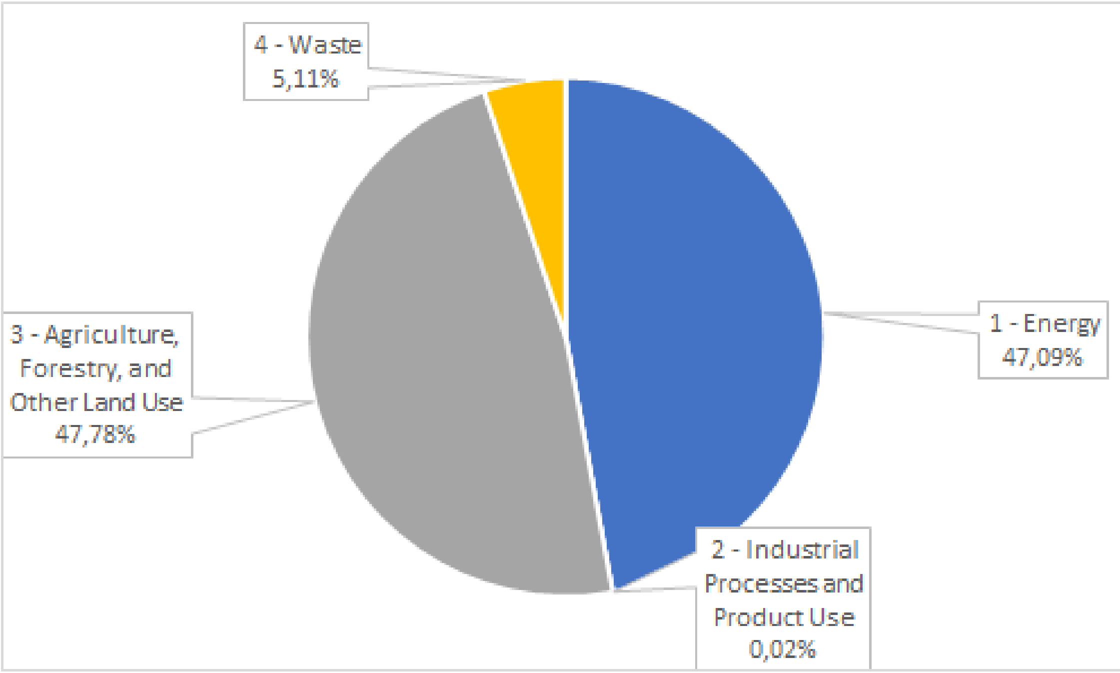


Figure 4: Contribution of gases to total GHG emissions in 2018

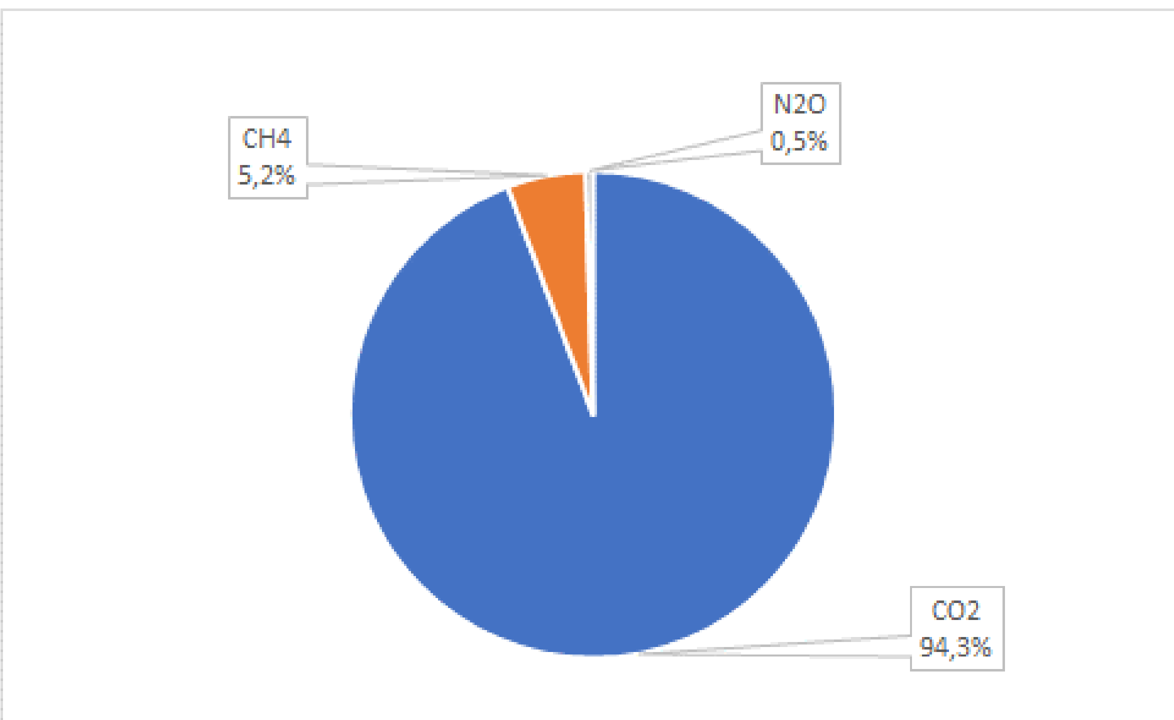
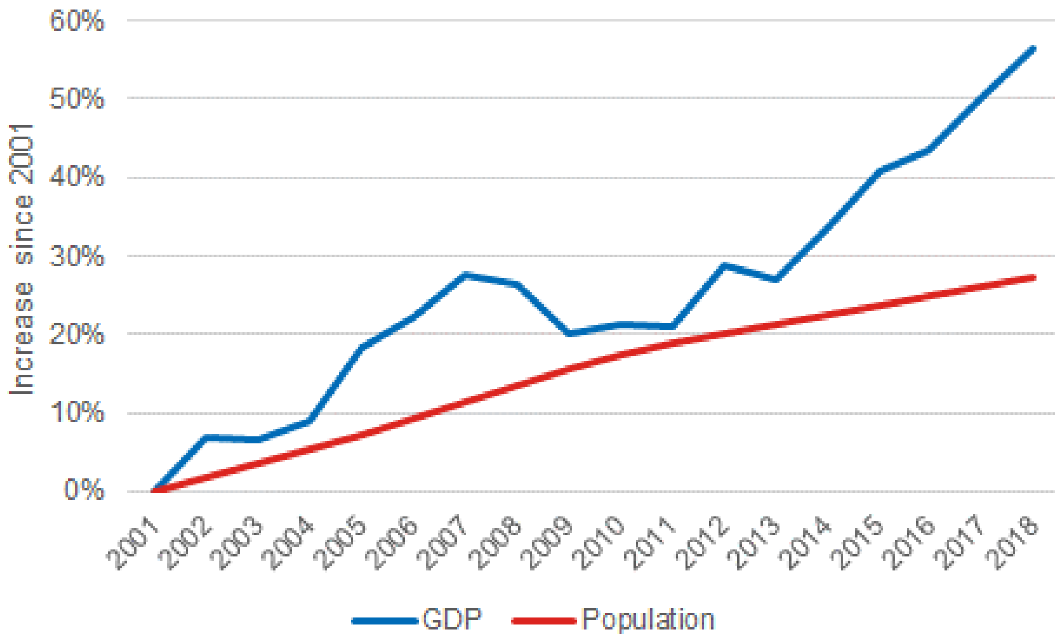


Figure 5: Increase in GDP and population in the Bahamas between 2001-2018



The GHG emissions per capita in The Bahamas was 16.24 tCO_2eq in 2018, which represents a decrease of 3.2 per cent compared to 2001.

V.II Energy sector

An overview of GHG emissions in the Energy sector by category and by gas is presented below. Total GHG emissions in the energy sector amounted to 2435.21 Gg CO_2-eq in 2001 and 2949.58 Gg CO_2-eq in 2018, see Figure 6. This represents an increase by 21.1 per cent. In the same time frame, GDP has increased by over 60 per cent and population by nearly 30 per cent.

Main power and heat generation is the largest GHG emission source in the energy sector with 48.5 per cent of total emissions, followed by transport with 24.7 per cent. Manufacture and construction contributes 11.9 per cent and Other 15.0 per cent. The contribution of Fugitive Emissions category is minute with 0.0006 per cent (Figure 7).

Figure 6: GHG emissions in the energy sector 2001-2018, by categories

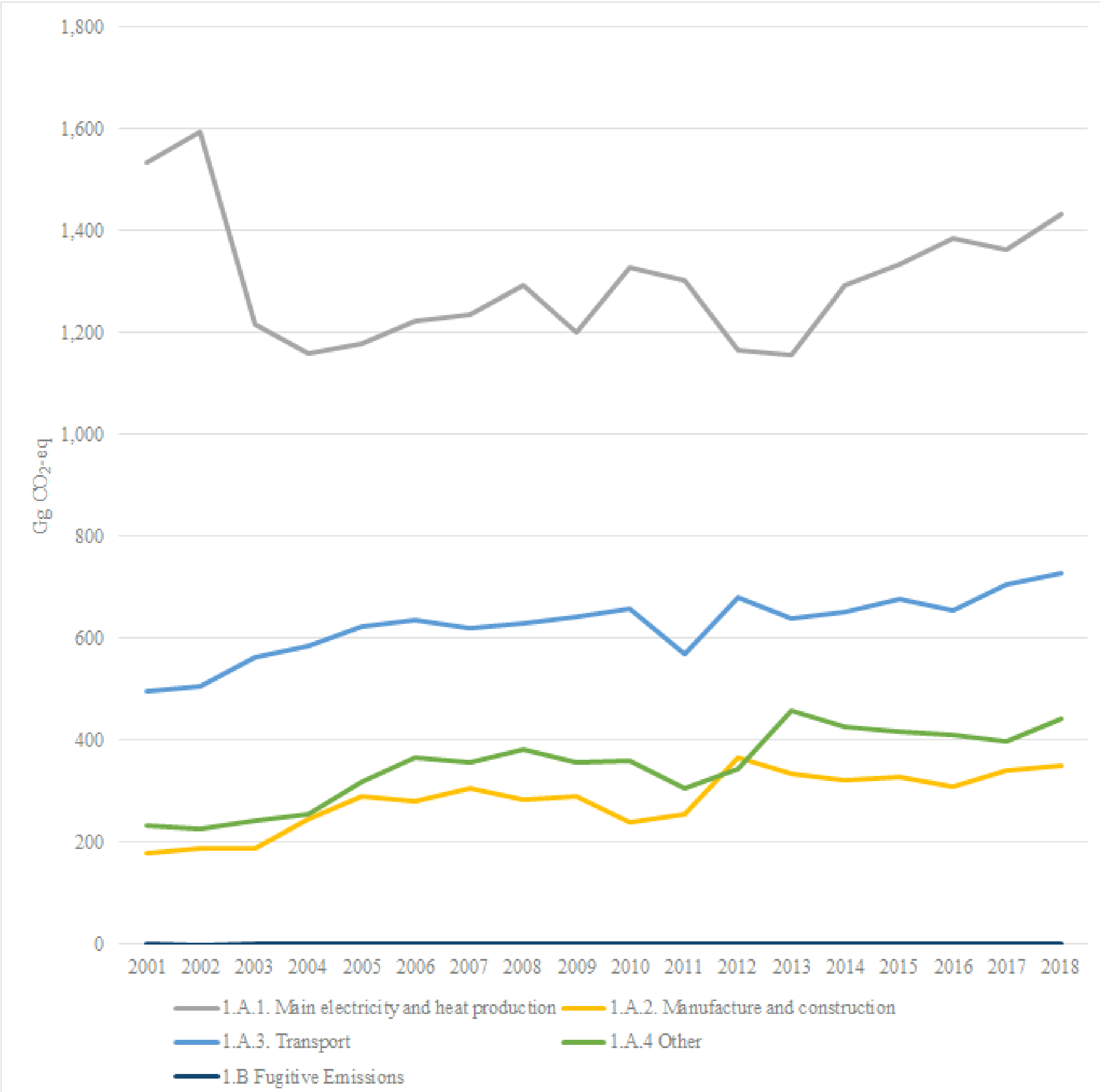
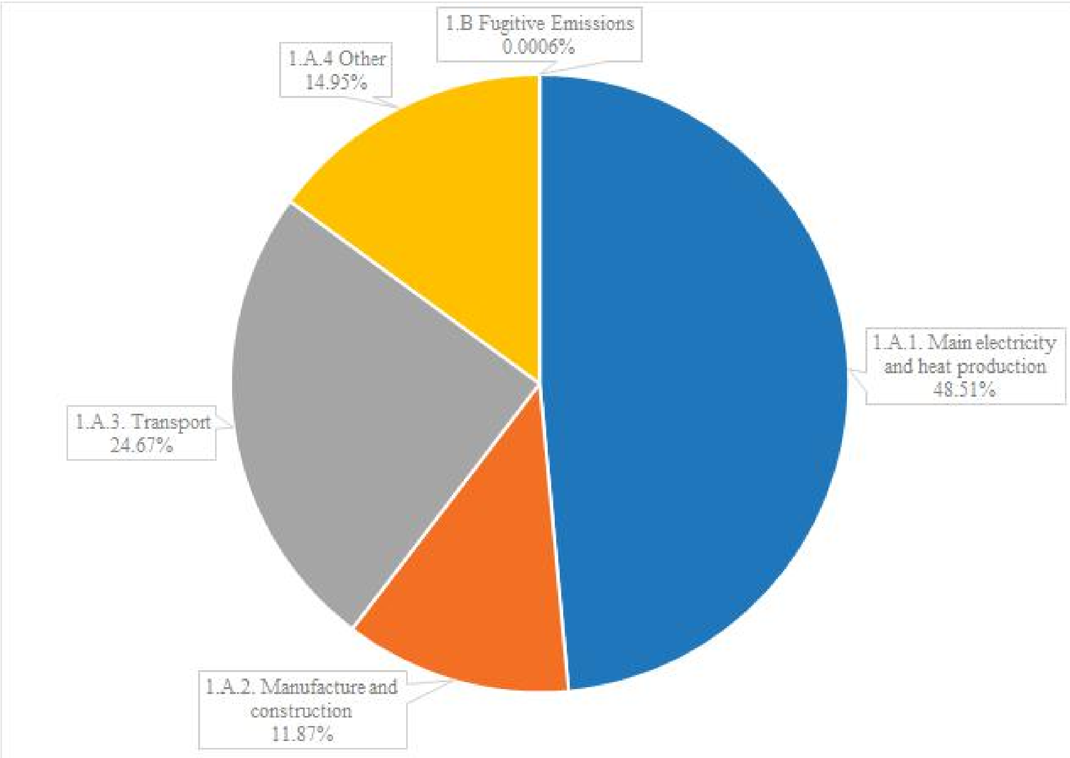
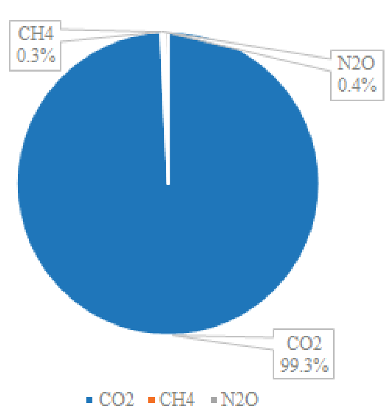


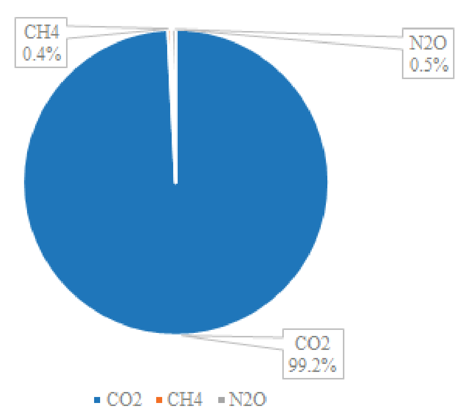
Figure 7: Contribution of categories to total GHG emissions in the energy sector in 2018



Shares of the gases in total emissions have remained similar over time, around 99 per cent for CO_2 and below 1 per cent for CH_4 as well as for N_2O. Figure 8 shows the contribution of the three gases to total GHG emissions in the energy sector in 2001 as well as in 2018.

Figure 8: Contribution of gases to total GHG emissions in the energy sector in 2001 and 2018





GHG emissions for the subcategories 1.A.1 Main Electricity and Heat Production, 1.A.2 Manufacture and Construction, 1.A.3 Transport and 1.A.4 Other sector all show an increasing trend since 2011. Before, they had shown an overall slightly downward trend. For the energy sector as a whole, GHG emissions have increased by 21.1 per cent between 2001 and 2018. This includes a reduction of 6.6 per cent from Main Electricity and Heat Production, and an increase by 97.7 per cent in Manufacture and Industries, 90.8 per cent in Other and 47.2 per cent in Transport. The increase in population as well as in GDP and related to that, tourism activity, can be deemed to have played a key role in the generally upwards moving trend since 2011. Technological change, e.g. the replacement of equipment for power generation, might potentially have played a role in reducing fuel consumption in earlier years of the time series. Data indicates that generation efficiency has considerably increased from 2003 onwards compared to 2001 and 2002. Furthermore, GDP has remained nearly stable between 2002-2004. A general decrease in fuel consumption in the sectors Transport and Other can be seen between 2009-2010. This might be related to the global financial crisis 2008-2010.

V.III Industrial Processes and Product Use

The industrial processes and product use sector covers a wide range of sources of GHG emissions. These include process (i.e., non-energy related) emissions from industrial production as well as emissions related to the use of certain products. GDP in The Bahamas focuses on the financial sector as well as on tourism, with only very limited industrial production taking place.

Data collection and consultation with experts indicates that no relevant industrial production, e.g., of cement clinker, glass, ceramics or steel takes place in The Bahamas at present.

A number of product use categories clearly occur or are likely to occur, while no data is available. These are presented in
Table 3.

Table 3: Categories of the IPPU sector not estimated due to lack of data

Gas and IPCC category	IPCC category code	Likelihood of occurrence
CO_2 emissions from the use of paraffin waxes and solvent use	2.D.2, 2.D3	Likely
HFC emissions from the operation and discharge of refrigeration and air conditioning equipment	2.F.1	Emissions do occur
HFC emissions from the use of building foams, aerosols and solvents	2.F.2, 2.F.3, 2.F.4	Likely
SF_6 emissions from the operation of electrical equipment	2.G.1	Likely
N_2O emissions from the use of N_2O in hospitals	2.G.3	Likely

Due to the lack of data, GHG emissions from these categories could not be estimated. Particularly the HFC emissions from the operation and discharge of refrigeration and air conditioning equipment are likely to make a relevant contribution to The Bahamas total GHG emissions. The collection of relevant data for the compilation of the next GHG inventory should thus be considered a priority. Annex III presents suggestions on how to retrieve relevant data in the course of future GHG inventory compilations.

Emissions of product use which occur and for which data was available, relates to the use of lubricants. This source only leads to emissions of CO_2. These fell from 3.75 Gg CO_2-eq in 2001 to 1.08 Gg CO_2-eq in 2018. This means that emissions have decreased by over 70% over the time series, with a dip of over 50% happening between 2010 and 2011. Reasons for this development are presently unknown and should be researched as part of future GHG inventory compilations. A potential explanation could be structural changes after the economic crisis 2008-2010.

V.IV Agriculture, Forestry and Other Land Use

Agriculture

The agriculture sector covers a wide range of sources of GHG emissions including from livestock, crop production, fertilizer use, and soil management. The agriculture sector in The Bahamas represents about 2.3% of the national GDP. These practices include small-scale farming of food crops, limited livestock production throughout the islands and more significantly, poultry egg and broiler production, and soil enrichment from fertilizers. The addition of lime to agricultural soils was not estimated, as all national soils are considered calcareous[5].Biomass burning was also not estimated, as post-crop burning is not considered a common practice.

Total GHG emissions in the agriculture sector amounted to 16.08 Gg CO_2-eq in 2001 and 14.23 Gg CO_2-eq in 2018, see Figure 9 (below). This represents a decrease by 11.54% per cent.

Per cent contributions of individual gases in total emissions have remained similar over time, with N_2O accounting for 88.3 per cent in 2001 and 83.6 per cent in 2018, less than 1% CO_2 in both 2001 and 2018, and 11.3 per cent and 15.6 per cent for CH_4. Total direct N_2O emissions on managed soils, particularly from fertilizer was the highest contributor to sector emissions (56.1 per cent). This is attributable to the importation of nitrogen-based fertilizers during the time series. This is followed by indirect N_2O emissions to managed soils from leaching and atmospheric volatilization from fertilizers and managed animal waste, accounting for (18.per cent). Emissions from livestock enteric fermentation (11.9 per cent) and manure management (10.2 per cent) followed. Indirect N_2O emissions from manure management and urea application jointly represented about 3 per cent of sector emissions (see Figure 10).

[5] All Bahamian protosols are alkaline, usually in the range 7.5 t0 8.5, with its red soils being less so, or neutral depending on the amount of limestone they include, *Soil and Land Resources of The Bahamas, N. Sealey*

Figure 9: GHG emissions in the agriculture-sector 2001-2018, by categories

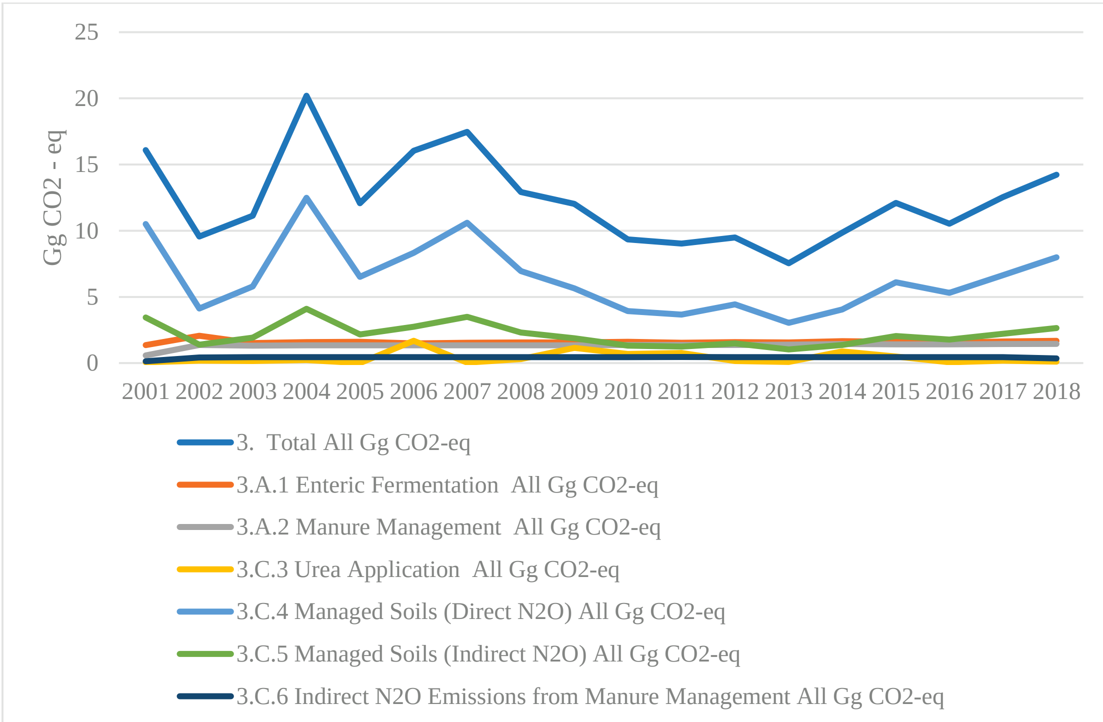
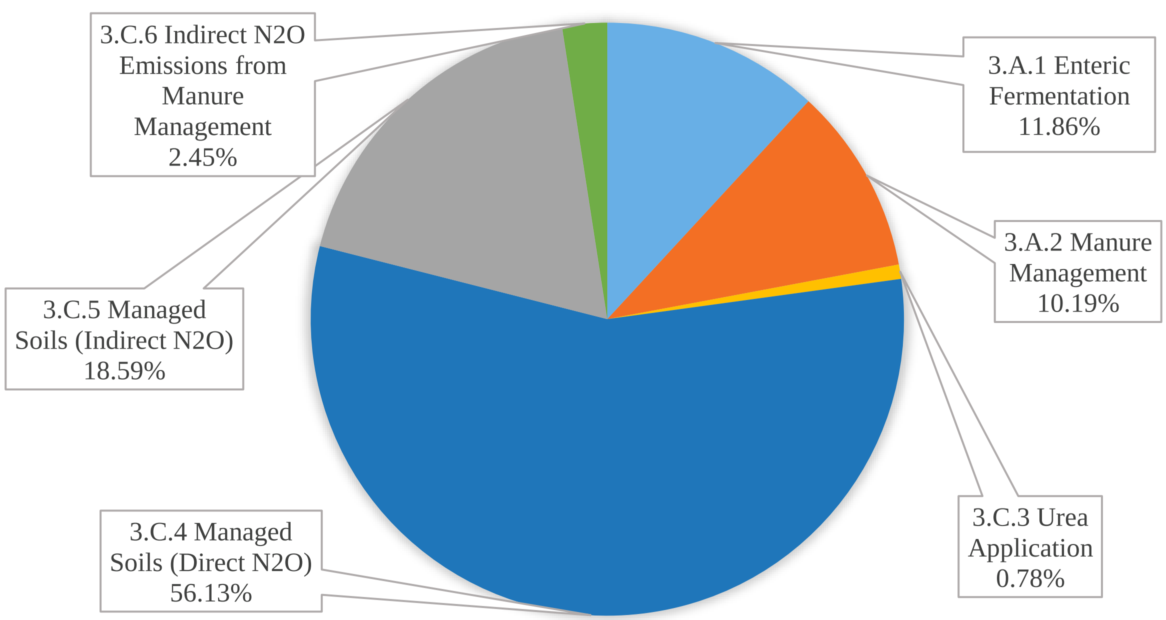


Figure 10: Per cent contribution of agriculture categories to total agriculture sector GHG emissions in 2018



Forestry and Other Land Uses

GHG emissions in the Forestry and Other Land Use (FOLU) sector typically come from a number of sources related to CO_2 emissions and removals from carbon stock changes in above and below-ground biomass pools of forest land. This includes forest land converted to other land uses such as cropland, grasslands, wetlands, and settlements. CH_4 and N_2O, and additional CO_2 emissions arise from fires and drainage of organic soils, however, these emissions were not estimated due to unavailability of data on forest fires and non-occurring drainage of organic soils.

Total GHG emissions in the FOLU sector were dominated by the land converted to grassland category in 2018, with conversion from forest land to grassland (shrublands and grasslands) representing 75 percent of emissions (as opposed to net-emissions) in this sector. All emissions and removals estimated within this sector relate to CO_2.

Across the time series, the trends that influenced annual emissions were those categories that contain the greatest amount of carbon stock (i.e. Forest land, Grassland, and conversion to either). Lowest emissions were noted within the time period of 2005-2009 (955.66 Gg CO_2 eq yearly emissions) attributed to land conversion to forest land (more removals). This effect was noted after the passing of two hurricanes, Hurricane Frances and Hurricane Jeanne, occurring two weeks apart in October of 2004. Both hurricanes severely impacted the north-western Bahamas, including Abaco, Andros, Berry, Bimini, Eleuthera, Exuma, Grand Bahama, and New Providence islands which are mainly forested islands. The pine forests of Grand Bahama were especially impacted with regeneration not comparable to its previous state. The effects of secondary foliage regrowth (and subsequently greater removals) enhanced sinks and reduced emissions in the 2005-2010. This regrowth is discernible by satellite imagery and can be viewed for the year 2010 on Grand Bahama and Abaco Islands.

In the subsequent years, from 2010 to 2014, a 30 per cent increase in emissions occurred

Figure 11: FOLU Sector Emissions by Category

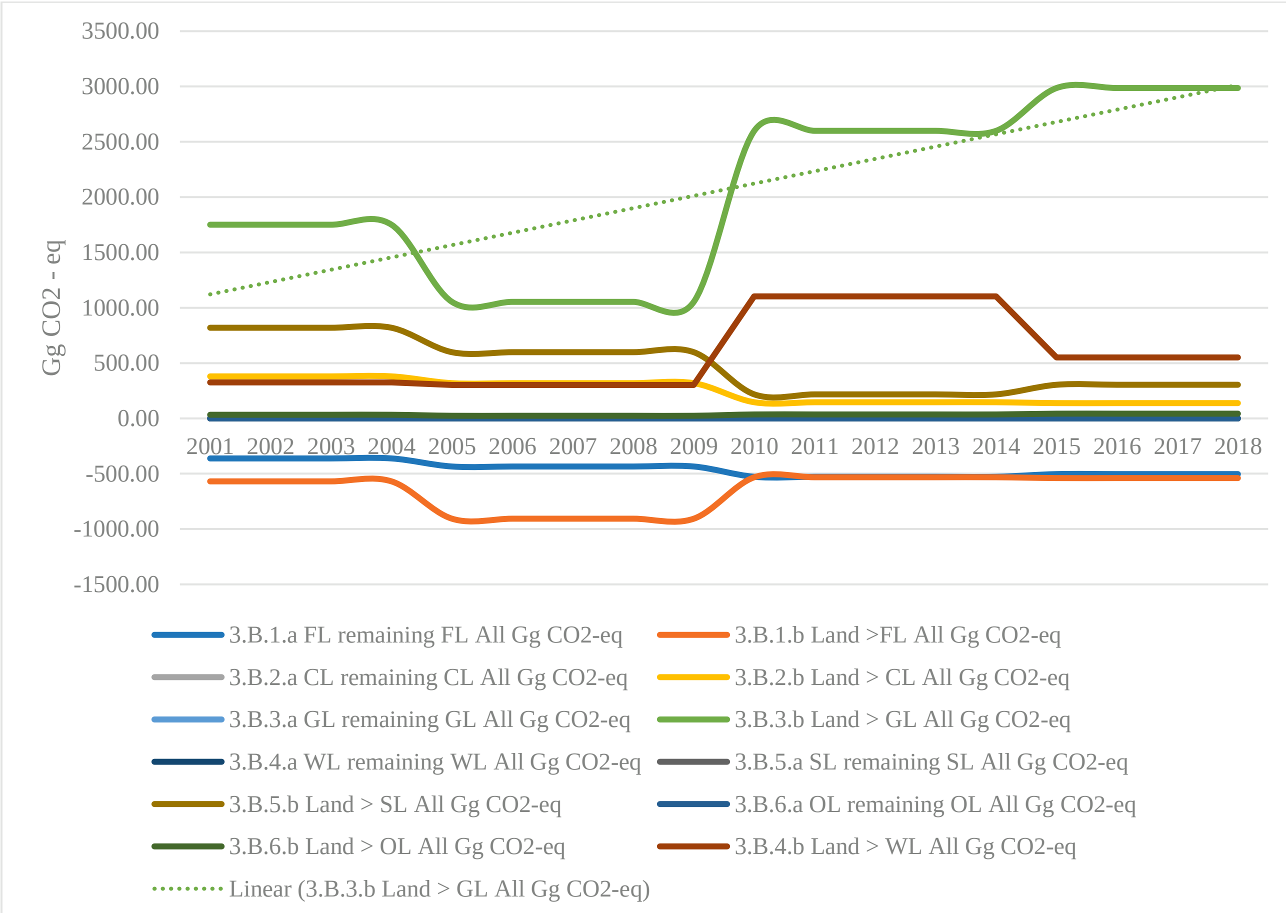
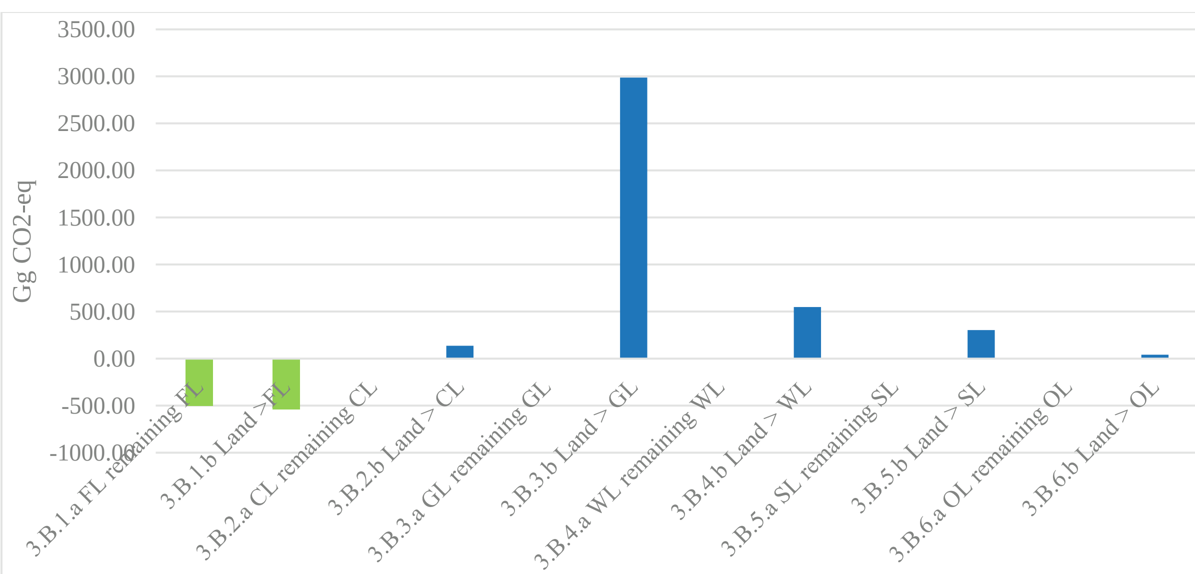


Figure 12: Contribution of categories to total FOLU GHG emissions in 2018



due to conversion from forestland to grassland and secondarily from a large conversion of forest land to wetlands (reduction in carbon stocks). Furthermore, in more recent natural disasters, Hurricane Dorian in 2019 has demonstrated partial to severe destruction to mangroves, coral reefs, and forests of Abaco and Grand Bahama, particularly the eastern sides of Grand Bahama, however the overall emissions from land use change between 2010 and 2020 were relatively constant.

V.V Waste

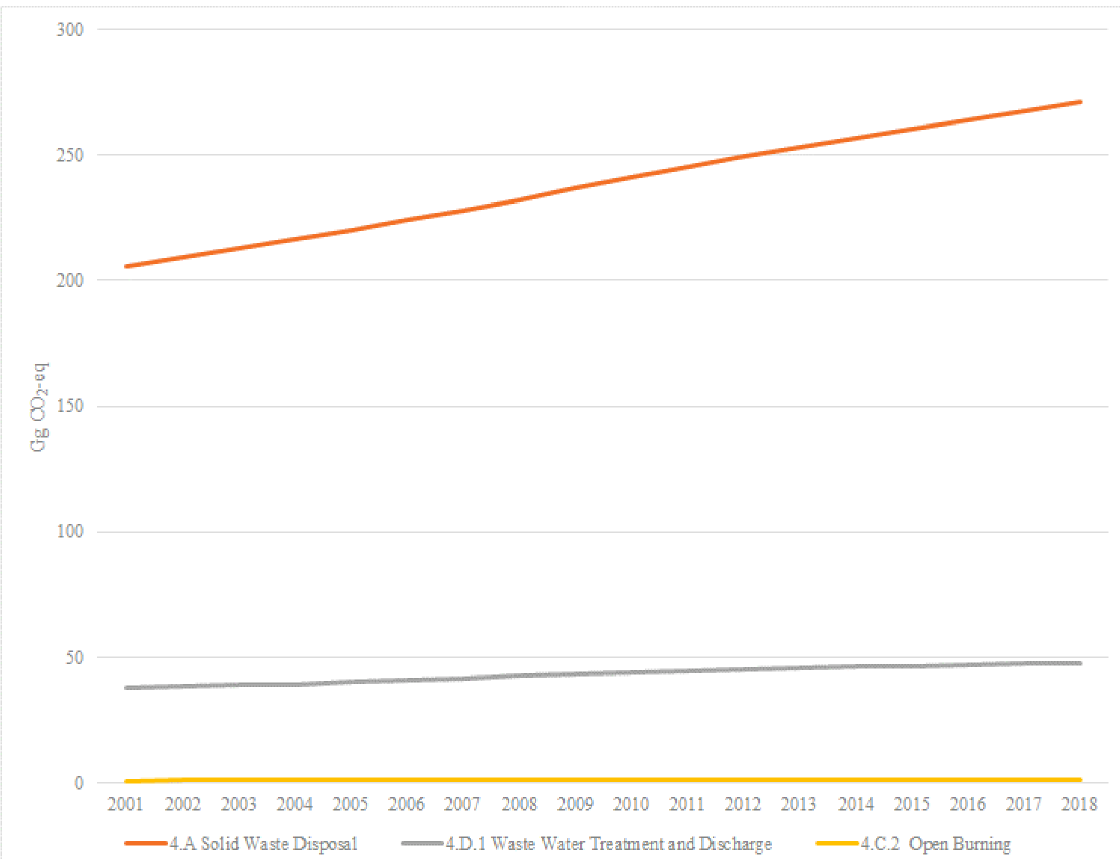
GHG emissions in the waste sector typically come from a number of sources related to the treatment of solid waste as well as the management of wastewater. With regards to solid waste, solid waste disposal (i.e., landfilling of solid waste) and, to a small extent, open burning of waste, take place in The Bahamas. One landfill is currently being converted to a managed form, while the remaining landfills are unmanaged. Biological treatment of solid waste does not take place. Large scale waste incineration does not take place in The Bahamas according to available information and expert judgement. The incineration of hazardous waste at smaller facilities, e.g. in hospitals, might take place according to expert judgement. Information on amounts of hazardous waste and treatment approaches could not be obtained, this is clearly an area for improvement.
On this basis, GHG emission estimates for the gases CO_2, CH_4, N_2O were compiled for the waste sector categories presented in Table 4 below.

Table 4: IPCC 2006 GL categories for which Waste GHG emissions were estimated

IPCC Category	Category Name
4.A	Solid Waste Disposal
4.C.2	Open burning of waste
4.D.1	Domestic Wastewater Treatment and Discharge

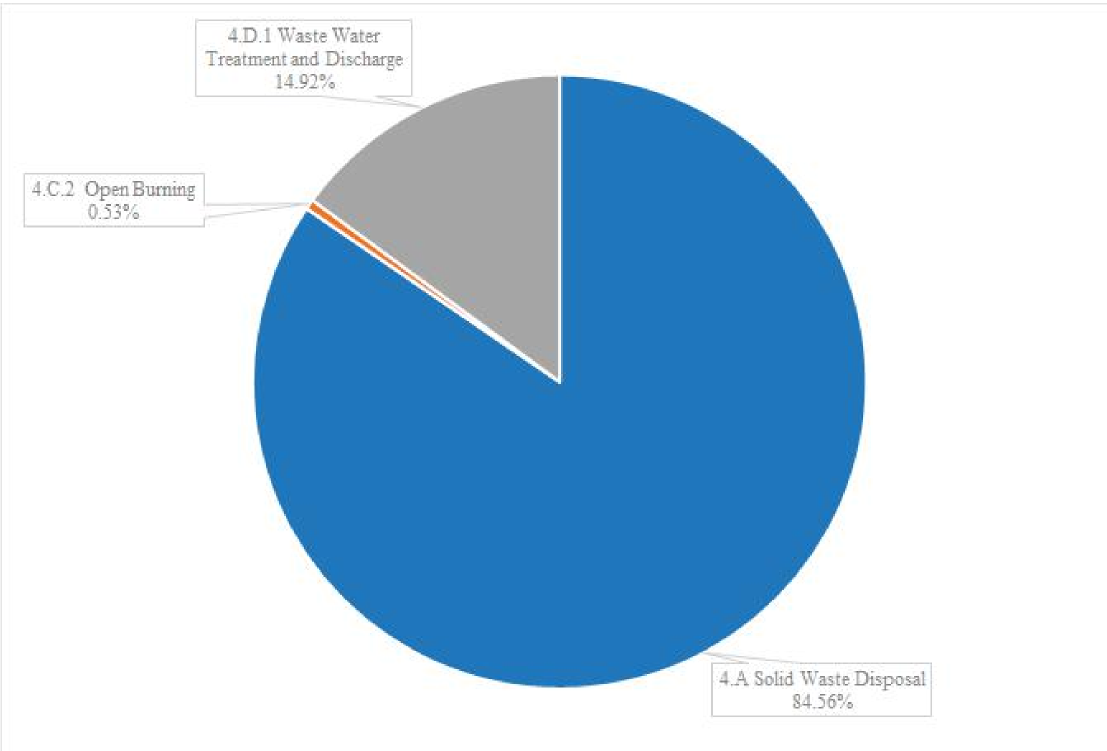
Total GHG emissions in the waste sector amounted to 245.20 Gg CO_2-eq in 2001 and 320.31 Gg CO_2-eq in 2018, see Figure 13. This represents an increase by 30.6 per cent. It is important to note that the calculation has heavily relied on IPCC default values and assumptions (e.g., waste generation rate, waste composition), so that the current estimations mainly reflect The Bahamas' population increase over the time series. Information indicating technological change and change in treatment approaches (e.g., moving from shallow to deep landfills over time) was not available. Generally, the increase in GDP and also tourism activity are likely to influence GHG emission developments in the waste sector, but are currently not reflected in the calculation. Annex II suggests improvements which would allow considering these drivers in the future.

Figure 13: Total GHG emissions in the waste sector 2001-2018, by categories



Total GHG emissions in the waste sector are dominated by the category solid waste disposal contributing 84.6 per cent in 2018. Wastewater treatment and discharge contribute 14.9 per cent and 0.5 per cent, see Figure 14. Between 2001 and 2018, the three subcategories show similar growth rates. GHG emissions from solid waste disposal grew by 31.6 per cent, from wastewater treatment and discharge by 27.4 cent and from open burning by 25.4 per cent.

Figure 14: Contribution of categories to total GHG emissions in 2018 in the waste sector



Planned improvements

During the compilation of The Bahamas' national GHG inventory, future improvement potential was identified and documented. The full list of improvements are presented in Annex III. The improvement options presented in the Annex differ in both their urgency and timeframes for which they could be implemented in. This chapter presents the improvements deemed most relevant, as they pertain to the set-up of a sustainable national GHG inventory system, the existing key categories, and the categories for which no or only limited activity data were available.

Table 5: Most relevant areas for improvement

Area	Most relevant areas for improvement
Cross-cutting	• Set up appropriate institutional, procedural, legal arrangements, and documentation for recurring preparation of the national GHG inventory • Appoint a national GHG inventory compilation team • Fully establish and implement QA/QC procedures for the national GHG inventory
Energy	• Ensure data on fuel imports compiled by the Central Bank of the Bahamas are complete and accurate • Obtain disaggregated data of fuel imports (potentially with the help of fuel distributors) by relevant subcategories, e.g. manufacture and industries (1.A.2), commercial/institutional (1.A.4.a), and residential (1.A.4.b). • Develop a national energy balance in the longer term • Collect power generation and fuel consumption from local power producers (Bahamas Power and Light, Company Ltd. Grand Bahama Power Company) • Develop country-specific emission factors • Better understand which relevant manufacture and production activities take place and collect activity data • Obtain complete activity data on vehicle population across the entire time series
IPPU	• Collect HFC and PFC import data (as substance and in products) • Assess which IPPU categories occur (e.g. electrical equipment, category 2.G.1)
AFOLU	• Develop country-specific emission factors for categories 3.B.1.a-b, 3.B.2.b, 3.b.3.b, 3.B.4.b and 3.b.5.b

	• Establish and validate (i.e. ground-truth) a sample of permanent plots of each land use type (at minimum the main IPCC classes, especially pine and mangrove for forest land which are prominent in the Bahamas) to improve land classification maps and remote sensing model • Determine the occurrence of harvested wood products, biomass burning and mineral soils in the country • Determine the end use of fertilizers and other agricultural additives reported in the annually produced Customs Imports report with Agriculture experts • Conduct a survey of livestock in country, including livestock manure management practices on an annual basis, and align with National Agricultural Census cycle
Waste	• Collect information on the depth of landfills (one-time survey) • Assess solid waste generation and composition • Collect data from national food and beverage manufacturing companies on industrial wastewater flows

c) Measures to Facilitate Adequate Adaptation to Climate Change

The scientific evidence that climate change is caused by human interference is unequivocal. In its latest report, the Intergovernmental Panel on Climate Change (IPCC) states that human influence is contributing to many observed changes in weather and climate extremes, such as heat waves, torrential rains, and drought, which are likely to become more frequent and severe as global temperature keeps increasing.

Historic records show that there is a clear evidence of climate change in The Bahamas with mean annual temperature increasing 0.5°C, and seal level rising 0.3m in the past century.

The future scenarios are not very optimistic with the latest projections indicating that these trends will continue in the future. In addition, due to its geographic location, historically The Bahamas has been affected by numerous hurricanes and the last IPCC report concludes with medium confidence that, due to climate change, tropical storms and severe storms are expected to happen more often in the Caribbean region.

The Vulnerability and Adaptation Chapter provides a comprehensive assessment of the vulnerability and adaptive capacity of various socioeconomic sectors of The Bahamas, namely Agriculture, Natural Resources, Energy, Human Health, Human settlements and infrastructure, Tourism, Transport, Water Resources, and Disaster management.

This assessment followed a three-step methodology that aimed at:

- Analysing the main climate change-related hazards that are already affecting The Bahamas and the latest climate scenarios and projections for the country.
- Assessing the main climate impacts that are affecting the prioritised sectors and their associated risk.
- Identifying sectoral adaptation recommendations to be implemented in the short, medium and long-terms.

Agriculture: There are a few climate change hazards that may impact the Bahamian Agriculture sector. Due to the islands low topography, rises in sea level can cause flooding events that can not only increase the risk of removal of soil nutrients, but also damage crops and agricultural land, as well as other infrastructure and facilities in the agricultural sector. In addition, sea level rise can also lead to the contamination of freshwater resources due to saltwater intrusion including aquifers, a very important source of freshwater for the agricultural activity of the islands. Higher temperatures and extended periods of drought can lead to an increase in the propagation of diseases in crops and livestock, and also the invasion of alien species, and extreme weather events can completely destroy seasonal crops.

Adaptation measures for the sector include improve planning and management of water resources, adopting a climate resilient agricultural development strategy that promotes food and nutritional security by, for example, implementing agricultural practices adapted to the new climatic conditions and promoting soil restoration and conservation activities.

Natural Resources: With temperatures rising climate change poses a risk to marine and terrestrial ecosystems in The Bahamas. Higher temperatures can lead to the proliferation of invasive species and the spread of plagues that can negatively affect some species and also decrease the availability of natural resources. Increased temperatures also contribute to ocean acidification which can significantly affect coastal and marine ecosystems such as coral reefs and mangroves which are known to offer natural protection of the coast and are also habitat to a variety of species. Additionally, ocean acidification can also negatively affect fish and other marine species biomass.

Overall, climate change impacts on this sector can lead to losses in marine and terrestrial ecosystems and biodiversity which can ultimately lead to ecosystem services loss and also the loss of livelihoods for the people that depend on these natural resources for a living.

Adaptation options for the sector are focused on public dissemination, building awareness and promoting the adoption of good practices including the use of Nature-based Solutions, and improving planning and regulations to assure conservation and protection of ecosystems at risk.

Energy: The Energy sector in The Bahamas is highly exposed to climate change impacts that can ultimately lead to increases in the risk of energy insecurity and an increase of energy prices. A rise in sea level would increase the risk of coastal erosion and saltwater intrusion causing potential damage to the energy infrastructure located in coastal areas or areas in the country prone to flooding from sea level rise. In addition, extreme weather events increase the risk of damaging the country's power generation and distribution infrastructure and causing power outages. Furthermore, higher temperatures and extended periods of heat waves can increase the demand for refrigeration systems and air conditioning in the country, which could rise the electric tariffs.

Adaptation measures for the sector are focused on diversifying the energy matrix to minimize shortages during extreme weather events, and also focused on enhancing enegy efficiency and reducing vulnerability of key facilities and infrastructure.

Human Health: The health sector is particularly vulnerable to climate change with impacts not only affecting health-related infrastructure but also the wellbeing of the Bahamian population.

For example, extreme weather events such as hurricanes can both damage or even destroy healthcare facilities and cause physical harm to people. Sea level rise and flooding can contribute to a decline in surface and groundwater quality leading to a less availability of freshwater resources for the population, and higher temperatures and flooding events associated with extreme weather events can also lead to an increased presence of vectors of disease and the propagation of water-borne and communicable diseases. In addition, drought can lead to a decrease in food production and availability and an increased risk in wildfires which can decrease the air quality.

Overall, climate change impacts on the sector can lead to an increased incidence of respiratory and cardiovascular problems and diseases, other physical injuries as well as psychological stress, which can increase the pressure on public health services due to an accumulation of patients.

Adaptation measures for the sector are, on one hand, focused on improving (i) healthcare infrastructure and healthcare access for the population, (ii) planning for water and sanitation services, and (iii) awareness on climate change and the importance of maintaining a healthy lifestyle. And, on another hand, focused on monitoring (i) the spread and transmission of vector-borne diseases and other climate related illnesses, and (ii) methods and indicators to determine the impacts of climate change on human health.

Human Settlements and Infrastructure: Climate change poses a significant threat to human settlements and infrastructure, as it can increase the risk of loss or damage of households and other buildings and facilities and key infrastructure. Extreme weather events such as hurricanes could increase the risk of disruption of transportation networks, widespread power outages, the displacement and migration of people, and the isolation of communities.

Adaptation options for the sector include the implementation of the new building code and developing contingency planning to ensure essential systems will not be cut off during for example extreme weather events.

Tourism: Climate change poses a significant threat to The Bahamas' tourism sector. Extreme weather events can lead to a displacement and migration of people, reducing the availability of tourism-related services, and hence, the number of visitors to the country and can also cause significant damage to tourism-related transportation infrastructure, such as airports and roads, that can lead to a reduction of visitor's arrivals. Ocean acidification from higher temperatures climate change also poses a significant threat to coral reefs, which are an important touristic attraction in the country, and sea level rise and flooding from extreme weather events can lead to coastal erosion leading to a loss of touristic attractions such as beaches. These events can also damage and destroy tourism-related infrastructure and cause the disruption of essential services such as water supply and electricity, leading to a devaluation of coastal properties. These impacts can not only significantly affect the number of visitors to the country, but can also affect the country's GDP as the sector is the main core of The Bahamas economy.

In terms of adaptation options for the tourism sector, while there is the need for The Bahamas to develop a strategic planning for the sector that considers climate variability, tourism policy development is definitely needed. In addition, due to the reliance on the environment for so much of the country's tourism activity and livelihoods, environmental policy implementation is considered a priority for the sector. Planning, building and designing smarter and more dispersed tourism facilities should also be encouraged, and reducing the sector's dependence on fossil fuels and the enhancement of a low-carbon tourism economy should be desirable in the longer term.

Transport: Climate change impacts in The Bahamas are a threat to all transportation infrastructure and transportation networks, including inter-island systems, and can make some roads and other facilities unusable, reduce traffic safety, disrupt the vital connections that provide the population's access to economic opportunities, education, and healthcare, and also reduce the transportation of important supplies such health and food which can ultimately lead to the isolation of communities. Populations living in more isolated areas or where with poor availability of alternative routes or other transport options are the most vulnerable.

Adaptation measures for the sector are focused on strengthening the monitoring and preventive maintenance of the Bahamian road networks and planning and implementing solutions to help protect the main transport networks and infrastructure from climate change-related threats. In addition, new transportation infrastructure should incorporate resilience considerations from the planning stage onwards. Finally, the promotion of electric vehicles as opposed to fossil-fuelled ones should be enhanced.

Water Resources: In The Bahamas, freshwater resources are extremely vulnerable to climate change as they are finite and limited to very fragile freshwater reservoirs in the shallow aquifers. Some of the expected impacts include: saltwater intrusion in aquifers from seal level rise and water pollution and contamination from flooding events that can lead to an increased propagation of infectious diseases, and also to a decrease in freshwater availability. In addition, extreme weather events like hurricanes can lead to damages to waterwork infrastructure, malfunctioning of the sanitation system and also damages to natural habitats and the ecosystem services linked to the water cycle. The overall impacts on the sector can eventually translate not only into water availability shortages, but also in increases in drinking water prices.

Adaptation measures will contribute to ensure universal access to quality water and sanitation services considering present and future conditions by (i) improving planning and management of water resources, (ii) exploring new technological solutions for the provision of fresh and potable water and sanitary sewage, and (iii) developing contingency plans for situations of water scarcity. Finally, activities to raise public awareness on the importance of water conservation and promoting water reuse and water efficiency measures across different economic sectors should be implemented.

Disaster Management: With impacts leading to, among others, (i) the disruption of transportation networks, (ii) the destruction of households and infrastructure, displacement and migration of people, (iii) the isolation of communities, and (iv) substantial income and productivity losses that can lead to a reduction in GDP, climate change necessarily leads to the need of enhanced disaster risk management strategies that take into consideration climate change projections.

In this context, the adaptation options for the sector are focused on enhancing preparedness and planning to prepare, respond and recover from climate change impacts. This includes (i) improving monitoring and forecasting in coastal areas, (ii) creating and implementing action protocols including disaster management and evacuation plans that establish specific care guidelines for certain populations and minorities, (iii) developing and implementing contingency planning for essential systems, (iv) developing more robust disaster communication plan to ensure cross-sectoral communication, real-time communication, and specific contact information for each relevant agency in a disaster scenario, (v) developing policy of financial incentives or aids to draw populations in at risk-areas to resettle on safer ground.

Finally, recognizing that to be effective, climate change adaptation needs to be mainstreamed across multiple sectors, the following **cross-sectoral** adaptation options were also identified:

- Implement awareness and dissemination activities on climate change impacts in The Bahamas across sectors.
- Further explore and enhance intersectoral linkages to avoid efforts duplication and take advantage of common challenges and opportunities.
- Enhance regional collaboration for knowledge exchange.
- Ensure the regulatory framework sits on the most accurate climate data and predictions.
- Develop studies on sectoral vulnerability and cost benefit analysis of adaptation options.
- Secure and channel adaptation investments across all economic sectors focusing on the most vulnerable islands and populations.

d) Programmes Containing Measures to Mitigate Climate Change

The purpose of this chapter is to discuss existing and proposed mitigation actions for five IPCC sectors (Energy, Industrial Processes and Product Use, Agriculture, Land Use, Land Use Change and Forestry, and Waste) in The Bahamas. Based on the latest inventory estimates, the majority of GHG emissions are contributed by two sectors; the Land Use, Land Use Change and Forestry and Energy sectors, which each account for over 45 % of the total emissions.

To address The Bahamas' GHG emissions, mitigation actions presented in this chapter were prepared based on desk reviews and consultations with key stakeholders in both the private and public sector. Many mitigation actions discussed in this chapter result in direct emissions reductions. Other actions, known as enabling measures, create opportunities for direct emissions reductions. These measures are policies or incentives whose implementation will indirectly lead to emission reductions.

In addition to GHG emissions reduction, the mitigation actions have many sustainable development benefits associated with the seventeen sustainable development goals (SDGs).

This chapter outlines a total of 35 mitigation actions and 6 enabling measures, with several being enhanced from the Second National Communication (SNC) or are newly proposed actions.

The actions are heavily focused on the energy sector, with over eighty per cent (80%) of the actions focussed on the subsectors of Energy Demand, Electricity Generation and Transport.

Examples of country-wide mitigation actions include increasing the use of solar water heaters by 40%, increasing sales of electric vehicles by 35%, lighting retrofits for all government occupied buildings in The Bahamas, and the phasing out of hydrofluorocarbons. While, examples of island specific mitigation actions include implementing sustainable agroforestry practices in Acklins, Andros, Crooked Island, Grand Bahama Plana and Samana Cays or the installation of a 3-megawatt solar farm in Grand Bahama.

Examples of enabling measures include upgrading incentives for renewable energy systems, implementing standards for vehicle fuel efficiency and the implementation of charging stations for electric vehicles. All of proposals in this chapter, whether a mitigation action or an enabling measure, are intended to achieve the goals of the Paris Agreement, to limit global temperature rise to 1.5℃, and enable The Bahamas to meet its 2030 NDC Targets.

This chapter provides two scenarios for mitigation actions and enabling measures. They are the mitigation and ambitious mitigation scenarios. Compared to a business as usual (BAU) scenario for 2030, the mitigation scenario reduces emissions by 16% and the ambitious mitigation scenario by 33%. Compared to the BAU for 2050, the mitigation and ambitious mitigation scenario reduce emissions by 18% and 63% respectively.

Where possible, this chapter models mitigation actions and estimates emission reductions in gigagrams of carbon dioxide equivalent. The total estimated reductions from modeled mitigation actions is approximately 4,170 Gg CO_2-eq

As a non-Annex 1 Party, The Bahamas was eligible to participate in the Clean Development Mechanism (CDM) under the Kyoto Protocol. There are currently no projects registered with the CDM or other international markets. Under Article 6, The Bahamas is interested in pursuing suitable, beneficial projects, in the International Markets and is also exploring opportunities in the Voluntary Carbon Market space.

e) Integration of Climate Change into National Development Priorities

The Bahamas is committed to the implementation of the 2030 Agenda for Sustainable Development in national programmes and policies, making strides across all sectors. However, integrating climate change into national development programmes and policies requires a holistic and integrative lens, as systems and sectors are interdependent.

This chapter provides several proposals and recommendations across different sectors within The Bahamas. These sectors include: Energy, Transport, Water, Tourism, Agriculture, Fisheries, Construction, Finance, Waste Management, Health, Land Use and Forestry, Marine and Coastal Habitats, and Biodiversity.

It also proposes several cross-sectoral actions, for example:

a) Learning on adaptation and multi-stakeholder engagement (inclusive of an annual learning forum on adaptation)
b) Ensuring availability of data and information (inclusive of improving the amount and quality of information being collected across a range of Climate Change, Sendai Framework, and Sustainable Development Goals indicators, and prioritization of the disaggregation of data by gender, education level, socioeconomic status, and age)
c) Developing an education programme on climate change (inclusive of climate education from primary school, training all teachers on this topic, etc.)
d) Building safe, resilient and sustainable communities (inclusive of capacity building within local communities, regional real-time early warning systems, involvement of local communities in every phase of development from project design to implementation).

f) Development and Transfer of Environmentally Sound Technologies (EST)

The Commonwealth of the Bahamas is a Small Island Developing State. Like all other Small Island Developing States, the nation is extraordinarily vulnerable to the effects of climate change impacts, such as sea level rise, increasing temperatures, drought, flooding, storm surge and tropical storms. The nation has the added vulnerability of being extremely suceptible to fluctuations in the oil market, as the nation heavily depends on fossil fuel imports to produce power, facilitate transportation on and between islands and produce potable water via salt water reverse osmosis plants.

Many of the technologies and strategies detailed in this chapter were prompted by The Bahamas' dramatic encounter with Hurricane Dorian. The effects of Hurricane Dorian are twofold. On one hand it resulted in massive loss of human life, and damage to major infrastructure and communities, forests and marine life: thereby creating the need for scores of restoration projects, replanting efforts, clean ups and further highlighted the need for the removal of invasive species and the protection of the nation's flora and fauna.

On the other hand, Hurricane Dorian exposed the need for improved resilience to the nation's health care systems, disaster management plans and sectors, critical infrastructure, water and food security, and the energy sector.

As indicated in the Second National Communication, The Bahamas has proceeded to conduct a Technology Needs Assessment. Thus far, The Bahamas has selected four sectors: Meteorology, Education, Waste and Forestry and has completed the multi-criteria analysis needed to select the Environmentally Sound Technology for each sector. The details of which are discussed within this chapter.

g) Research and Systematic Obeservation

Research and systematic observation or RSO are a means to reduce uncertainties we take on climate action. Climate change research in The Bahamas includes research on, but is not limited to:

- Climate change, tourism and sustainable development
- Non-economic loss and damage
- Management of loss and damage
- Climate change and human rights
- Climate change impacts on marine, coastal and terrestrial habitats and the organisms that utilize these habitats inclusive of AGRRA surveys of coral reef systems and assessments of pine forest systems on Abaco and Grand Bahama
- Tropical cyclone development under climate change
- Climate change awareness
- Hurricane Dorian's impacts on coral reefs of Abaco and Grand Bahama
- Perceptions of climate change and health
- Adaptation capacity of men and women

The country has also undertaken a Storm Surge Model project. The model is a TELEMAC hydrodynamic model, which forecasts storm surge and associated flooding. Additional funding is required to address the long-term objectives of this project.

Moreover, advancing RSO in The Bahamas requires a number of actions including:

1. Participating in the Global Basic Observing Network (GBON)
2. Determining relevant Essential Climate Variables (ECVs)
3. Determining research priorities
4. Developing a national framework inclusive of RSO
5. Engaging with regional and international partners and networks

While some of these actions are already underway, others still need to be initiated.

h) Information on Research Programmes

Chapter 8 is divided into two sections. The first section details current and recent research projects that various sectors in the Bahamas have employed and the needs, gaps, and constraints that exist therein. The second section of the chapter details a list of technologies that are being implemented or about to be implemented in other countries in the Caribbean region that may also be able to assist The Bahamas in its efforts to improve biodiversity, climate change resilience, food safety, water management, and climate change mitigation.

Current research projects and needs are assessed in the following sectors: Biodiversity, Forestry, Water Resource Management, Land Use and Land Degradation, Meteorology & Disaster Preparedness & Management and Health. Similar to the Environmentally Sound Technologies (EST) Chapter, many of the research projects have arisen as a result of the devastation brought on by Hurricane Dorian.

These include: Pine replanting and studies of its methodology, investigations of the extent of the damage done by salt water intrusion in the well fields of Grand Bahama and particularly that of Well 6, and studies of the impact done to coral reefs and fish and bird populations, and the impact of hurricanes on mental health. Other, non- Dorian related, research include critical efforts to address the often-fatal Stoney Coral Tissue Loss Disease, which since 2019 has spread at astonishing speeds; Coral propagation methods and implementation; the plausibility of using Ocean Thermal Energy Conversion (OTEC) in The Bahamas, and other meteorological projects.

Throughout this chapter, the most commonly stated needs, capacity gaps, and constraints were: human capacity related, particularly the need for more GIS analysts; the establishment of a data sharing network; improved inter-agency collaboration; the establishment of baseline data in order to accurately detect and monitor changes in the environment and identification of financial resources to perform much needed research.

i) Education, Training and Public Awareness

Education on climate change occurs at various levels of education within The Bahamas (primary through tertiary) and a summary of key aspects of curriculum and educational opportunities are described in Sections 9.1.1. – 9.1.3.

Informal education is done primarily by Government agencies that have climate change as a part of their mandate and by non-Governmental organizations (NGOs). The websites of these agencies, as well as their social media pages, are the main vehicles for sharing educational resources (as outlined in section 9.1.4)

Outside of formal education, a number of training activities have been organized or facilitated by Government agencies (as outlined in section 9.2). Some of these include:

- GHG Management Institute/Caribbean Cooperative MRV Hub trainings on: development of greenhouse inventories using the 2006 IPCC Guidelines and mitigation modelling using the Low Emissions Analysis Platform (LEAP)
- Various training workshops were held on integrating climate change into policy and research and systematic observations (RSO)
- In preparation for COP-27, C^{2}EAU and Young Marine Explorers (YME) developed a Climate Crusaders training programme over 19 weeks to educate Bahamian and Caribbean high school and college students about climate change issues and international negotiations on climate change. The training was supported by Bahamian and regional experts as well as the non-profit, Smart and Strong Sisterhood (SASS).

Over eighteen (18) recommendations, as outlined in Section 9.6, were provided to advance Education, Training and Public Awareness in The Bahamas – that were general in nature, addressed the primary through tertiary education systems, informal education, training, public awareness and public access to information and participation.

j) Capacity Building

Capacity building in climate change in The Bahamas needs to occur at three levels:

1. **Individual** – The goals of capacity building at this level are to change attitudes and behaviours as well as providing knowledge and developing skills. Education, training and public awareness (ETPA) outline tools to be used in providing knowledge and developing skills at the individual level.
2. **Institutional** – The goals of capacity building at this level are to improve overall institutional performance and functioning capabilities as well as the ability of institutions to adapt.
3. **Systemic** – The goals of capacity building at this level are to ensure there is a policy framework in place within which individuals and institutions can function effectively and interact with those outside their institutions as well as outside the country.

Through the TNC-BUR process, stakeholders identified the following capacity needs in being able to effectively work on climate change:

1. Carbon auditing
2. Carbon budgeting
3. Communication on climate change
4. Consultation skills
5. Education or changing behaviour
6. Energy management
7. Embedding climate change into decision making
8. Green economic planning
9. Low-carbon procurement
10. Renewable energy
11. Sustainable planning
12. Sustainable transport planning

Institutional and Systemic Capacity Building Initiatives are further outlined in this Chapter.

k) Information Sharing and Networking

As a Small Island Developing State with associated capacity constraints, The Bahamas must engage regionally and internationally to enable information sharing and networking to complement its national efforts to address climate change. Information sharing and networking also enables the country to share its experiences and solutions with respect to climate change impacts.

Nationally, information sharing and networking are mainly done through the National Climate Change Committee (NCCC). This interagency committee, consisting of public, NGO and private sector representatives, meets regularly to engage on climate change issues. The NCCC lead the development of the Third National Communication (TNC) and Biennial Update Report (BUR). Other than the NCCC, assessments indicated that national information sharing and networking efforts are currently limited.

In January 2022, the Government of The Bahamas (GOB) established the Climate Change and Environmental Advisory Unit (C^2EAU) whose activities include advancing issues related to climate finance, carbon credits and promoting greater youth involvement in climate spaces. This Unit can aid in promoting information sharing and networking opportunities within the country along with the NCCC

There are a number of regional and international information sharing and networking opportunities that are available to The Bahamas. Some of these are already being accessed by individual agencies within the countries. These are further explored in Section 11.1.

Recommendations for developing a strategy for information sharing and networking are outlined in Section 11.2, and involve:

a) Establishing and enhancing networking activites
b) Information sharing and networking regionally and internationally

l) Gender and Climate Change

The disproportionate ways that people are impacted by climate change has garnered more attention in the climate change and disaster risk management sphere in The Bahamas. The country is a signatory to several human rights and climate change frameworks; however, existing national climate change policies do not explicitly address the linkages between gender inequality and climate change. Rather, national climate change policies employ gender neutral perspectives that do not consider structural inequalities and the exacerbated impacts of climate change on marginalized groups. Notably, the Initial and Second National Communications to the UNFCCC did not include standalone chapters on gender and climate change. This chapter therefore seeks to fill that gap by employing a gendered analysis of climate change adaptation (CCA) and disaster risk management (DRM).

Gender mainstreaming climate change policy and programming challenges the socio economic, cultural, and political structures of inequality that shape disproportionate climate vulnerability and outcomes.[6] It applies an intersectional approach that takes into account social indicators like age, ethnicity, sex, and disability status as determinants of climate vulnerability.[7] Gender mainstreaming adaptation should go beyond preventing disproportionate gendered outcomes to address the sources of inequalities as a central part of adaptation and mitigation strategies.[8] This chapter defines gender from a sociological perspective, moving away from a binary interpretation to instead recognize the influence of social structures and power dynamics on livelihood outcomes and resource accessibility. The diversity within the population requires an intersectional approach to mainstreaming gender into climate change policies as levels of vulnerability are mutable and influenced by the compounding sources of inequality.[9] Adaptation and

[6] Alston, M. 2014. Gender mainstreaming and climate change. In *Women's Studies International Forum* 47:287-294.
[7] Hosein, Gabrielle, Tricia Basdeo-Gobin, and Lydia Rosa Gény. 2020. Gender mainstreaming in national sustainable development planning in the Caribbean. CEPAL,
[8] Gonda, Noemi. 2019. Re-politicizing the gender and climate change debate: The potential of feminist political ecology to engage with power in action in adaptation policies and projects in Nicaragua. *Geoforum* 106: 87-96.
[9] Hosein, 15

mitigation strategies should seek to address both the causes and consequences of disproportionate gendered outcomes.

m) Constraints, gaps and related financial, technical and capacity needs, including information on support received for preparation and submission of the TNC

This chapter outlines constraints and gaps that has hindered complete and accurate UNFCCC reporting for The Bahamas. In preparation of this TNC, The Government of The Bahamas has focused on a review of the following:

- Constraints and gaps in GHG inventory, mitigation, adaptation, and climate finance reporting
- Prioritised needs and improvements to facilitate improved reporting for future cycles in adherence with the TACCC principles

The Bahamas, like most SIDS and other developing countries, faces challenges due to limited human, technical and institutional capacity while attempting to meet its reporting requirements to the UNFCCC and to implement planned and ongoing climate action activities. The Bahamas has shown its commitment to improvements, as outlined in the previous 12 chapters and in noting its challenges, will require both internal and external support to close these gaps.

Regarding GHG inventory, lack of adequate data, limited coordination for the GHG inventory cycle, capacity constrains in applying GHG inventory methodologies, limited understanding of all GHG emitting activities in country, and a lack of archiving previous reporting cycles were constraints and gaps observed in this reporting cycle.

Regarding Mitigation, lack of adequate data, willingness to supply data, intra-ministerial coordination and communication, high capital costs, and technology suitability/availability, and data transparency issues were constraints and gaps observed in this reporting cycle.

Regarding Adaptation, stakeholders with technical capacity constraints, intra/inter-organization coordination and communication, lack of adequate data, key equipment and regulatory frameworks, in addition to high capital costs were constraints and gaps observed in this reporting cycle.

While regarding MRV Assessment, intra-organizational coordination and communication, need for greater public awareness, limited staff and funding, stakeholder hesitation, and difficulty in collecting data were constraints and gaps observed in this reporting cycle.

Prioritized needs to address the above related constraints and gaps include, setting up appropriate intuitional, procedural, legal arrangements and documentation for the recurring preparation of reports for the UNFCCC, appointing a national GHG inventory compilation team, fully establishing and implementing the QA/QC procedures for the national GHG inventory (particular from the QA exercise conducted by the UNFCCC in January 2022), fully establishing data collection and archiving procedures for climate data, improving training and capacity, continuation of modelling done in country (i.e. LEAP), and ensuring all relevant agencies and industries are involved in continuous and open communication to enhance data collection/exchange and improve the timely production of climate reports.

The country has made good progress from its last reporting cycle to the UNFCCC, as outlined in Table 124 and identifying Environmentally Sound Technologies (ESTs) for the country to implement via a Technology Needs Assessment (TNA) project. The TNA project has prioritized the following sectors: Waste, Forestry, Meteorology and Education.

While The Bahamas has not been able to conduct an assessment and quantification of supported needed during this reporting cycle, given the special circumstance of The Bahamas as a small island developing state across all areas of climate MRV in The Bahamas, technology transfer, capacity-building, and financial - support is needed as soon as possible.

Regarding support received, as highlighted in the climate finance section of the domestic MRV chapter (Chapter 2 of The Bahamas' BUR1 (2022)), The Bahamas through the GCF Readiness and Preparatory Support Programme, engaged in a project to develop a national database system for the MRV of financial investments with specific emphasis on identified actions in The Bahamas' NDC.

After extensive analysis of readily available documentation and a data collection mission in-country (inclusive of stakeholder interviews), The Bahamas was able to provide an initial mapping of climate finance recipients, mobilising entities and support received values (USD) for the time period 2010-2020. It should be noted that due to data gaps from stakeholders, as well as the need to improve on the outputs of the project, will be improved upon in future reporting cycles.

A summary of The Bahamas climate finance inflows for the period 2010-2020 can be described as follows:

a) Overall climate finance inflows amount to approximately $155M USD
b) When the above figure is disaggregated into Mitigation focused activities, this amounts to over $140M USD, while Adaptation focused activities were funded approximately $15M USD.

This shows a clear imbalance in Adaptation vs Mitigation funding that has been called for by SIDS like The Bahamas, where the former is vital to improving the country's resilience to climate change.

Taking into account finance flows disaggregated by mobilizing entity during the 2010-2020 time series:

a) The Ministry of Environment has mobilized the largest amount of funds – as an in-country/national entity (approx. $56.5M USD). This is not surprising given that the Ministry contains the Department for which Multilateral Environmental Agreements are executed (the DEPP).
b) The largest out of country entity, mobilizing funds for The Bahamas is the UN Environment Programme (UNEP), with approximately $89.2M USD.

Regarding preparation of the TNC, The Bahamas received multilateral financial support from the GEF in 2019 in the amount of 852,0000 (USD) to develop its first TNC (in addition to its First Biennial Update Report). The funding was administered through the Global Environment Facility (GEF) with UNEP having the responsibility as the implementing agency, and the DEPP serving on behalf of the Government of The Bahamas, as the executing agency. The funding was used to contract members of the PMU, consultants and auditors to ensure the production of a high-quality document and proper fiscal management of donor funds.

Chapter 1 – National Circumstances

Introduction

The Commonwealth of The Bahamas is recognized as one of the most vulnerable countries in the world to climate change. The country was ranked third of most affected countries in 2019 with a Climate Risk Index of 6.5 and losses per unit GDP of 31.59% (Eckstein et al, 2021).

The Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) provides evidence that the global climate is changing (Nurse et al 2014), and that Small Island Developing States (SIDS), like The Bahamas, are on the frontline of these changes; the economic cost of adapting to the impacts of climate change is high. Global Circulation Model (GCM) projections from a 15-model ensemble indicate that The Bahamas may experience the following impacts:

- *"Temperature rise*: The Bahamas may experience warming of mean annual temperature of between 0.8°C to 1.9°C by the 2050s and 1.0°C to 3.2°C by the 2080s, relative to the 1970-1999 mean. The ranges reflect minimum and maximum projections under three emissions scenarios (A2, high emissions; A1B, medium high emissions; and B1, low emissions) from the Special Report on Emissions Scenarios (SRES). The rate of warming is expected to be pronounced year-round, but particularly significant in the summer months (June-August).

- *Changing precipitation patterns*: GCM projections of future precipitation for The Bahamas span both overall increases and decreases, but tend towards decreases in most models. Projected change in mean annual precipitation range from -20 mm per month to 15 mm per month across the SRES A2, A1B and B1 emissions scenarios. The more recent Representative Concentration Pathways (RCPs) scenarios were used in the IPCC's Working Group I AR5 report, which project that warm/wet season (summer) precipitation will likely decrease in the Caribbean region over the coming century (Nurse et al, 2014). This is consistent with other recent assessments that predict declining annual average precipitation across the Caribbean, with the most pronounced drying during the wet season from May to October. In addition to the overall drying trends, recent models also predict that The Bahamas and other Caribbean countries will have to grapple with increasingly intense precipitation events (Taylor et al, 2018).

- *Increasing intensity of tropical storms*: Climate modelling of projected changes in tropical storms is associated with high uncertainty; however, both the IPCC AR4 and AR5 reports conclude that projections suggest little change in tropical storm frequency, but a likely increase in intensity of tropical storms making landfall in the Caribbean. Some recent models suggest that over the coming decades, rainfall associated with tropical cyclones could increase by 20-30% (near centre of the storm) and 10% at radii of 200km or greater, and that maximum winds speeds could increase by 2-11% (Taylor et al., 2018)".

1.1 Geography

The geography of The Bahamas contributes to its vulnerability. Geographic characteristics of the country include low relief with generally flat terrain and elevations of less than 32 feet (10 metres). 80% of the land lies less than 1.5 metres above sea level and as such, is vulnerable to floods cause by sea level rise and storm surges due to hurricanes (World Bank Group, 2021). A higher coast ridge occurs on most islands, usually located on the exposed side. Islands of the southeast and central Bahamas are generally of higher elevation than islands in the northern Bahamas. The highest elevation in the country is Mount Alvernia on Cat Island which is approximately 211 feet (64 metres).

1.2 Geology

The Bahamas archipelago is situated in the western North Atlantic and is comprised of extensive carbonate islands and shallow banks. There are 29 large islands, over 600 small cays, and more than 2,000 rocks, all low-lying. The surface deposits of archipelago are of Late Quaternary limestones from a glacioeustatic sea-level highstand position; a depositional record of platform flooding and carbonate sediment production. Simply put, alternating glacial expansions and retreats created vast changes in sea levels across geologic time, allowing for the formation of the islands. The islands are tectonically stable, consisting of carbonate sediments with interspersed paleosols (Mylroie, 2016).

With geologic origins that are biogenic and completely carbonate, The Bahamas differs from other islands in the region. The islands rest on shallow water banks which are primarily composed of calcium carbonate sediments. These limestone sediments were created from rapidly growing marine life which extracted calcium carbonate from seawater creating voluminous depositions of sand and mud. The Bahamas consists of eight carbonate banks with the north and central islands resting on two of these banks. New Providence, centrally located, is part of the largest formation – the Great Bahama Bank. The banks are separated by a series of deep-water channels upon which the islands occur unevenly usually on the margins of the larger and in the center of the shallower banks.

Oolitic sands have also contributed to the geologic development of the islands, specifically during the last ice age when sea levels were significantly lower. It was during that time period that oolitic sand dunes hardened and when sea levels rose, the rock ridges formed by these dunes became islands along the edges of the shallow banks.

Another source of islands in the archipelago are limestone rocklands, which were formed from the seabed when sea levels were at their highest. As sea level declined, the exposed seabed underwent erosion and weathering. The resulting formation was rocklands. Rocklands make up the broader islands in the archipelago (such as Andros and Grand Bahama) and oolitic sand dunes are represented in thin long islands (for example, Long Island and Cat Island).

Soil composition in the archipelago consists of organic and inorganic materials and the young age of the soil is reflective of the geologically young age of the limestone. Soils layers are typically thin and usually arranged in one or two layers above bedrock. Three soil types are recognized throughout the islands: organic, red clay, and sedimentary soils. New Providence is primarily made up of organic soils, which is the most common soil type in the archipelago (Currie, 2019).

The dry nature of the soils in The Bahamas means that they are particularly vulnerable to temperature increases and decreasing rainfall.

1.2.1. Hydrogeology

In The Bahamas, the physical geology, hydrogeology, water resources, and coastal zone are diametrically linked, as there are no true rivers in The Bahamas. The sole natural means of recharge for the underlying 'freshwater resources' is via rainfall.

The groundwater resources of The Bahamas are comprised of the fresh, brackish, saline and hyper-saline waters found in the subsurface and in the lakes and ponds that intercept the land surface. There is a direct connection between the landform and the marine and coastal environment, which are separated by a typical mangrove vegetation buffer on the protected coastal flats.

The freshwater resources occur as three-dimensional lens-shaped bodies, which overlie brackish and saline water. All freshwater in The Bahamas is as a result of rainwater that penetrates the ground surface.

Generally, there is no place on the islands that groundwater cannot be met in holes that penetrate 10 ft (3 m) below sea level. Water is typically encountered in the range 0 to 3 ft (0 to 0.9 m) above sea level. Tidal action induces an up and down movement to the entire groundwater table ranging from negligible amounts to about 3 ft (0.9 m). The effect of tides usually decreases inland, but may be substantial if an established cavern or other large opening directly connects an inland area to the sea. In many places inland, rise and fall of the water table is less than 1 ft (0.3 m).

The typical normal water table elevations are estimated at 3 to 5 ft (0.9 to 1.5 m) below ground level. Seasonal high-water table elevations can range from 1 to 3 ft (0.3 to 0.9 m) below ground level. During certain storm periods, the water table elevation can be above ground for a period ("perennial wetland areas"), but dissipates following the storm period. The main freshwater aquifer in The Bahamas occurs in the 'Pleistocene Age' formations named the Lucayan Limestone, from approximately 3 to 130 ft (1 to 40 m) below ground level (BGL). Younger Holocene deposits can contain freshwater, but freshwater is not present in older deposits beyond 150 ft (45 m) BGL (Cant & Weech, 1986).

Groundwater saturates the rock and all its pores, fissures and interconnected cavities. The size, shape and orientation of the island, the subsurface geology and the amount of rainfall control the shape size and thickness of the freshwater bodies. In excess of 90% of the freshwater lenses are within five feet of the surface.

Due to climate change, The Bahamas will face several challenges with respect to its water security. These include (MOEH & CDB, 2017):

- *Declining freshwater availability:* With declining average precipitation in the wet (summer) season, increasing temperatures throughout the year (thus increasing evaporation and evapotranspiration) and a potentially longer and drier dry (winter) season, the frequency of droughts is expected to increase and the availability of freshwater is likely to decline. These challenges will be particularly pronounced for the southernmost islands, which already have more limited freshwater supplies due to the tendency for precipitation to decline from north to south in the archipelago. At the same time, the prospects for expanding water supply through seawater reverse osmosis (SWRO) is somewhat constrained. SWRO provides more than 50% of The Bahamas potable water supply, but comes from groundwater sources due to limitations set on marine environment abstractions. Although SWRO will continue to form an important part of the country's system and efforts to safeguard water security, these regulations limit the extent to which the country can depend on SWRO – a reality that reinforces the need to pursue other solutions in parallel.

- *Increasing contamination of freshwater:* Compounding the challenge of declining freshwater availability is the fact that climate change will increase contamination of freshwater in The Bahamas. Increasingly intense precipitation events and tropical storms, coupled with sea level rise, are expected to increase the frequency and intensity of floods in The Bahamas. This is expected to increase turbidity and the rate at which pollutants contaminate the islands' groundwater lenses which (due to their shallow nature) are highly vulnerable to anthropogenic pollution. Further exacerbating this dynamic is the fact that increasingly intense extreme weather events may damage wastewater treatment and collection systems, flood septic tanks and thereby also increase the risk of contaminated groundwater. Previous flooding in The Bahamas resulted in contamination of the soil and groundwater with seawater, sewage, petroleum and agricultural pesticides – occurrences that could become more pronounced as climate change progresses. Furthermore, The Bahamas is already grappling with sea level rise that is causing saline intrusion of aquifers. These challenges could become increasingly difficult to manage as sea levels continue to rise over the coming decades.

- *Negative impacts on critical water infrastructure:* More intense hurricanes and other extreme weather, as well as heavier precipitation events, are expected to inflict significant damage on water storage, treatment and distribution infrastructure in The Bahamas. This may disrupt efforts to reliably distribute water to end-users throughout the country. This may also increase leakage rates precisely as the country is grappling with declining freshwater availability. The Government is currently working to reduce non-revenue water (NRW) rates in recognition of the fact that this constitutes an effective way to address looming water supply shortages.

Table 6 details freshwater availability per island in The Bahamas.

Table 6: Freshwater resources in The Bahamas

Island	Size (Acres)	Freshwater Lens (Acres)	LensArea/Size	Max. Daily Abstraction (MIG)	Water Available (IG/D) Person 1990 Census	Total Population 1990 Census
Abaco	415,360	116,280	0.28	79.10	7.906	10,003
Acklins	96,000	15,783	0.16	4.36	10,765	405
Andros	1,472,000	338,585	0.23	209.92	25,672	8,177
Bimini	7,040	395	0.06	0.17	104	1,639
Cat Island	96,000	14,774	0.15	6.80	4,005	1,698
Crooked Is.	58,900	5,923	0.10	1.74	4,223	412
Eleuthera	128,000	16,599	0.13	8.13	768	10,584
Exumas	71,680	6,586	0.09	2.90	816	3,556
Grand Bahama	339,200	147,884	0.44	93.17	2,278	40,898
Gt, Inagua	383,360	3,571	0.01	0.86	873	985
Long Island	147,200	9,301	0.06	2.88	977	2,949
Mayaguana	70,400		0.03	0.65	2,083	312
New Providence	51,200	2,340	0.34	9.63	60	172,196
TOTAL	**3,336,340**	**695,524**	**0.208**	**420.31**	**60,530**	**253,814**

Source: Water & Sewerage Corporation, 2007

1.3 Climate

The climate of The Bahamas is tropical marine, wet and dry with winter incursions of modified polar air from the North American continent (Bahamas Department of Meteorology, 2021).

The Bahamas Department of Meteorology (2021) characterizes the trade wind flow as “the single most important climatic agent affecting The Bahamas”. The trade wind is generated by the quasi-permanent Bermuda Azores anticyclone, which is a large area of high atmospheric pressure, covering part of the subtropical north Atlantic Ocean. The trade winds blow at an average speed of 8 knots, mainly from the east and southeast during the months of May to September and mainly from northeast and east during the remaining months. The trade winds are “relatively dry and yield fair-weather cumulus clouds with long period of bright sunshine, broken from time to time by weather systems” (Bahamas Department of Meteorology, 2021).

Summer conditions

"During the summer months, temperatures reach 32 degrees Celsius (90 degrees Fahrenheit) by day and afternoon showers or thunderstorms occur for up to an hour; [the latter] may be widespread and more prolonged when developing weather systems are affecting the islands. These systems include migratory areas of persistent rain, tropical waves and tropical cyclones. These latter may be tropical storms with winds up to 63 knots (73 miles per hour), or hurricanes with stronger winds." (Bahamas Department of Meteorology, 2021).

Winter conditions

"From about late October through April into early May, the trade winds flow from the east and northeast is interrupted by cold fronts which move south and southeast over North America into The Bahamas, followed by cold polar air and strong northwesterly breezes. In winter months, periods of a day or two of north and northeast winds of about 25 knots may occur. Winds gradually slacken as they shift through northeast, and return to east, their normal direction, over a varying period of up to four days.

Temperatures fall soon after frontal passage, sometimes going as low as the upper forties Fahrenheit, but gradually warm up as the wind returns to its normal easterly direction. These cold fronts from the leading edge of bursts of polar air from the continent and are the main winter feature. This cold air is modified as it traverses the warm Gulf Stream and ambient Bahamian waters, which save The Bahamas from the full frigid blast of the North America winter.

Although cold fronts can yield much rain, they pass through these islands once every five days and therefore the rainfall in winter is scant; the dry season is from November to April. January the driest month for New Providence has an average of 1.86 inches (47.24mm) of rain." (Bahamas Department of Meteorology, 2021).

1.3.1. Weather conditions

Temperature

"In centrally situated New Providence, winter temperatures seldom fall much below 60°F and usually reach about 75°F in the afternoon (the lowest recorded temperature was 41.4°F on 20 January 1981). In summer, temperatures usually fall to 78°F or less at night, and seldom rise above 90°F during the day. Winter temperatures are lower in more northerly islands than in New Providence, and about five degrees higher than in the south. In summer, temperatures tend to be similar all over The Bahamas. Winds are predominantly easterly throughout the year, but there has been a tendency to become northeasterly from October to April and southeasterly from May to September" (Bahamas Department of Meteorology, 2021).

The CMIP5 models included in the IPCC's Fifth Assessment Report (AR5) projected the mean annual temperature to increase by 0.8 - 2.3°C by the 2060's and 1.2 - 2.5°C by the 2090's (Nurse et al, 2014). Projected rate of warming is most rapid in the summer from June-August and September - November. Substantial increases in the frequency of 'hot' days and nights and decreases in the frequency of cold days and nights are projected to occur, with the most rapid changes occurring in the June - August period.

Rainfall

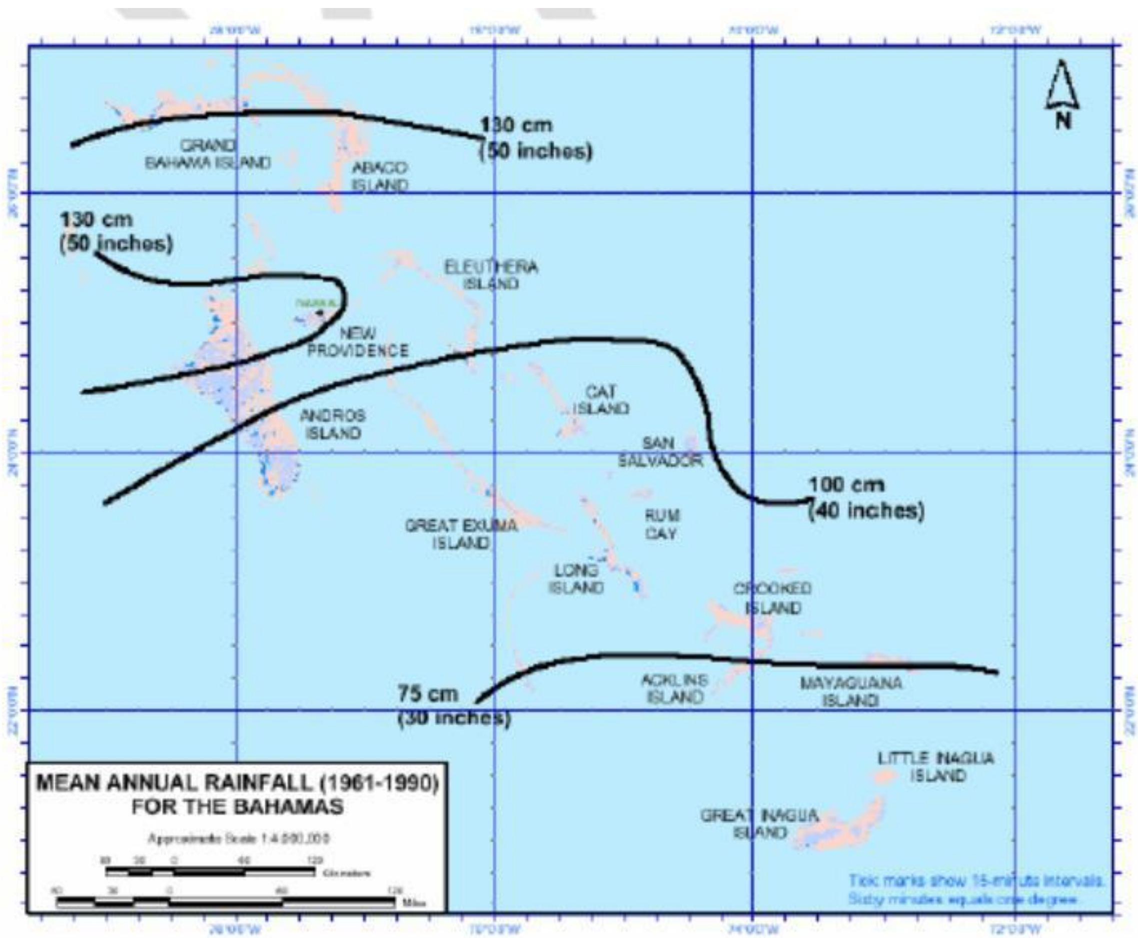
Rainfall is unevenly distributed across The Bahamas.

Figure 15 shows the distribution of rainfall for The Bahamas.

The north and north central Bahamas receive annually some 50 to 60 inches (1270 to 1524 millimeters) of rainfall annually, while in the southeast Bahamas, the rainfall decreases to some 36 inches (914 millimeters) annually. Moving across the archipelago, the average annual rainfall varies from about 60 inches (15.24mm) per year at Abaco in the northwest to less than half this amount at Inagua in the southeast.

There is a distinct dry season (November to April) and a pronounced wet season (May to October). The seasonal effects of tropical cyclones have a pronounced effect on annual rainfalls across The Bahamas. Additionally, winter storms flowing off the North American continent also impact rainfall during the normally dry period. However, this effect rarely extends into the central and southern Bahamas.

Figure 15: Mean annual rainfall for The Bahamas



Rainfall projections indicate decreases in rainfall for The Bahamas, mainly due to decreases in rainfall during the March-May and June-August periods. The decreases in the months from March to August however are partly offset by overall increases in rainfall in the September-November period.

The risk of drought increases along a southeastern gradient since the more southern islands already experience only half of the rainfall that falls in the more northern islands.

Additionally, since the weather of The Bahamas is influenced by ENSO events, the likelihood of drought is increased if El Nino episodes become more frequent and/or intense.

1.3.2. Hurricanes and other extreme events

Natural hazards to the country are tropical storms (including hurricanes), lightning, tornado and droughts. These are the extreme events that would cause major losses in the future in The Bahamas. There are other natural phenomena that have lower probability of affecting the country, such as floods and storm surge, but these can also result in significant local damage.

The Bahamas has a history of suffering major impacts from destructive storms and hurricanes. From 1871 to 2000, 186 hurricanes and 86 tropical storms passed within 160 km of The Bahamas (BEST Commission, 2014).

Hurricanes Maria and Irma in 2017 and Dorian in 2019 (a Category 5 Hurricane) have caused significant loss of life, evacuation of affected islands and damage to infrastructure and the economy in billions of dollars. Hurricane Dorian alone is estimated to have caused over US$ 3 billion in damages. These hurricanes happened shortly after Hurricanes Joaquin (2015) and Matthew (2016) which also inflicted significant damage on The Bahamas. Hurricanes have had dramatic negative impacts on economic development across The Bahamas (as outlined in Table 7)

During Hurricane Dorian, the wind speeds were up to 220 mph with gusts of 310 mph, Dorian decimated the islands of Abaco and Grand Bahama. In January 2020, the Government of The Bahamas reported the official deaths from Dorian as 71 persons and 282 persons missing. According to the official Census 2010, the islands of Abaco and Grand Bahama are home to approximately 17,000 and 51,000 residents respectively.

According to Shelter Cluster Bahamas, it is estimated that 9,000 homes were affected. Damage to the housing sector is estimated at US$1.48 billion, 88.9% of which took place in Abaco. The Ministry of Housing and Environment issued a Prohibition to Build Order for the Mudd, Pigeon Pea, Sand Bank and Farm Road shanty towns located on the island of Abaco, where a large number of vulnerable, irregular migrants used to live.

Table 7: Hurricanes impacting The Bahamas 2015 – 2019

Name of Hurricane	Active dates	Category	Estimates of loss and damage (US$)
Joaquin	28 Sep – 15 Oct 2015	4	120+ Million
Matthew	28 Sep – 10 Oct 2016	4	600 Million
Irma	30 Aug – 13 Sep 2017	5	135 Million
Dorian	24 Aug – 8 Sep 2019	5	3.4 Billion

Sources: NOAA, 2021; Bahamas Department of Meteorology, 2016; IADB, 2019; MOEH, 2018

1.3.3. Sea level rise

Sea level rise (SLR) and other oceanic climate change will result in salinization, flooding, and erosion. SLR will also affect human and ecological systems, including health, heritage, freshwater, biodiversity, agriculture, fisheries and other services. Increased heat in the upper layer of the ocean is also driving more intensive storms and greater rates of inundation, which, together with SLR, are already driving significant impacts to sensitive coastal and low-lying areas.

By the end of the 21st century, it is very likely that sea level will rise in more than about 95% of the ocean area and about 70% of the coastlines worldwide are projected to experience a sea level change within ±20% of the global mean (IPCC Global Warming of 1.5 °C Report, 2018).

1.4 Governance in The Bahamas

A sovereign nation since 1973, The Bahamas has a democratic, Parliamentary system of governance. The Head of State (King of England) is represented by the Governor-

General and the Government comprises the Executive Branch 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.

1.4.1. National government

Parliament constitutes the Legislative Branch and is a two-chamber system based on the Westminster model, with a House of Assembly and a Senate. There are currently 39 seats in the House of Assembly and 16 members of the Senate.

The Judiciary comprises the Court of Appeal and the Supreme Court. They function as independent institutions under the Constitution and are not Government departments.

1.4.2. Local government

Each island, with the exception of New Providence, is divided into Local Government districts under the Local Government Act 1996. There are 32 Local Government districts. Local elections are held every three years.

Local Government districts do not have revenue-raising powers; they receive transfers from Central Government. Their responsibilities include supply of potable water by standpipes, upkeep of public schools and other public buildings as well as general health and sanitation.

1.5 Population

The most recent published population census was in 2010. Approximately 30 of the over 700 islands are inhabited. The population of The Bahamas was estimated to be approximately 295,000 in 2000, growing at a rate of just over 1%. By 2010, The Department of Statistics recorded that the population growth increased to approximately 351,471 persons in The Bahamas. The key demographic indicators for 2020 and 2025 are outlined in Table 8 (Bahamas Census, 2010).

Table 8: Key Demographic indicators for The Bahamas 2020 and 2025

Demographic Indicator	2020 Projection	2025 Projection
Total population	389,410	408,930
Average annual growth rate	1.02	0.92
Number of births	6,040	6,260
Number of deaths	2,470	2,800
Natural increase	3,570	3,460
Total immigrants	400	300

Most of the population lives in urban areas, with two-thirds living on New Providence Island where the capital city of Nassau is located.

1.5.1. Living conditions

According the 2013 Bahamas Household Expenditure Survey, 58.5% of the dwellings in The Bahamas are separate, detached houses (houses that did not share walls, roofs, or floors with other houses). The second most significant type of dwelling is single, attached houses (24.8%), while apartments or flats account for 15.1% of total dwelling units. In New Providence, there is a higher proportion of separate, detached houses (27.3%) and of apartments or flats (16.5%), while in Grand Bahama and Family Islands is significantly higher the proportion of separate, detached houses (66.8% and 70.2%, respectively).
There seems to be a positive relation among the percentage of households living in separate detached houses and the level of per capita consumption of the quintile: the proportion of households living in separate detached houses tends to increase when consumption level grows.

The average number of rooms of a Bahamian dwelling is 4.2, with 2.6 bedrooms. Dwellings in Grand Bahama have, on average, more rooms (4.5), while the opposite is true for dwellings in Family Islands (3.9). The numbers of rooms in the dwelling increases as the level of per capita consumption expenditure of the household increases. Over fifty-night percent (59.2%) of the households in The Bahamas have access to public water piped into the dwellings, and 33.1% have a private source of water piped into the dwelling. At the regional level there are some differences: in Grand Bahama the percentage of households with public water piped into the dwellings is 94%, but in New Providence and Family Islands this percentage decreases to 52% and 59%, respectively.

Regarding the access to lighting, the information presented shows that electricity is the main lighting source (98%). The rate of coverage is almost the same as the national level in New Providence and Grand Bahama, but in the Family Islands, the rate of coverage is lower (96%). Electricity is the main source of lighting for households across all consumption quintiles. However, a significant proportion (almost 8%) of households in the poorest quintiles tends to use kerosene, oil or gas lamp as source of lighting.

At the national level, 74% of the households have toilets attached to a cesspit or septic tank and for 14% of the households the toilet is linked to public sewer. Only 0.6% of households report having no toilet.

The three most important expenditure items for total population, in terms of its budget share, are the following:

- housing, water, electricity, gas and other fuels (46.7%);
- transportation (13.8%); and
- food and non- alcoholic beverages (11.9%).

For the poorest 10% of the population, the budget share of food and non- alcoholic beverages climbs to 24.7%, while the budget share of transportation decreases to 7.4%. The overall poverty rate in The Bahamas is 12.5 %. New Providence and Grand Bahama present similar or lower poverty rates (respectively 12.4% and 9.4%) whereas Family Islands have a higher rate (17.2%). Hence, poverty rates are higher in rural communities. However, the majority of the poor (71.5%) are located in New Providence (Bahamas Household Expenditure Survey, 2013).

1.5.2. Migration trends due to hurricanes and other extreme events

All the major hurricanes in the past 7 years have resulted in displacement of people. As of January 2020, the International Organization for Migration (IOM) estimated that 2,000 internally displaced people were still residing in collective centres, rental apartments and with host families in New Providence following Hurricane Dorian.

The Internal Displacement Monitoring Centre (2020) estimated that 9,840 people were displaced due to Hurricane Dorian. The majority of persons displaced were from the islands of Abaco and Grand Bahama, which were hardest hit by the storm. Most of them were evacuated to New Providence, while approximately 500 went to Eleuthera; some migrated to the United States and Canada with the help of extended family members. According to the Miami-based Consul General of The Bahamas, an estimated 650 people now reside in Florida.

Two months following Dorian, 3,142 displaced people returned to Abaco. The majority were men who returned to their home communities where they lived in tents and began clean-up and reconstruction efforts (IDMC, 2020).

1.6 Economy

The economy of The Bahamas is primarily dependent on tourism and financial services. Tourism accounts for approximately 50% of GDP; financial services account for about 15% of GDP (Government of The Bahamas, n.d.). Manufacturing and agriculture contribute approximately 7% of GDP. Public debt increased in 2017 largely due to hurricane reconstruction and relief financing.

Due its heavy reliance on tourism, the country is vulnerable to changes in the global economy. The 2017 assessment by the Central Bank of The Bahamas showed very mild growth of the economy. The country’s GDP was US$12.16 billion in 2017 with tourism accounting for more than 50%, financial services about 20% and the balance spread among retail and wholesale trade, fishing, light manufacturing and agriculture. The Bahamian tourism infrastructure supports approximately 1.5 million stopover visitors and 3.5 million cruise visitors annually. Just under 50% of the labour force is directly employed in tourism. When one adds persons indirectly employed, this increases to 70%.

Most of the infrastructure and settlements of the islands are located along or near to the coast where they are particularly vulnerable to flooding and sea level rise which will have serious economic and social implications for residents and for sectors of the economy, particularly the tourism sector.

Table 9 provides information on GDP per capita since 2000 along with unemployment rates. Table 10 provides nominal GDP by island with percentage change from 2015 – 2019. Of the 2019 GDP of $13,578 billion in nominal (current) dollars, New Providence represented $10.114 billion (74%), Grand Bahama $1.876 billion (14%) and other Family Islands grouping, the remaining $1.588 billion (12%). The high percentage for New Providence was primarily due to high levels of construction and tourism activity as well as gains in economic activity, stemming from the relocation of persons from hurricane-affected islands to the capital. Grand Bahama's overall increase in 2019 was supported by increases in contribution from construction, accommodation, and food services sectors.

Table 9: The Bahamas unemployment rate and GDP per capita

Year	**Unemployment rate**	**% change**	**GDP per capita, current prices**	**% change**
2000	7	-10.21%	25823.64	4.79%
2001	6.9	-1.43%	26682.62	3.33%
2002	9.102	31.91%	27436.9	2.83%
2003	10.835	19.04%	27206.74	-0.84%

2004	10.202	-5.84%	27802.01	2.19%
2005	10.17	-0.31%	29249.63	5.21%
2006	7.628	-25%	30518.48	4.34%
2007	7.853	2.95%	31412.35	2.93%
2008	8.703	10.82%	30914.64	-1.58%
2009	14.246	63.69%	29510.23	-4.54%
2010	15.082	5.87%	29978.72	1.59%
2011	15.889	5.35%	30452.46	1.58%
2012	14.367	-9.58%	31641.21	3.9%
2013	15.782	9.85%	31710.07	0.22%
2014	14.636	-7.26%	31905.94	0.62%
2015	13.379	-8.59%	32224.26	1.0%
2016	12.15	-9.19%	31672.41	-1.71%
2017	10.1	-16.87%	32376.79	2.22%
2018	9.2	-8.91%	33494.19	3.45%
2019	9.046	-1.67%	34421.23	2.77%

Source: International Monetary Fund, 2019

Table 10: Nominal GDP by Island 2015 – 2019 (in B$ Million)

ISLANDS/YEARS	2015	2016	2017	2018	2019
New Providence	8,258	8,524	8,950	9,513	10,114
NP % change		3.2%	5.0%	6.3%	6.3%
% of Total GDP	71%	71%	72%	73%	74%
Grand Bahama	1,980	2,025	2,008	1,833	1,876
GB % change		2.3%	-0.8%	-8.7%	2.3%
% of Total GDP	17%	17%	16%	14%	14%
Family Islands	1,473	1,380	1,533	1,676	1,588
FI % change		-6.3%	11.1%	9.3%	-5.2%
% of Total GDP	13%	12%	12%	13%	12%
All Bahamas	11,711	11,929	12,491	13,022	13,579
All Bah % change		1.9%	4.7%	4.3%	4.3%

Source: Bahamas Department of Statistics, 2019

1.6.1. Energy

The electricity and transport sectors are the main users of fossil fuels in the country. The two major utility companies in the country, Bahamas Power and Light Company Limited (BPL) and Grand Bahama Power Company respectively generate 438 MW and 98.5 MW of power (Bahamas National Energy Policy, 2013).

The high dependency on imported oil, almost 100%, has made energy production in The Bahamas vulnerable to global oil price fluctuations, making budgeting and reinvestment into equipment difficult for state-owned electricity company, Bahamas Power and Light Company Limited (Holdom, 2019), as well as other energy providers. This has resulted in significant debt to BPL and the reliance on price increases to maintain its service.

For renewable energies to supply more than 20% of The Bahamas' power needs, different islands must be interconnected to enable electricity to flow between them. This was the recommendation from the National Energy Policy Committee's second report presented to the Government in April 2011 that also urged the Government to focus on deploying water heaters, bio-energy and nearshore wind power as renewable energies in the short-term.

The Bahamas National Energy Policy 2013 – 2033 was designed to ensure that by 2033 The Bahamas has "a modern, diversified and efficient energy sector, providing Bahamians with affordable energy supplies and long-term energy security towards enhancing international competitiveness and sustainable prosperity".

In an effort to achieve the targets set by the Policy, the Government has developed and implemented a number of projects including:

- **Ragged Island Microgrid** – A hybrid solar-battery microgrid coupled with an existing diesel plant is being developed on Ragged Island for power generation. Previous power generation was approximately 100% diesel. Once completed, the capacity of the microgrid will be 402 kW.

- **Solar car park** – A 925 kW-solar array has been installed at the Thomas A. Robinson Sports Centre car park. The installation is estimated to displace 310,000 litres of diesel and offset 856 tonnes of carbon dioxide annually. The system has been designed to withstand extreme weather conditions with winds of up to 160 mph. The power generated at the facility feeds into the national grid and also provides power to charging stations for electric cars free of charge to the public (The Tribune, 2019).

Other mitigation measures are further outlined in the Chapter 4 of this TNC.

1.6.2. Transport

The Bahamas has 13 international airports and numerous smaller Government-owned and private airports with regularly scheduled flights across the island chain and to various parts of the world. 23 seaports span the archipelago, facilitating regular shipping connections to Europe and the Americas. The ports in Nassau and Freeport are major international transshipment centres, servicing both tourism and commerce.

Electric vehicles (EVs) sales have continued to increase annually in The Bahamas. From 2019 to 2020, there was a 133% increase in sales and sales for 2021 are on track to be higher (Tribune, 2021). Tax incentives for purchasing electric vehicles include lower import duty of 10% (for EVs under $70,000) and 25% (for EVs over $70,000) compared to vehicles powered by fossil fuels. Government agencies, including BPL, have also begun transition to include electric vehicles as a part of their vehicle fleet.

1.6.3. Water

In general, water resources vary between islands and the supply-demand balance is highly dependent on population density. New Providence, which is the main population centre, has far less water available in freshwater lenses than is needed, and therefore relies heavily on reverse osmosis plants. Although there is not yet a net shortage of water on many islands, the population centres on each island have a major deficiency.

The Water and Sewerage Corporation (WSC) is the country’s main water supplier; the Corporation is owned by the Government and falls under the portfolio of the Ministry of

Works and Utilities. The Water and Sewerage Corporation Act of 1976 established WSC and defines the responsibilities of the Corporation. WSC has a Water Resource Management Unit (WMRU) to manage water resources and water quality.

The water sector is identified as a national priority for climate change adaptation in the first Nationally Determined Contribution (NDC) for The Bahamas, and previously in the National Climate Change Adaptation Policy.

Agricultural practises have negatively impacted the water quality of The Bahamas. Studies on water quality have found traces of pesticides within the available freshwater. Floods are a particular problem in agricultural landscapes due to the erosion of the topsoil and the flushing of pesticides, fertilisers, animal waste and sewage into water sources. There is also increasing evidence of contaminants such as hormones, endocrine disruptors and drugs in the water supply. To safeguard water security in a changing climate, it is essential that The Bahamas minimize the extent to which climate change exacerbates these trends and risks.

Internally, WSC is making strides to assess, retrofit and fortify existing infrastructure to become more climate-resilient as well as implementing climate resilience for new construction. A project funded by the Caribbean Development Bank and the Bahamas Government is focused on increasing climate resilience for water infrastructure on five Family Islands.

1.6.4. Tourism

Tourism sector is the major driver of the Bahamian economy. In 2019, there were more than 7.2 Million visitors to The Bahamas even with destinations in Abaco and Grand Bahama being severely impacted by Hurricane Dorian. A significant decline in visitor numbers is expected for 2020 and 2021 due to COVID-19. Initial estimates indicate that stopover visitors for the country for 2020 was 452,640 versus over 1.8 Million in 2019, representing a decrease of 75% (Ministry of Tourism, 2021).

Accommodation is the most vital component of the tourism product and the tourist destination. There are approximately 65 hotels in Nassau, with 8,688 rooms. In The Bahamas there are 270 hotels with 14,797 rooms (Ministry of Tourism, 2021). Other components of the sector include food and beverage, recreation, transportation, attractions and conferences.

A 2011 ECLAC report on the economic impact of climate change on the Bahamian tourism sector noted the following:

The Bahamas is at great risk and vulnerability given its geographical features as a low-lying, sea encircled country. If projected sea level rise is reached by 2050, between 10-12% of territory will be lost, especially in coastal zones where the main tourism assets are located…The second and no less important threat is tropical cyclones, which may be associated with raising sea level. Estimations posited the amount of losses in excess of 2,400 million US$ for the four decades under examination…In the same period, total estimated impacts of progressive climate change are between 17 and 19 billions of B$ with estimated discount rates applied.

1.6.5. Agriculture – crops and livestock

Different types of land use in The Bahamas include (2016 estimates):

- Agricultural land – 1.4% which includes:
    - Arable land – 0.8%
    - Permanent crops – 0.4%
    - Permanent pasture – 0.2%
- Forest – 51.4%
- Other – 47.2%

Land classified as other includes developed areas, roads, other transportation features, barren land and waste land.

Approximately 90% of the available agricultural land is owned by the government and leased to farmers. Of the 95,000 ha of arable land in the country, only 7,650 ha is under cultivation, with two very distinct systems of agricultural production: mechanized methods in the northern islands that receive more rainfall and have large underground freshwater reserves; and shifting cultivation in the central and southern islands that are characterized by subsistence farming. More than 5,000 acres of agricultural land in The Bahamas are used for citrus production. Major crops for export are grapefruit, limes, avocados, papaya, okras and pineapples. The soils in the country are generally poor in terms of nutrient availability and water holding capacity, so farmers rely on heavy inputs of chemical fertilizer.

A 2014 IICA-IFAD report on climate-smart agricultural production in The Bahamas noted the following concerns about the impacts of climate change which were raised by smallholder rural producers and other stakeholders in the agricultural sectors:

- Crop loss and infrastructure damage (e.g. access roads washed out) due to hurricanes;
- Variability of access to freshwater due to unpredictable rainfall. There seems to be variation from drought to flood in any given year. This also impacts recharge of groundwater lenses which some farmers use for irrigation;
- Lack of information available to them about climate change and its potential impacts on their farms. Farmers want there to be more training opportunities and more communication from the Ministry of Agriculture, Marine Resources and Local Government and the Department of Agriculture; and
- Insurance for farmers so that they can receive at least 15% of the value of their farms in the event of a hurricane or storm surge. After Hurricane Sandy, farmers in Cat Island were given $75 - $100 by the Ministry as damage assistance.

Some of the recommendations for the same report to facilitate climate-smart agriculture in the country include:

- Replacement of traditional slash-and-burn systems with agroforestry systems, greenhouse production and/or hydroponics. These methods are already being used by some farmers.
- Increase soil carbon stocks through restoration of degraded lands and conservation agriculture.

- Using drought-resistant and salt-tolerant varieties of crop species.
- Identification of lands that are best suited for agriculture over the long-term, considering sea level rise and SLOSH (sea, lake and overland surges from hurricanes) modeling, and designation of these areas as agricultural lands.
- Development of policies to build economic resilience at the farm level (e.g. provision of insurance, securing land tenure).
- Training for farmers in sustainable soil and water management practices. This could involve local preparation of bio-fertilizers and bio-pesticides to reduce dependency on expensive, imported fertilizers and to replace hazardous agro-chemicals being used in local agriculture (Sanchez Hermosillo, 2011). Inter-cropping or alley cropping were also recommended; inter-cropping was observed on small farms in Cat Island.

1.6.6. Fisheries

The fisheries sector plays an important role in the Bahamian economy in terms of foreign currency earnings, food supply and employment. The commercial fisheries sector supplies 31 kg/capita/year of fish and fishery products to the population, generates some US$80 million annually in export earnings and provides full-time employment to 9,300 commercial fishers and thousands of jobs more in recreational fisheries, vessel maintenance, fish processing, retail and trade. The fishing fleet is characterized as small-scale and counts approximately 4,000 fishing vessels ranging in length from 3 meters to 30 meters, but generally less than 7 meter in length.

The total commercial fisheries production in 2015 was estimated at nearly 12,000 tonnes. The total production has fluctuated in recent years. Fluctuations are largely caused by the variations in landings of spiny lobster, which were nearly 10,000 tonnes in 2010 and 2012 and around 6,500 tonnes in 2015 (FAO, 2021).

Spiny lobster stocks in The Bahamas are being fully exploited, while conch, snappers and groupers are, like in the rest of the Caribbean, under heavy fishing pressure and some stocks are probably overexploited. The major threats to the marine fisheries resources are coastal zone development, boat and diver damage to the reef, over-harvesting of commercial species and disturbance to sensitive sites.

The recreational and sport fisheries subsector of the fisheries sector is also very important to the country contributes an estimated US$500+ million annually to the national economy through related expenditures by tourists and provides employment for some 18,000 Bahamians. The recreational and sport fisheries target game fish, such as marlins and sailfishes, as well as bone fish.

1.6.7. Industry

Industry includes activities such as light manufacturing and resource mining, particularly for aragonite. There has been recent consideration by the Government of oil exploration. Oil refining is presently occurring on Grand Bahama. Grand Bahama is the most industrialized of the Bahamian islands with an industrial sector which includes a container port, shipyard, oil refining, storage and transshipment, cement manufacturing, and pharmaceutical manufacturing.

1.6.8. Construction

The entire Bahamas due to its size and topography is vulnerable to the impacts of climate change. Increased development along coastlines tends to increase coastal erosion and therefore vulnerability of populations. Yet coastal development is one of the primary income generators of the country, and therefore this dichotomy has engendered conflicting approaches to management of coastal resources. Most of the critical infrastructure in the country (e.g. ports, roads, power stations) is found in vulnerable coastal areas.

1.6.9. Finance

The sector consists of commercial banks, savings banks, trust companies, offshore banks, insurance companies, a development bank, a publicly controlled pension fund, a housing corporation, a public savings bank, private pension funds, cooperative societies and credit unions. Capital and money market activities received a significant boost in

2000, with the introduction of The Bahamas International Securities Exchange (BISX), which operates alongside the informal over-the-counter exchange of public sector bonds and bills, which is administered through the Central Bank.

The array of financial services in The Bahamas also includes international business companies (IBC), mutual funds, and insurances services. The IBC is a flexible form of corporate vehicle governed by the International Business Companies Act, 2000. IBCs can only be incorporated by a bank or trust company - which is regulated by the Central Bank - or a person licensed under the Financial and Corporate Services Providers Act, 2000. Mutual funds operating in The Bahamas take the form of either managed investment companies with shares, or trusts with units representing ownership.

A significant number of insurance companies are also registered to operate in or from within The Bahamas. While many of these insurance companies service the domestic risk needs of The Bahamas, a number were also established to insure risks situated elsewhere in the world.

1.6.10. Waste management

Bahamians and visitors together generate more than 264,000 tons of municipal solid waste annually (World Bank, 2016) with New Providence contributing about 77% (GIS, 2016) and Grand Bahamas 17% of this total, leaving only about 6% or 15,800 tons annually generated on the Family Islands.

The typical mode of solid waste disposal on the Family Islands is to dump at formal sites near main settlements, burn and sporadically push aside the burned material to make room for more refuse. Almost all sites are unregulated, have debris spread over wide areas and are contaminating water supply areas. Indiscriminate dumping along roadsides is common on all islands, including New Providence. Some islands do have sanitary landfills that are maintained and some resorts operate a system of daily waste management geared toward maintaining compost bins, segregating, preparing and transporting bottles and cans for shipment to recycling facilities overseas.

New Providence Ecology Park (NPEP) is a private entity that has been engaged by the Government to manage the landfill on New Providence. NPEP has undertaken several activities to improve waste management at the landfill including:

- Consolidating and capping over 80 acres of waste;
- Implementing rigorous solid waste handling practices; and
- Commencing recycling and recovery activities for construction demolition debris and vegetative waste.

Future plans include landfill gas collection and recycling infrastructure as well as a public green space on reclaimed landfill property.

The Bahamas first large-scale biodiesel production facility was opened in February 2011 by Bahamas Waste Limited. It will allow for up to one million gallons of waste cooking oil collected from restaurants in Nassau, such as McDonald's, Burger King, KFC and Wendy's, as well as cruise ships to be processed and converted into biodiesel each year. Currently, four Bahamas Waste trucks are using a 50:50 blend of biodiesel to petroleum diesel. The company hopes to eventually run its entire fleet of 50 vehicles off of 100% biodiesel as production increases.

1.6.11. Health

The Bahamian government is making a conscious effort to improve its health care system, investing around 8% of its GDP into health care in 2018, and building new hospitals and facilities. Public health services are delivered through a network of 57 community clinics and 54 satellite clinics in New Providence and the Family Islands (PAHO, 2021). For those living on smaller islands without medical facilities, travel by boat or plane is required. The Public Hospitals Authority in the Bahamas oversees the quality of the three public hospitals in The Bahamas. These three hospitals are the Princess Margaret Hospital, the Sandilands Rehabilitation Centre, both on New Providence, and the Rand Memorial Hospital on Grand Bahama. There are also two main private hospitals in The Bahamas, both on New Providence - Doctors Hospital and Lyford Cay Medical Facility.

The National Health Insurance (NHI) programme was launched in 2016 and offers Bahamian residents access to primary health care, which is free at the point of service. While the government is initially paying for the care offered, this is expected to change in the future with NHI members and their employers being required to pay up to 1.5% of their income towards the programme.

Despite initiatives like NHI, many Bahamians still struggle to access the health care they need. The majority of Bahamians do not have health insurance and are unable to afford the high costs of secondary (specialists such as cardiologists) and tertiary medical care (such as surgeries).

There are a number of projects underway to mainstream climate change into the health sector. These include:

- **Developing a climate resilient health system in The Bahamas** – Through funding from the Green Climate Fund, the project will result in the development of climate change-specific chapters as a part of The Bahamas National Health System Strategic Plan (NHSSP). These chapters will address resource mobilization, SMART health facilities and policies, and health workforce to address climate change and health mainstreaming. The project will also enhance national public health surveillance systems of hospitals and primary care clinics and strengthen communication across agencies to respond to climate change impacts.
- **EU/CARIFORUM climate change and health project** – The objective of this project is to improve the capacity of Caribbean countries (including The Bahamas) to reduce the negative impacts of climate change on health. Benefits of the project to The Bahamas will include development of a health adaptation plan to advance national climate change and health prioritization and financing; strengthening of water, sanitation and food safety systems to be more resilient to climate change; and a national climate informed disease surveillance and modelling system.

1.6.12. Education

Education is available to all segments of the Bahamian population and is compulsory to children aged 5 to 16. There are 170 public schools in the country; total enrollment for K-12 is more than 50,000.

The Bahamian education system is structured in a 6-3-3 format. The first cycle is primary education, which lasts for six years and is designed to cater to students aged five to eleven. Secondary education is divided into two equal parts of three years' duration; junior high is designed to accommodate students from age 11 to 14 while it is expected that students aged 14 to 17 attend senior high. Although not yet mandatory, education at the preschool and post-secondary levels is rapidly expanding (MOEST, 2020). Climate change is incorporated into the national curriculum beginning in primary school at fourth grade level.

An example of climate change activities at school was a climate change workshop held at Columbus Primary School for fourth and fifth grade students; the students learned about global warming, climate change, and its impact on the environment. The workshop was a collaborative effort between the Science Specialist at the Sadie Curtis and Columbus Primary Schools and Innovative Science, a private sector organization that provides interactive science experiments for primary school children.

The Bahamas has further strengthened its commitment to climate education, with the appointment of an Action for Climate Empowerment (ACE) Focal Point in the Ministry of Education.

Tertiary education is provided at the University of The Bahamas (UB), which offers both associate's and bachelor's degrees in the arts and sciences. The Climate Change Adaptation and Resilience Research Centre (CCARRC) is a part of UB. Established in 2019, the Centre serves as a resource for SIDS and coastal communities throughout the world to effectively address the human dimensions of climate change. The Centre focuses on the impacts of climate change on societies in at-risk regions and how members of these communities can best prepare for and respond to the many risks posed by climate change.

There are also a number of privately-run institutions that also offer associate degrees and are affiliated with tertiary educational institutions in the United States. Technical and vocational training is available at the Bahamas Technical and Vocational Institute (BTVI) (PAHO, 2021).

Considerable efforts have been made within the past ten years to incorporate technology in the both public and private schools in The Bahamas. To date, Almost 5 million dollars was spent in the last 2 years to install computer labs, and E-literacy capabilities in every junior and senior high school in The Bahamas.

The Ministry of Education has implemented training programmes for teachers to ensure that they are able to teach technology to students and improve achievement levels using this vital teaching tool.

The Ministry of Education also works with non-Governmental agencies on climate change education including:

Bahamas Reef Environment Educational Foundation (BREEF) – BREEF provides teacher training programmes every summer. It also produces teacher resource materials including a guide for educators on consumers, corals and climate change.

1.6.13. Social Services

The Department of Social Services provides food, financial services, counselling, advocacy, education, health and wellness, shelter and housing, and protection services. There are 13 divisions within the Department including a Disaster Management Unit.
The Disaster Management Unit (DMU) is primarily responsible for hurricane shelter management. The Unit is also tasked with assisting in national disaster preparedness and mitigation efforts relative to all natural and man-made events and disasters

throughout The Bahamas. DMU works in partnership with the National Emergency Management Agency (NEMA) and in compliance with the National Disaster Plan.

Benefits offered by the Department of Social Services following Hurricane Dorian included food assistance, home repair, assistance to purchase beds and appliances (up to $2,000), rent assistance for displaced hurricane victims (up to $700 per month), and burial assistance for persons who died during the hurricane (up to $5,000) (Freeport News, 2020).

1.7 National Priorities

National priorities specifically related to climate change are included in the 2001 First National Communication, 2014 Second National Communication, 2004 National Policy for Adaptation to Climate Change and the 2015 Intended Nationally Determined Contributions (INDC), and 2022 Updated Nationally Determined Contributions (NDC)

Other national policies and plans that identify priorities with respect to climate change include:

- 1968 Coastal Protection Act
- 1997 Conservation and Protection of the Physical Landscape of The Bahamas Act and Regulations
- 1999 National Biodiversity Strategy and Action Plan
- 2003 The Bahamas Building Code – 3rd edition – Ministry of Works and Utilities
- 2004 National Wetlands Policy
- 2004 The Environmental Health Services Act
- 2005 National Environmental Management and Action Plan
- 2006 The Planning and Subdivision Act
- 2009 The Utilities Regulation and Competition Authority (URCA) Act
- 2010 Disaster Preparedness and Response Act
- 2013 The Bahamas National Energy Policy 2013 -2033
- 2013 The Montreal Protocol (Controlled Substances) Act (Cap. 216A) and Customs Management (Amendment) Act of 2013

- 2013 National Invasive Species Strategy
- 2014 Forestry Act (Amended 2014) and Forestry Regulations
- 2015 National Maritime Policy
- 2015 SIDS DOCK
- 2015 Electricity Act (Renewable Energy) (Amended)
- 2015 Water and Sewerage Corporation Act (Amended)
- 2017 National Tourism Development Strategy 2017-2022
- 2019 Environmental Planning and Protection Act
- 2019 Environmental Protection (Control of Plastic Pollution) Act, 2019
- 2020 Bahamas Power and Light (BPL) requirements for grid interconnection of small-scale renewable energy generation systems
- 2021 National Biodiversity Strategy and Action Plan
- 2021 Civil Aviation Authority Bahamas (CAAB) Environmental Regulation
- 2022 Climate Change and Carbon Market Initiatives Act Bill
- 2022 Carbon Credit Trading Act Bill
- 2022 Grand Bahama Power Company (GBPC) rules and regulations for Renewable Generation Systems (RGS)
- 2022 Disaster Risk Management Act

A National Development Plan (NDP) was drafted in 2017, but has not been approved by Cabinet to be considered an official national document. The drafting of plan involved consultations across the country. Goals in the draft plan relevant to climate change include development of modern infrastructure in the country built to withstand the effects of climate change and rising sea levels and positioning The Bahamas as a leader in researching and implementing climate change adaptation and mitigation measures and as an incubator of green technologies.

The SDG informed policy recommendations report by the National SDGs Technical Committee and SDG Unit of the Office of the Prime Minister made the following climate change recommendations (OPM, 2020):

- Ensuring that support is not given to industries or practices that are not climate resilient including stockpiling oil, encouraging oil drilling or development that increases vulnerability to the impacts of climate change;
- Strengthen national social protection systems and the coherence of disaster management and climate change adaptation policies;
- Build national climate change expertise through capacity development to prepare and respond to all climate risks;
- Increase the number of communities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, and resilience to disasters; and
- Promote mechanisms for raising capacity for effective climate change-related planning and management, focusing on women, youth and local and marginalized communities.

Moreover, in January 2022, the Climate Change & Environmental Advisory Unit (CCEAU) was established, as the technical advisory arm of the Office of the Prime Minister (The Bahamas) to provide support on matters of the blue and green economy, renewable energy, reduction in the use of fossil fuels, carbon credits, large scale climate change mitigation and adaptation projects, climate risk insurance and the other progressive climate policy agenda items.

1.8 The Environment

The environment of The Bahamas is characterised by coastal and marine habitats and ecosystems that are areas with high productivity, biological diversity and natural beauty (Newbold, 2016). These attributes have been the foundation of the country's tourism-based economy for decades and provide opportunities for sustainable livelihoods, including ecotourism and sustainable harvesting. Sustainable forestry is an area that the Government is exploring through the GEF Pine Islands project. Sustainable fisheries is being promoted through the Marine Stewardship Council certification program for spiny lobster in The Bahamas.

Exploring opportunities for economic growth linked to sustainability and the environment are vital for The Bahamas. The country must find ways to adapt to the shocks of increasingly frequent hurricanes associated with climate change. If immediate and significant mitigation action is not taken globally, even diversifying its economy to these sectors may not make The Bahamas sufficiently resilient to the severe impacts of climate change.

1.8.1. 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. Coastlines of New Providence, in particular, have been extensively cleared for hotels, luxury housing complexes and private homes. The interior of the island is also subject to unprecedented urban sprawl. Large tracts of land are being cleared for housing and business developments as well as road construction. Other islands in the archipelago have also been affected by rapid urbanization and development.

The lumber industry in the 20th century devastated the pine forests of The Bahamas. A sawmill operated in Abaco until 1943, and then 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 species 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 as 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. 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.

1.8.2. Marine and coastal habitats

Marine and coastal habitats of The Bahamas include coral reefs, seagrass beds, mangroves, sandy beaches, and rocky shorelines. The health of these habitats are important to ensuring resilience of the islands of The Bahamas. With unplanned and unregulated development, these are often some of the most impacted habitats, particularly for tourism-based development.

The Bahamas Coral Reef Report Card, Volume 2011 – 2013 classifies Bahamian reefs as impaired overall (Dahlgren et al, 2016). Other key findings of the report include (Dahlgren et al, 2016):

1) Lower live coral cover on Bahamian reefs than on other Caribbean reefs;
2) Low coral recruitment (though similar to the rest of the Caribbean);
3) Reef structure, parrotfish populations were scored as fair in most areas surveyed; and

4) Large groupers were fairly common on Bahamian reefs but practically absent from the rest of the Caribbean. Grouper populations were healthiest in the Exuma Cays. It is important to note that the Exuma Cays Land and Sea Park is a marine protected area in the Exuma chain.

Key threats to coral reefs include climate change. Climate-related changes in habitat include coral bleaching as a result of increasing sea surface temperatures, rising sea levels, and coastal erosion. Impacts on the marine environment specifically, will be felt across ecosystems like coral reefs, and mangroves due to changes in sea level. With changes to these ecosystems, we may also see changes in populations of marine and terrestrial organisms that are dependent on these ecosystems for the various ecosystem services they provide (NBSAP, 2021).

1.8.3. Biodiversity

The distinct environment of The Bahamas gives rise to numerous irreplaceable habitats and species, including vast expanses of Caribbean pine forest, tidal flats with thriving bonefish populations, extensive barrier reefs, the highest concentration of blue holes in the Western Hemisphere, and critical fish nursery habitat believed to contribute significantly to fisheries stocks throughout the Caribbean region. The insularity and extensive carbonate shelf with productive coral reefs and other habitats, plus a large area of coastal wetlands, especially mangrove forests, contribute to the abundance and diversity of fish. Rare, critically endangered, and endemic species can also be found in The Bahamas including the Bahama parrot, several species of Rock iguana, Kirtland’s warbler, West Indian flamingo, Hutia, Smalltooth sawfish, Queen conch, and Loggerhead, Hawksbill, and Green turtles.

Important, and easily-recognized, Bahamian ecosystems include — but are not limited to — the following:

- Pine woodland (forest) – northern islands
- Coppice – central and southern islands

- Wetlands – may be allocated amongst five categories: mangrove swamps and marshes, beach vegetation, swashes, pine forests/barrens, broad-leaf coppice. Mangroves are dominated by one or more species of mangrove (*Avicennia, Laguncularia* and *Rhizophora,)*.
- Seagrass beds – dominated by turtle grass (*Thalassia testudinum*)
- Coral Reefs – of great significance in terms of Bahamian biodiversity
- Other shallow water marine habitats – rock and unvegetated sediments
- Caves, sinkholes and blue holes

In partnership with BirdLife International, the Bahamas National Trust (BNT) is in the process of developing a climate change adaptation strategy for the national parks and Key Biodiversity Areas (KBAs) on the islands of Grand Bahama, Abaco, New Providence, Andros, Eleuthera, Exuma, San Salvador and Inagua.

1.9 Institutional arrangement for preparation of NCs and BURs

The UNFCCC has prepared a toolkit to provide recommendations to non-Annex I Parties on establishing and maintaining institutional arrangement for preparing national communications (NCs) and biennial update reports (BURs). These recommendations include the following (UNFCCC, 2013):

- A single body be designated to be responsible for the overall coordination and management of the process and preparation of NCs and BURs.
- Due to volume and diversity of information required to prepare these reports, providers of key information should be identified and their roles and responsibilities within the process clearly defined.
- It is strongly recommended that the process, roles and responsibilities, including procedures for the flow of information, be formalized through an MOU or other formal agreement between the coordinating body and key stakeholders.

The initial discussion of institutional arrangements was held during stakeholder workshop for the Project Identification Plan phase of this project. Through the development of the TNC, these discussions have been further refined.

1.9.1. Current institutional arrangements

The Bahamas has never submitted a Biennial Update Report. However, past reports to the UNFCCC including its FNC and SNC were prepared through a collaborative effort of the National Climate Change Committee (NCCC) under the Bahamas Environment, Science and Technology (BEST) Commission (now the Department of Environmental Protection and Planning, DEPP). Experts from various Government and non-Governmental organizations were members of the Committee and responsible for either drafting sections of each Communication or reviewing sections. Some sections were developed by consultants, such as greenhouse gas inventory and vulnerability and adaptation assessments. A project manager was tasked with ensuring all the information provided by both Committee members and consultants was compiled into the final reports.

Figure 16: Institutional framework for 2001 First National Communication (FNC)

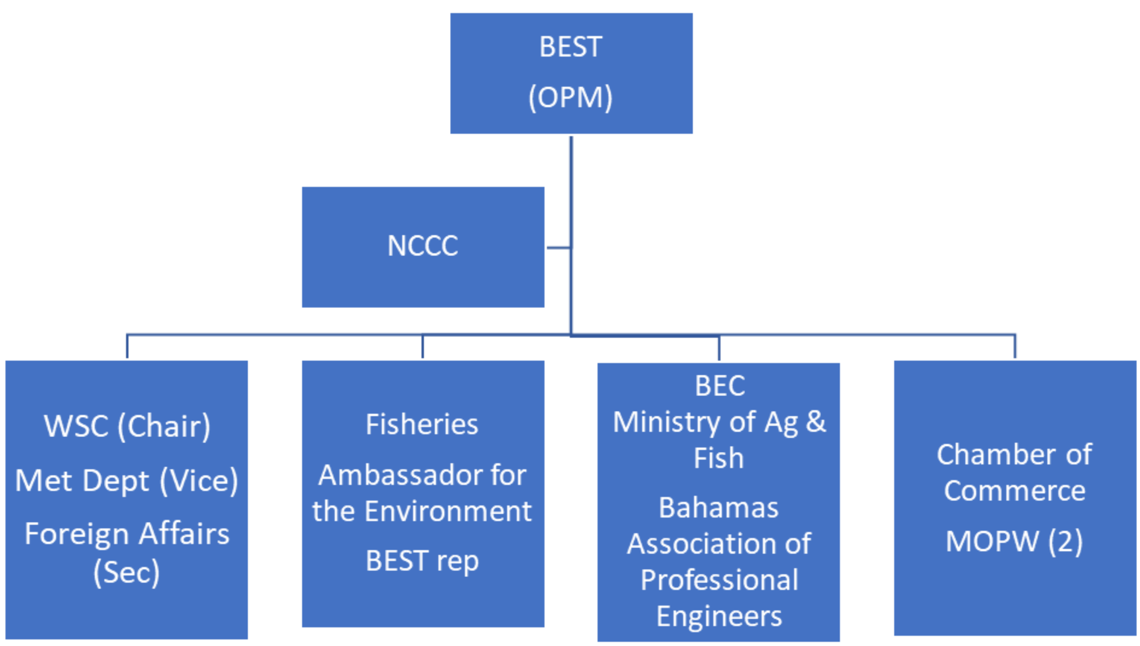
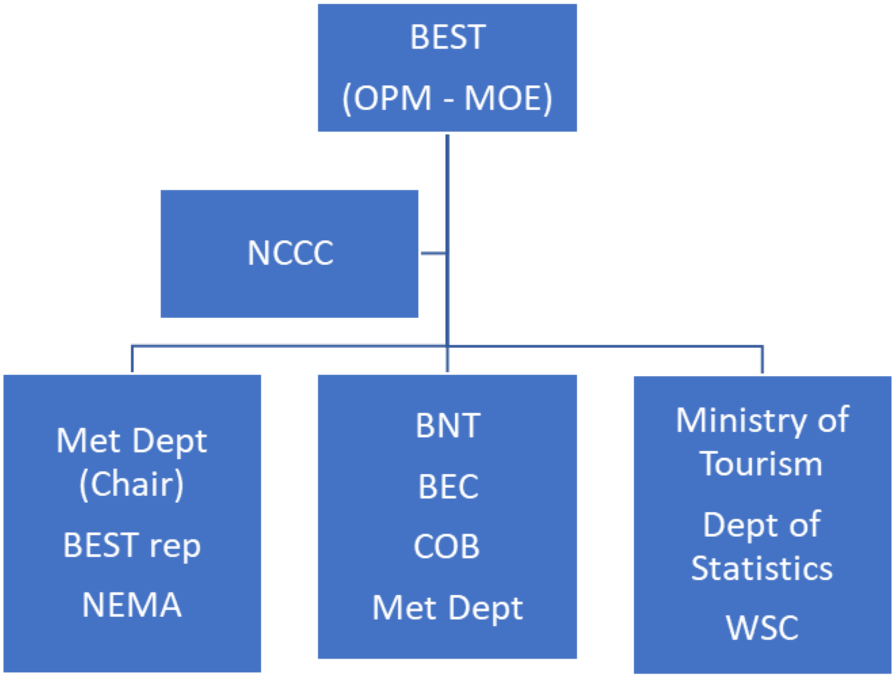


Figure 17: Institutional framework for the 2014 Second National Communication (SNC)



The TNC and BUR1 process is currently being led by DEPP and the NCCC. Again, consultants have been engaged to complete the various chapters of both documents. The project manager is a staff member of The Climate Change & Environmental Advisory Unit (CCEAU), a technical advisory arm of the Office of the Prime Minister (OPM), and all chapter drafts are reviewed by the project team members and the NCCC. NCCC members have also supported the process through provision of information and data from their respective organizations as well as ensuring the chapters accurately reflect circumstances in The Bahamas and future plans for addressing climate change.

The following agencies are currently represented on the NCCC:

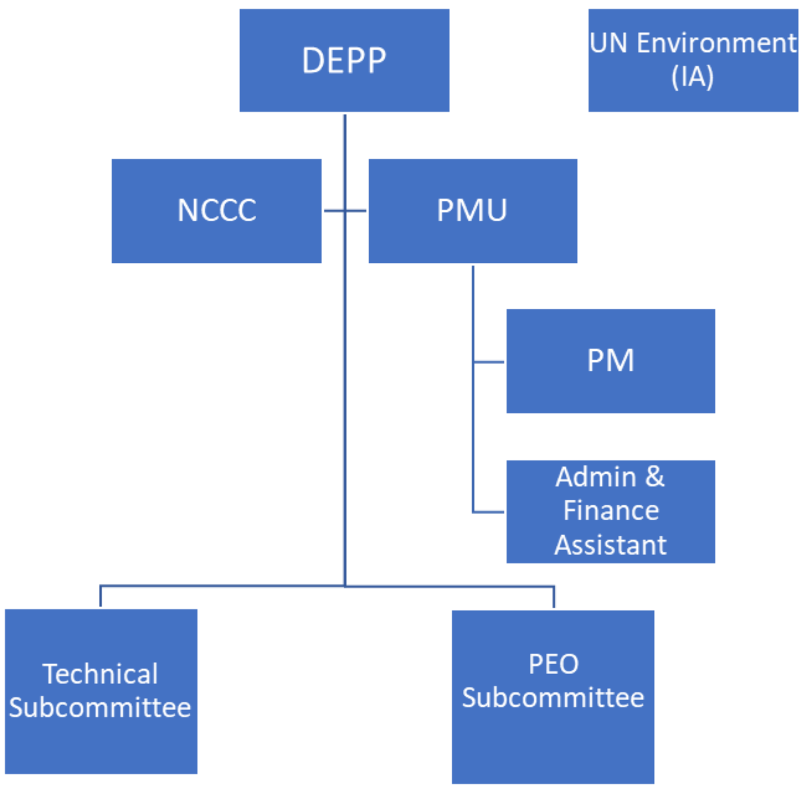
1. DEPP – Department of Environmental Protection and Planning
2. BDM – Bahamas Department of Meteorology
3. DMR – Department of Marine Resources
4. DMU - Disaster Management Unit (Department of Social Services)
5. DOA – Department of Agriculture
6. Department of Gender & Family Affairs

7. Department of Statistics (Bahamas National Statistical Institute)
8. Forestry Unit
9. MOHW – Ministry of Health and Wellness
10. MOWI – Ministry of Public Works
11. MOT – Ministry of Tourism
12. Ministry of Transport & Local Government
13. NEMA – National Emergency Management Agency
14. OPM – Office of the Prime Minister of The Bahamas
15. Port Department
16. UB – University of The Bahamas
17. BAHFSA - Bahamas Agricultural Health and Food Safety Authority
18. BMA – Bahamas Maritime Authority
19. BPL – Bahamas Power & Light Company Limited
20. WSC – Water & Sewerage Corporation
21. BNT – Bahamas National Trust
22. BPAF – Bahamas Protected Area Fund
23. BREEF – Bahamas Reef Environment Educational Foundation
24. TNC – The Nature Conservancy
25. BCCEC – Bahamas Chamber of Commerce & Employers' Confederation

1.9.2. New institutional arrangements

It is recommended that the institutional arrangement outlined in Figure 18 be established for the TNC-BUR1 process and be utilized moving forward to facilitate the preparation of NCs and BURs

Figure 18: Recommended institutional arrangement for NC-BUR preparation



As the UNFCCC Focal Point, DEPP will serve as the Coordinating Body for the NC-BUR process. Its responsibilities will include:

1. Identify all institutions and teams that will be involved in the preparation of the NC and BUR, including establishing any formal working arrangements.
2. Ensure that the Project Management Unit (PMU) is adequately staffed throughout the NC and BUR preparation process.
3. Allocate responsibilities for all components of the NC and BUR ensuring that there is a clear lead for each section, and establish a formal approval process.

4. Develop and maintain an archiving system to ensure institutional memory.
5. Keep stakeholders informed of any emerging issues related to climate change and the UNFCCC.

Specific responsibilities of the PMU will include:

1. Plan and conduct all coordination and consultation activities with stakeholders.
2. Develop and monitor a timeframe and schedule for the preparation of the NC and BUR, including specific milestones and dates for deliverables.
3. Keep stakeholders informed of progress and any emerging issues related to NC and BUR.
4. Develop and oversee the implementation of a quality assurance strategy for the reports.
5. Manager the overall budget for the preparation of reports.
6. Document systematically all the assumptions, data and methods used to prepare the reports.
7. Integrate and compile all sections of the NC and BUR into a cohesive document.
8. Conduct an evaluation exercise to identify key lessons learned and areas for improvement.

For any GEF-funded projects, DEPP will liaise with UN Environment as the Implementing Agency (IA).

A Project Management Unit (PMU) will be created within DEPP, consisting of a project manager and assistant for administrative and finance issues related to NC-BUR preparation. The NCCC will continue to fulfil its role with respect to the UNFCCC. Over time, the capacity of the Committee will be built to develop all chapters within the reports without the need for external consultants.

The NCCC will create two subcommittees:

- **Technical Subcommittee** – This Subcommittee will provide technical expertise for the five Technical Expert Group (TEG) areas – GHG Inventory, V&A Assessment, Mitigation Analysis, Environmentally Sound Technologies (EST) and

Research & Systematic Observations (RSO). Recommended agencies to be represented include: Bahamas National Statistical Institute (formerly known as the Department of Statistics), BDM, DMR, DOA, MOWU (MOPW), Road Traffic Department, BPL and WSC.

- **Public Education & Outreach (PEO) Subcommittee** – This Subcommittee will be responsible for the sixth TEG area. Recommended agencies to be represented include Bahamas Information Services (BIS), Department of Gender & Family Affairs, Ministry of Education, UB, BREEF, BCCEC and Bahamas Press Club.

Table 11: Recommended duties for Technical Expert Groups (TEG)

	TEG	**Recommended Duties**
Technical Subcommittee (TEGs 1 through 5)	Greenhouse Gas Inventory	1. Advise on selection and application of appropriate inventory methodologies. 2. Assist in data quality assistance and key source analysis. 3. Recommend the ways of improvement of the national emission actors. 4. Contribute substantially to development of the *National Inventory Report* and identify the follow-up activities. 5. Assist the PMU in arrangement of the national review and training workshops on improving quality of the national GHG inventory. 6. Make suggestions on technical capacity building and participate in the subregional, regional and

		international training on GHG inventory.
	Vulnerability & Adaptation Assessment	1. Advise on selection of appropriate methodologies to assess vulnerability and adaptation. 2. Oversee the development of climatic scenarios and selection of relevant methodologies. 3. Supervise/conduct an assessment of vulnerability and climate change impact. 4. Contribute substantially to development of the National Strategy on Adaptation to Climate Change and identify the follow-up activities. 5. Help the PMU to organize the national review and training workshops on vulnerability and adaptation measures. 6. Make suggestions on capacity building and participate in the subregional, regional and international trainings on integrated assessment modeling.
	Mitigation Analysis	1. Assist the PMU in search and choice of appropriate training courses on applying macro-economic models. 2. Advise on selection of macro-economic models for evaluating mitigation options and measures for GHG emission reduction.

		3. Overview and select measures to mitigate climate change and identify the follow-up activities. 4. Assist the PMU in arranging the national review and training workshops on climate change mitigation measures. 5. Suggest on technical capacity building and participate in the subregional, regional and international trainings on mitigation measures analysis.
	Environmentally Sound Technologies	1. Advise on selection of priority technological needs. 2. Analyze the cost-effectiveness of the technologies and the opportunities for their application. 3. Assess the existing endogenous technologies for further promotion within the context of national circumstances. 4. Contribute substantially to the establishment of a database for ESTs, including both mitigation and adaptation technologies. 5. Identify the follow-up activities 6. Assist in arranging the national review and awareness raising workshops on ESTs and participate in the subregional, regional and international trainings on ESTs.

	Research & Systematic Observations	1. Assess the existing system for early warning on extreme weather events and methods of seasonal forecasting. 2. Analyze the existing barriers for development of observation systems and research, and identify the follow-up activities *3.* Contribute substantially to development of the *National Information Report on Research and Systematic Observation.* 4. Assist the PMU in arranging the national review and awareness raising workshops on research and systematic observation, and participate in the sub regional, regional and international trainings on the matter.
PEO Subcommittee (TEG 6)	Education, Training & Public Awareness, Information & Networking, Capacity-building	1. Compile and analyse information on activities/tasks relating to the implementation of the New Delhi work program on Article 6 of the Convention. 2. Compile and analyse information on activities/tasks relating to the implementation of the capacity-building framework of the UNFCCC. 3. Identify the needs and priorities for climate change education, training and public awareness and capacity-

		building as they relate to the other 5 TEGs. 4. Liaise and consult with the various TEGs. 5. Assist in implementation of the National Plan for Article 6 of the Convention and the UNFCCC capacity-building framework. 6. Identify technology needs for information and networking. 7. Assist the PMU in organizing workshops on ways to promote climate change education, training and public awareness. 8. Substantially contribute to chapters in the NC on (i) Education, Training and Public Awareness, (ii) Information and Networking, and (iii) Capacity-building.

Chapter 2 – National Greenhouse Gas (GHG) Inventories

Introduction

This chapter presents The Bahamas's national GHG inventory for the years 2001-2018, prepared in line with the IPCC 2006 Guidelines for national GHG inventories. The inventory scope covers the geographical borders of The Bahamas. Gases covered are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). While it is assumed that emissions from hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) are at least likely to occur, the necessary data to perform estimates for these gases were not available. The Bahamas intends to move towards covering these gases in future GHG inventory submissions.

The Global Warming Potential (GWP) values from the IPCC's 5th Assessment report[10] were used (see Table 12).

Table 12: Global warming potentials used

Gas	GWP
CO_2	1
CH_4 (from biogenic sources)	28
CH_4 (from fossil sources)	30
N_2O	265

2.1 Inventory preparation

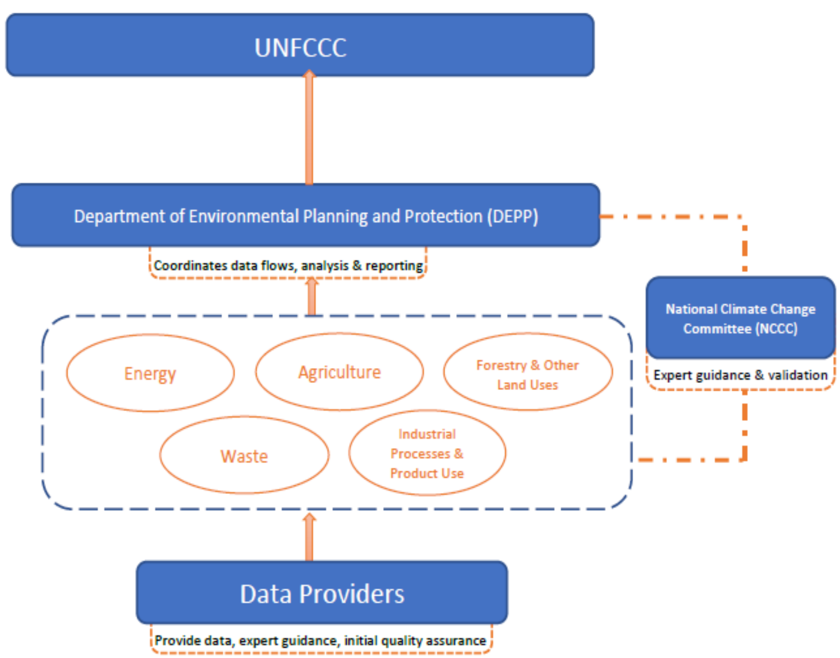
At present, The Bahamas National Climate Change Committee (NCCC) provides strategic level guidance on climate change related activities, policies, and plans, including the preparation of National Communications, Biennial Update Reports, National Inventory Reports, among others. The NCCC was established in 1996 by The Bahamas

[10] See Table 8.A.1, WG III, Chapter 8. Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestvedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura and H. Zhang, 2013: Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Environment Science and Technology (BEST) Commission while under the Office of the Prime Minister, and now chaired and led by the Department of Environmental Planning and Protection (DEPP) (formerly BEST Commission). The Bahamas National Climate Change Committee (NCCC) consists of representatives from the government, private sector, non-governmental agencies and academic institutions.

The DEPP, apart from its role as the chair of the NCCC, is also the UNFCCC and GEF operational focal point, and coordinates the preparation and presentation of all reporting requirements to the UNFCCC. At present, the technical aspects of the preparation of the National Greenhouse Gas Inventory Report are led by regional consultants in a collaborative fashion with national experts with an aim to build national capacity. This includes both GHG inventory compilation training and hands-on participation in data collection, and quality assurance activities during inventory compilation. The institutions and roles of these actors involved are described in "Annex II - Institutions and Roles of those involved in the Preparation of The Bahamas' NIR". An illustration of these roles is shown below in Figure 19.

Figure 19: Institutional arrangements for the national GHG inventory preparation



2.2 Quality Assurance and Quality control

At present, The Bahamas is in the process of institutionalising its National Inventory Team and a system for quality control and quality assurance. For this inventory preparation cycle, sector level quality control checks on data being collected and estimations were made by the inventory compilers. Quality control checks were done to ensure that country estimations were developed and reported according to IPCC Good Practice Guidelines and follow the transparency, accuracy, consistency, comparability, completeness (TACCC) principles.

Existing QA/QC practices cover the following areas:

- Selection of methodologies
- Underlying assumptions of method for GHG estimation
- Selection of activity data and emission factors
- Means of data acquisition and management
- Documentation

The following quality control steps were undertaken initially by the inventory compiler, and secondarily internally reviewed by MRV Hub GHG accounting experts as a quality control check for each sector inventory. These quality control steps include:

- Check that assumptions and criteria for the selection of activity data and emission factors are documented
- Check for transcription errors in data input and reference
- Check that emissions/removals are calculated correctly
- Check that parameters and emission/removal units are correctly recorded and that appropriate conversion factors are used
- Check completeness, that estimates are reported for all categories and for all years from the appropriate base year over the period of the current inventory

In terms of quality assurance, national sector experts are increasingly being involved in data collection and understanding sector specific assumptions for methods. Other line Ministry representatives, and experts from non-governmental organizations and academia were also available for providing thorough review and assessment of the outputs from the emissions estimates and methodological assumptions.

The documentation and archiving of emissions estimates, worksheets, activity data, expert judgement and assumptions was done by the inventory compilers, and shared with the Department of Environmental Planning and Protection through a Dropbox folder, organized by all stages of the inventory cycle. This is done to ensure transparency, national ownership of data and reports, and promotes continuity of the inventory preparation for subsequent cycles.

The final stage of the inventory preparation cycle includes identification and documentation of further improvements. The current emissions inventory has already identified a range of cross-cutting improvements relating to both the emissions inventory data and the institutional arrangements, detailed in Annex II. These will be taken into account as the Government of The Bahamas continues to develop its national inventory team and system.

2.3 Description of Key Categories

A key category assessment was carried out for The Bahamas' GHG inventory estimates for the time series 2001-2018.[11] Both the level and trend assessments under approach 1 according to Volume 1, Chapter 4 of the IPCC 2006 Guidelines were conducted. The level of disaggregation chosen for the assessment was chosen according to table 4.1 of Chapter 4, Volume 1 of the IPCC 2006 Guidelines. Table 13 below presents the 13 key categories identified and indicates, whether they have been identified by the level assessment (L) and/or the trend assessment (T).

The majority of key categories identified, were identified under both level and trend assessment. They include stationary as well as mobile fuel combustion activities in the

[11] The previous National GHG Inventory of The Bahamas was published as part of The Bahamas' Second National Communication in 2014. This GHG inventory did not include a key category assessment, it is therefore not possible to assess how key categories have changed over time.

energy sector, land-based categories in the AFOLU sector (all aforementioned for CO_2) as well as solid waste disposal (for CH_4). Table 14 and Table 15 further below present the full results of the level and trend assessment.

A qualitative assessment in line with chapter 4, Volume 1 of the IPCC 2006 Guidelines considering the criteria mitigation techniques and technologies, expected growth and completeness have not led to the identification of additional key categories. At the same time, categories which could not be estimated due to lack of data have in most cases been prioritised in the improvement plan.

Table 13: Key categories identified

IPCC Category Code	IPCC Category Name	Gas	Key category related to Level (L) and/or Trend (T)
1.a.1.a.i	Electricity Generation	CO_2	L, T
1.A.2.m	Non-specified Industry	CO_2	L, T
1.A.3.b.i	Cars	CO_2	L, T
1.A.3.b.ii	Light-duty trucks	CO_2	L
1.A.3.b.iii	Heavy-duty trucks and buses	CO_2	L, T
1.A.4.a	Commercial/Institutional	CO_2	L, T
3.B.1.a	Forest land Remaining Forest Land	CO_2	L, T
3.B.1.b	Land Converted to Forest Land	CO_2	L, T
3.B.2.b	Land Converted to Cropland	CO_2	L, T
3.B.3.b	Land Converted to Grassland	CO_2	L, T

3.B.4.b	Land Converted to Wetlands	CO_2	L, T
3.B.5.b	Land Converted to Settlements	CO_2	L, T
4.A	Solid Waste Disposal	CH_4	L

Table 14: Results of the level assessment

IPCC category code	IPCC Category	Greenhouse gas	Latest year estimate in Gg CO_2-eq	Absolute value of latest year estimate	Level assessment	Cumulative value	Key category?
3.B.3.b	Land Converted to Grassland	CO2	2986.350	2986.350	0.3577	0.3577	Yes
1.a.1.a.i	Electricity Generation	CO2	1426.017	1426.017	0.1708	0.5285	Yes
3.B.4.b	Land Converted to Wetlands	CO2	550.035	550.035	0.0659	0.5943	Yes
3.B.1.b	Land Converted to Forest Land	CO2	-539.285	539.285	0.0646	0.6589	Yes
3.B.1.a	Forest land Remaining Forest Land	CO2	-503.335	503.335	0.0603	0.7192	Yes
1.A.3.b.i	Cars	CO2	380.434	380.434	0.0456	0.7648	Yes
1.A.4.a	Commercial/Institutional	CO2	354.086	354.086	0.0424	0.8072	Yes
3.B.5.b	Land Converted to Settlements	CO2	304.201	304.201	0.0364	0.8436	Yes
1.A.2.m	Non-specified Industry	CO2	282.663	282.663	0.0339	0.8775	Yes
4.A	Solid Waste Disposal	CH4	270.854	270.854	0.0324	0.9099	Yes
3.B.2.b	Land Converted to Cropland	CO2	138.313	138.313	0.0166	0.9265	Yes
1.A.3.b.ii	Light-duty trucks	CO2	131.971	131.971	0.0158	0.9423	Yes

1.A.3.b.iii	Heavy-duty trucks and buses	CO2	119.522	119.522	0.0143	0.9566	Yes
1.A.3.a.ii	Domestic Aviation	CO2	73.724	73.724	0.0088	0.9654	No
1.a.2.k	Construction	CO2	66.353	66.353	0.0079	0.9734	No
1.A.4.b	Residential	CO2	51.729	51.729	0.0062	0.9796	No
3.B.6.b	Land Converted to Other Land	CO2	42.826	42.826	0.0051	0.9847	No
4.D.1	Domestic Wastewaster Treatment and Discharge	CH4	42.565	42.565	0.0051	0.9898	No
1.A.4.c	Agriculture/Forestry/Fishing/ Fish Farms	CO2	32.061	32.061	0.0038	0.9936	No
3.C.4	Direct N2O Emissions from managed soils	N2O	7.988	7.988	0.0010	0.9946	No
1.A.3.d.ii	Water-borne navigation	CO2	5.971	5.971	0.0007	0.9953	No
1.A.3.b.i	Cars	CH4	5.435	5.435	0.0007	0.9959	No
4.D.1	Domestic Wastewaster Treatment and Discharge	N2O	5.210	5.210	0.0006	0.9966	No
1.A.3.b.i	Cars	N2O	4.655	4.655	0.0006	0.9971	No
1.a.1.a.i	Electricity Generation	N2O	3.033	3.033	0.0004	0.9975	No
3.C.5	Indirect N2O Emissions from managed soils	N2O	2.645	2.645	0.0003	0.9978	No
1.A.4.a	Commercial/Institutional	CH4	1.803	1.803	0.0002	0.9980	No
1.a.1.a.i	Electricity Generation	CH4	1.717	1.717	0.0002	0.9982	No

3.A.1	Enteric Fermentation	CH4	1.688	1.688	0.0002	0.9984	No
1.A.3.b.ii	Light-duty trucks	N2O	1.670	1.670	0.0002	0.9986	No
1.A.3.b.iii	Heavy-duty trucks and buses	N2O	1.667	1.667	0.0002	0.9988	No
1.A.3.b.ii	Light-duty trucks	CH4	1.476	1.476	0.0002	0.9990	No
2.D.1	Lubricant Use	CO2	1.085	1.085	0.0001	0.9991	No
3.A.2	Manure Management	N2O	0.918	0.918	0.0001	0.9993	No
4.C.2	Open Burning of Waste	CH4	0.857	0.857	0.0001	0.9994	No
1.A.4.a	Commercial/Institutional	N2O	0.821	0.821	0.0001	0.9995	No
4.C.2	Open Burning of Waste	CO2	0.739	0.739	0.0001	0.9995	No
1.A.2.m	Non-specified Industry	N2O	0.607	0.607	0.0001	0.9996	No
1.A.3.a.ii	Domestic Aviation	N2O	0.547	0.547	0.0001	0.9997	No
3.A.2	Manure Management	CH4	0.532	0.532	0.0001	0.9997	No
3.C.6	Indirect N2O Emissions from manure management	N2O	0.348	0.348	0.0000	0.9998	No
1.A.2.m	Non-specified Industry	CH4	0.346	0.346	0.0000	0.9998	No
1.A.3.b.iv	Motorcycles	CO2	0.310	0.310	0.0000	0.9999	No
1.A.4.b	Residential	CH4	0.195	0.195	0.0000	0.9999	No
1.A.3.b.iii	Heavy-duty trucks and buses	CH4	0.189	0.189	0.0000	0.9999	No
1.a.2.k	Construction	N2O	0.142	0.142	0.0000	0.9999	No
1.A.4.c	Agriculture/Forestry/Fishing/ Fish Farms	CH4	0.134	0.134	0.0000	0.9999	No
3.C.3	Urea application	CO2	0.11	0.111	0.0000	1.0000	No

4.C.2	Open Burning of Waste	N2O	0.088	0.088	0.0000	1.0000	No
1.a.2.k	Construction	CH4	0.081	0.081	0.0000	1.0000	No
1.A.4.c	Agriculture/Forestry/Fishing/ Fish Farms	N2O	0.071	0.071	0.0000	1.0000	No
1.A.4.b	Residential	N2O	0.053	0.053	0.0000	1.0000	No
1.A.3.d.ii	Water-borne navigation	N2O	0.041	0.041	0.0000	1.0000	No
4.C.2	Natural gas liquids transport	CO2	0.017	0.017	0.0000	1.0000	No
1.A.3.d.ii	Water-borne navigation	CH4	0.016	0.016	0.0000	1.0000	No
1.A.3.a.ii	Domestic Aviation	CH4	0.015	0.015	0.0000	1.0000	No
1.A.3.b.iv	Motorcycles	CH4	0.001	0.001	0.0000	1.0000	No
1.A.3.b.iv	Motorcycles	N2O	0.001	0.001	0.0000	1.0000	No
3.A.1	Enteric Fermentation	N2O	0.000	0.000	0.0000	1.0000	No

Table 15: Results of the trend assessment

IPCC category code	IPCC Category	Greenhouse gas	Base year estimate in Gg CO_2-eq	Absolute value of base year estimate in Gg CO_2-eq	Latest year estimate in Gg CO_2-eq	Absolute value of latest year estimate	Trend assessment	% Contribution to Trend	Cumulative value	Key category?
3.B.3.b	Land Converted to Grassland	CO2	1750.812	1750.812	2986.350	2986.350	0.127	0.268	0.268	Yes
3.B.5.b	Land Converted to Settlements	CO2	819.378	819.378	304.201	304.201	0.098	0.207	0.475	Yes
1.a.1.a.i	Electricity Generation	CO2	1527.482	1527.482	1426.017	1426.017	0.059	0.125	0.600	Yes
3.B.2.b	Land Converted to Cropland	CO2	380.163	380.163	138.313	138.313	0.046	0.097	0.698	Yes
3.B.1.a	Forest land Remaining Forest Land	CO2	-361.598	361.598	-503.335	503.335	0.031	0.065	0.763	Yes

3.B.4.b	Land Converted to Wetlands	CO2	324.778	324.778	550.035	550.035	0.023	0.048	0.812	Yes
1.A.4.a	Commercial/ Institutional	CO2	183.347	183.347	354.086	354.086	0.019	0.041	0.852	Yes
1.A.2.m	Non-specified Industry	CO2	143.274	143.274	282.663	282.663	0.016	0.034	0.886	Yes
3.B.1.b	Land Converted to Forest Land	CO2	-568.941	568.941	-539.285	539.285	0.012	0.026	0.912	Yes
1.A.3.b.iii	Heavy-duty trucks and buses	CO2	39.902	39.902	119.522	119.522	0.010	0.022	0.934	Yes
1.A.3.b.i	Cars	CO2	271.101	271.101	380.434	380.434	0.008	0.016	0.950	Yes
1.A.3.b.ii	Light-duty trucks	CO2	81.843	81.843	131.971	131.971	0.005	0.010	0.960	No
1.a.2.k	Construction	CO2	33.304	33.304	66.353	66.353	0.004	0.008	0.968	No
4.A	Solid Waste Disposal	CH4	205.783	205.783	270.854	270.854	0.003	0.007	0.975	No
1.A.3.a.ii	Domestic Aviation	CO2	75.218	75.218	73.724	73.724	0.002	0.005	0.980	No

1.A.4.b	Residential	CO2	30.023	30.023	51.729	51.729	0.002	0.005	0.985	No
1.A.4.c	Agriculture/ Forestry/ Fishing/Fish Farms	CO2	15.973	15.973	32.061	32.061	0.002	0.004	0.989	No
1.A.3.d.ii	Water-borne navigation	CO2	15.574	15.574	5.971	5.971	0.002	0.004	0.993	No
3.C.4	Direct N2O Emissions from managed soils (3)	N2O	10.508	10.508	7.988	7.988	0.001	0.001	0.994	No
2.D.1	Lubricant Use	CO2	3.754	3.754	1.085	1.085	0.000	0.001	0.995	No
3.B.6.b	Land Converted to Other Land	CO2	33.010	33.010	42.826	42.826	0.000	0.001	0.996	No
4.D.1	Domestic Wastewaster Treatment and Discharge	CH4	33.402	33.402	42.565	42.565	0.000	0.001	0.997	No

3.C.5	Indirect N2O Emissions from managed soils	N2O	3.452	3.452	2.645	2.645	0.000	0.000	0.998	No
1.A.3.b.iii	Heavy-duty trucks and buses	N2O	0.557	0.557	1.667	1.667	0.000	0.000	0.998	No
1.a.1.a.i	Electricity Generation	N2O	3.209	3.209	3.033	3.033	0.000	0.000	0.998	No
3.A.2	Manure Management	N2O	0.109	0.109	0.918	0.918	0.000	0.000	0.998	No
1.A.3.b.i	Cars	CH4	3.873	3.873	5.435	5.435	0.000	0.000	0.999	No
1.A.3.b.i	Cars	N2O	3.317	3.317	4.655	4.655	0.000	0.000	0.999	No
1.A.4.a	Commercial/ Institutional	CH4	1.043	1.043	1.803	1.803	0.000	0.000	0.999	No
1.a.1.a.i	Electricity Generation	CH4	1.816	1.816	1.717	1.717	0.000	0.000	0.999	No
1.A.3.b.ii	Light-duty trucks	N2O	1.020	1.020	1.670	1.670	0.000	0.000	0.999	No
4.D.1	Domestic Wastewaster	N2O	4.690	4.690	5.210	5.210	0.000	0.000	0.999	No

	Treatment and Discharge									
1.A.4.a	Commercial/ Institutional	N2O	0.427	0.427	0.821	0.821	0.000	0.000	0.999	No
1.A.2.m	Non-specified Industry	N2O	0.310	0.310	0.607	0.607	0.000	0.000	1.000	No
1.A.3.b.ii	Light-duty trucks	CH4	1.033	1.033	1.476	1.476	0.000	0.000	1.000	No
3.C.6	Indirect N2O Emissions from manure management	N2O	0.138	0.138	0.348	0.348	0.000	0.000	1.000	No
1.A.2.m	Non-specified Industry	CH4	0.177	0.177	0.346	0.346	0.000	0.000	1.000	No
1.A.3.a.ii	Domestic Aviation	N2O	0.559	0.559	0.547	0.547	0.000	0.000	1.000	No
1.A.3.b.iii	Heavy-duty trucks and buses	CH4	0.063	0.063	0.189	0.189	0.000	0.000	1.000	No

1.A.3.d.ii	Water-borne navigation	N2O	0.107	0.107	0.041	0.041	0.000	0.000	1.000	No
1.a.2.k	Construction	N2O	0.072	0.072	0.142	0.142	0.000	0.000	1.000	No
3.A.1	Enteric Fermentation	CH4	1.357	1.357	1.688	1.688	0.000	0.000	1.000	No
1.A.4.c	Agriculture/ Forestry/ Fishing/Fish Farms	CH4	0.067	0.067	0.134	0.134	0.000	0.000	1.000	No
1.A.4.b	Residential	CH4	0.120	0.120	0.195	0.195	0.000	0.000	1.000	No
3.C.3	Urea application	CO2	0.052	0.052	0.111	0.111	0.000	0.000	1.000	No
4.C.2	Open Burning of Waste	CH4	0.673	0.673	0.857	0.857	0.000	0.000	1.000	No
1.A.3.b.iv	Motorcycles	CO2	0.221	0.221	0.310	0.310	0.000	0.000	1.000	No
4.C.2	Open Burning of Waste	CO2	0.580	0.580	0.739	0.739	0.000	0.000	1.000	No
1.A.3.d.ii	Water-borne navigation	CH4	0.042	0.042	0.016	0.016	0.000	0.000	1.000	No
1.a.2.k	Construction	CH4	0.041	0.041	0.081	0.081	0.000	0.000	1.000	No

3.A.2	Manure Management	CH4	0.468	0.468	0.532	0.532	0.000	0.000	1.000	No
1.A.4.c	Agriculture/ Forestry/ Fishing/Fish Farms	N2O	0.036	0.036	0.071	0.071	0.000	0.000	1.000	No
1.A.4.b	Residential	N2O	0.029	0.029	0.053	0.053	0.000	0.000	1.000	No
4.C.2	Open Burning of Waste	N2O	0.069	0.069	0.088	0.088	0.000	0.000	1.000	No
1.A.3.a.ii	Natural gas liquids transport	CO2	0.011	0.011	0.017	0.017	0.000	0.000	1.000	No
1.A.3.a.ii	Domestic Aviation	CH4	0.016	0.016	0.015	0.015	0.000	0.000	1.000	No
1.A.3.b.iv	Motorcycles	CH4	0.001	0.001	0.001	0.001	0.000	0.000	1.000	No
1.A.3.b.iv	Motorcycles	N2O	0.001	0.001	0.001	0.001	0.000	0.000	1.000	No
3.A.1	Enteric Fermentation	N2O	0.000	0.000	0.000	0.000	0.000	0.000	1.000	No

2.4 Uncertainty assessment (qualitative)

This section provides an uncertainty assessment of The Bahamas' national GHG inventory at a qualitative level. The IPCC 2006 Guidelines consider a quantitative assessment good practice. Such a quantitative assessment can however only be meaningful, where estimates for the uncertainty of activity data and emission factors (or other factors/assumptions) are available. Alternatively, the IPCC 2006 Guidelines, in its sectoral chapters provides default values for the uncertainty assessment. The importance of the uncertainty assessment lies less in the overall uncertainty value for the national GHG inventory as a total for a specific year. The assessment becomes valuable once consistently produced uncertainty assessments are available for a number of GHG inventory submissions, thus allowing to understand improvements over time. Considering one specific GHG inventory submission, the assessment helps in identifying and prioritising categories with improvement potential.

Uncertainty data was not available for any activity data in The Bahamas and availability of activity data was limited. The decision was thus taken to focus the available resources on the data collection effort and filling of gaps, instead of conducting an uncertainty assessment based solely on IPCC defaults. Such an assessment would not have yielded any added value with regards to identifying and prioritising improvement potential, as a long list of improvements had already been compiled as part of the data collection process.

The following main sources of uncertainty for The Bahamas' national GHG inventory were identified:

- Related to completeness
    - Lack of information on the existence of emissions from specific IPCC categories (e.g. under category 1.A.2 Manufacture and construction, category 2.G Other product use)
    - Lack of activity data (e.g., 2.G.1 Refrigeration and air conditioning)

- Accuracy
    - Data was often available only for part of the time series making it difficult to understand the trends
    - No country-specific emission factors are available
    - National circumstances might not well or no longer align with the IPCC defaults (e.g. waste generation rates per capita, vehicle categories)
    - Information related to sector-specific assumptions is often not available (e.g. number of trips and average distances for category 1.A.3.b Road transport)

A detailed list of improvements required to reduce uncertainty related to these issues is presented in Annex II.

2.5 Improvement potential

During the compilation of The Bahamas' national GHG inventory, future improvement potential was identified and documented. Table 16 below presents the most relevant areas for improvements, while the full list of improvement options is presented in Annex II. The improvement options presented in the Annex differ in their urgency and timeframes they can be implemented in. This chapter shows the improvements deemed most relevant, as they pertain to key categories.

Table 16: Most relevant areas for improvement

Area	Most relevant areas for improvement
Cross-cutting	• Set up appropriate institutional, procedural, legal arrangements, and documentation for recurring preparation of the national GHG inventory • Appoint a national GHG inventory compilation team • Fully establish and implement QA/QC procedures for the national GHG inventory
Energy	• Ensure data on fuel imports compiled by the Central Bank of the Bahamas are complete and accurate

	• Obtain disaggregated data of fuel imports (potentially with the help of fuel distributors) by relevant subcategories, e.g. manufacture and industries (1.A.2), commercial/institutional (1.A.4.a), and residential (1.A.4.b). • Develop a national energy balance in the longer term • Collect power generation and fuel consumption from local power producers (Bahamas Power and Light, Company Ltd. Grand Bahama Power Company) • Develop country-specific emission factors • Better understand which relevant manufacture and production activities take place and collect activity data • Obtain complete activity data on vehicle population across the entire time series
IPPU	• Collect HFC and PFC import data (as substance and in products) • Assess which IPPU categories occur (e.g. electrical equipment, category 2.G.1)
AFOLU	• Develop country-specific emission factors for categories 3.B.1.a-b, 3.B.2.b, 3.b.3.b, 3.B.4.b and 3.b.5.b • Establish and validate (i.e. ground-truth) a sample of permanent plots of each land use type (at minimum the main IPCC classes, especially pine and mangrove for forest land which are prominent in the Bahamas) to improve land classification maps and remote sensing model • Determine the end use of fertilizers and other agricultural additives reported in the annually produced Customs Imports report with Agriculture experts • Conduct a survey of livestock in country, including livestock manure management practices on an annual basis, and align with National Agricultural Census cycle
Waste	• Collect information on the depth of landfills (one-time survey)

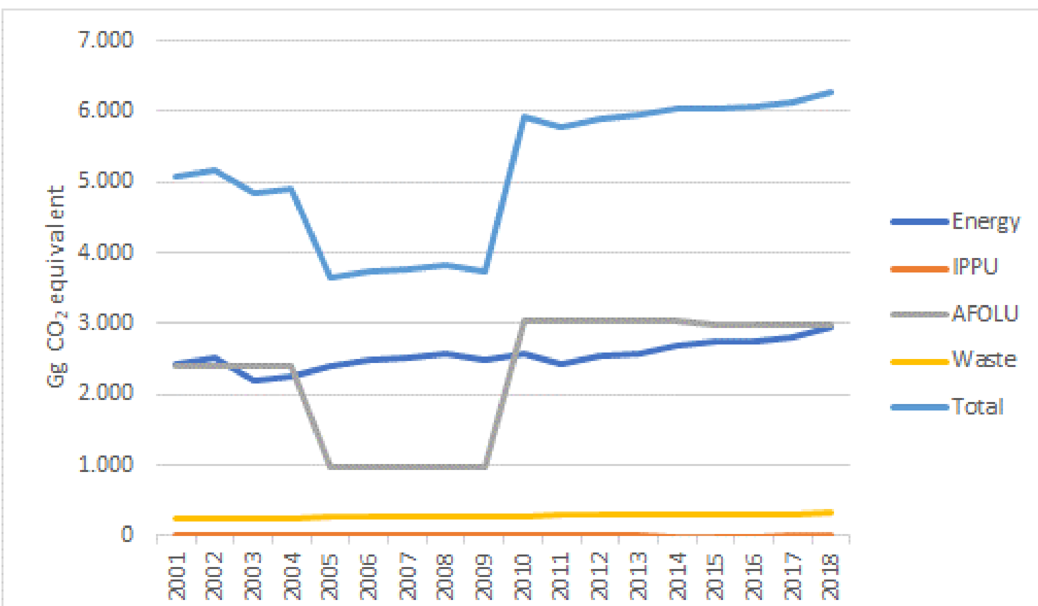
	• Assess solid waste generation and composition • Collect data from national food and beverage manufacturing companies on industrial wastewater flows

GHG emissions and removals 2001-2018

2.6 Overview

Total GHG emissions in The Bahamas rose from 5,074.09 Gg CO_2-eq in 2001 to 6,264.39 Gg CO_2-eq in 2018, which equals an increase by 23.5 cent (see Figure 20).[12] During the same time period GHG emissions from the waste sector rose by 30.6 per cent, from the AFOLU sector (including both emissions and removals) by 25.1 per cent, and from the energy sector by 21.1 per cent. IPPU sector emissions, to the extent estimated in this GHG inventory publication which covered only lubricant use[13], fell by 71.1 per cent. GHG estimates for 2001-2018 are presented in Table 17.

Figure 20: Total GHG emissions by sector 2001-2018



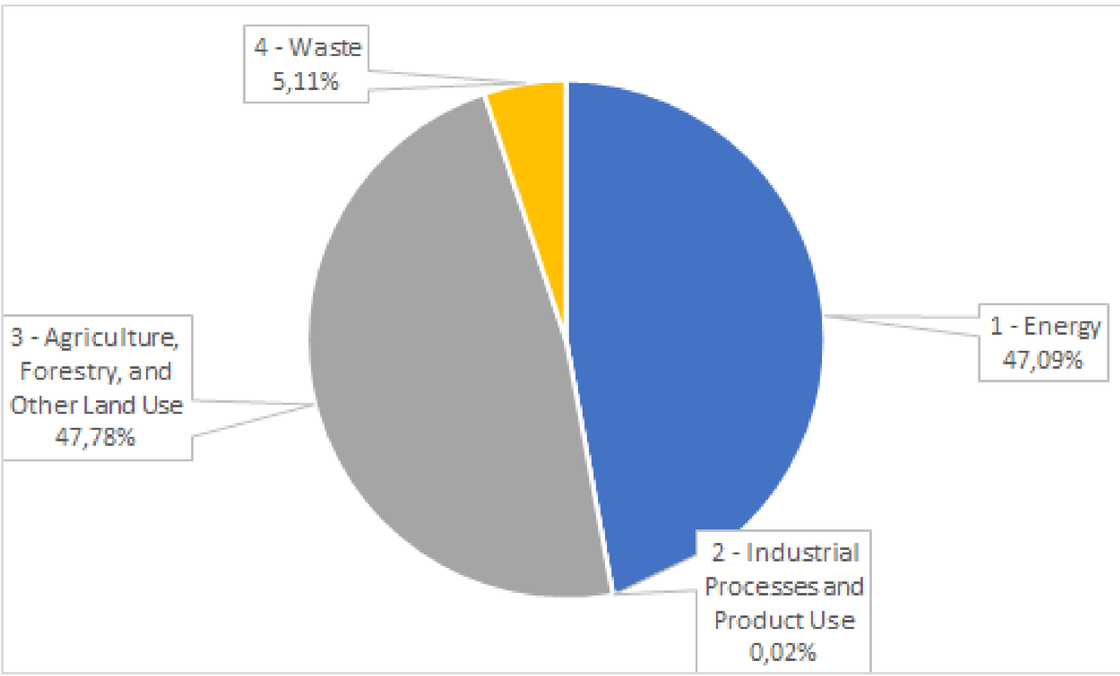
[12] The previous GHG inventory of the BAHAMAs published as part of The Bahamas Second National Communication in 2014 presented GHG emissions for the year 2000, amounting to 702.82 Gg CO_2-eq. when considering the gases CO_2, CH_4 and N_2O. These had been estimated using the IPCC Revised 1996 Guidelines for national GHG inventories and the GWPs from the IPCC's 2nd Assessment Report.

[13] Due to lack of data, GHG emissions from the use of HFCs and PFCs and of other potentially relevant sources could not be estimated. More information is provided in section 2 of this report.

Developments of and drivers for sectoral and category-level trends are presented in the forthcoming sectoral chapters (2.2 - 2.5)

The AFOLU and energy sectors dominate total national GHG emissions in The Bahamas, contributing 47.8 per cent and 47.1 per cent, respectively, to total emissions in 2018. The waste sector contributes 5.1 per cent and the IPPU sector was less than 0.1 per cent during the same year (see Figure 21).

Figure 21: Percent contribution of IPCC sectors to total GHG emissions in 2018



Total CO_2 emissions amounted to 5909.18 Gg in 2018, representing 94.3 per cent of total GHG emissions. CH_4 amounted to 11.68 Gg in 2018, representing 5.2 per cent of the total and N_2O to 0.12 Gg in 2018, representing 0.5 per cent of the total (see Figure 22).

Likely drivers to The Bahamas' GHG inventory emissions are the population and economic development. The increase in tourism has likely lead to an increase in demand on fuel and transportation, thus affecting energy sector emissions. GDP has increased by 56 per cent since 2001, the population by 27 per cent (see Figure 23).

Figure 22: Contribution of gases to total GHG emissions in 2018

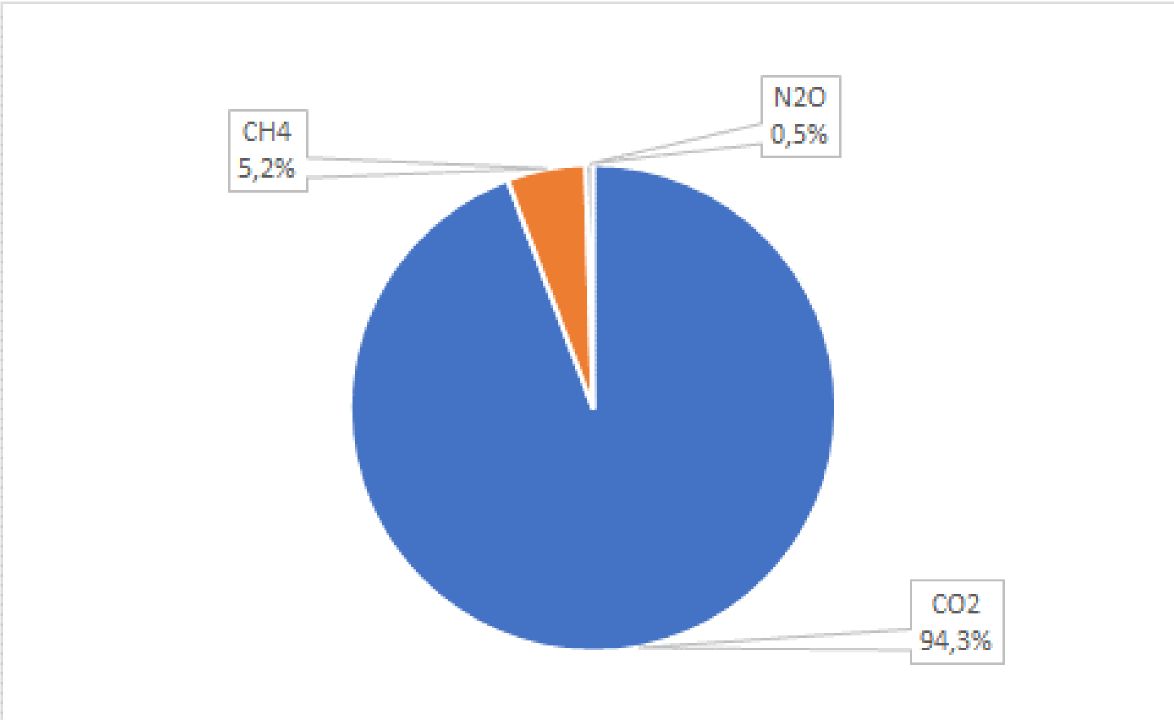
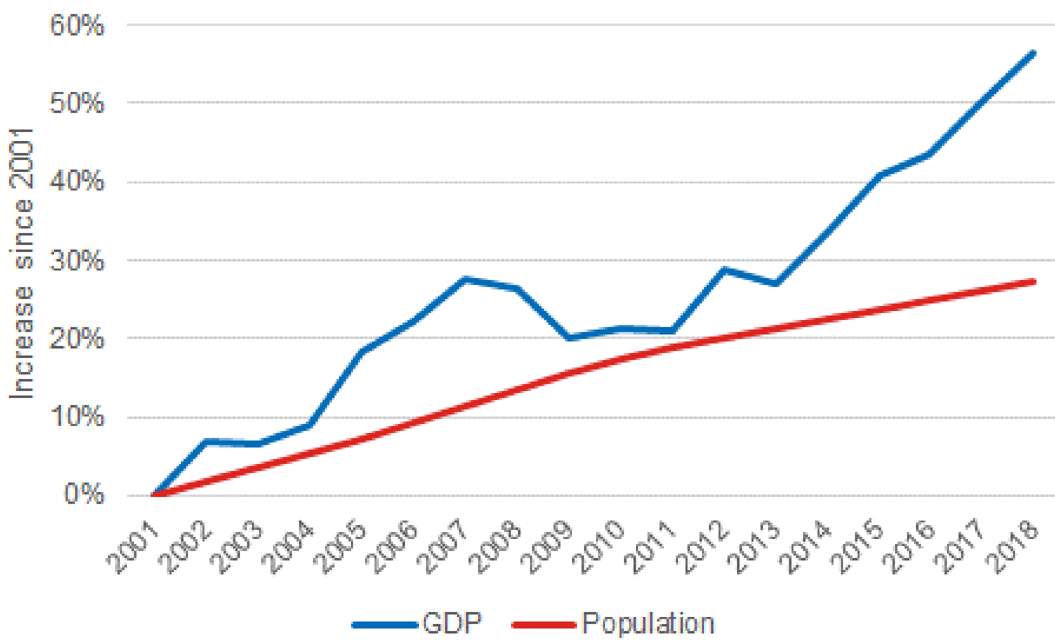


Figure 23: Increase in GDP and population in the Bahamas between 2001-2018



The GHG emissions per capita in The Bahamas was 16.24 tCO_2eq in 2018, which represents a decrease of 3.2 per cent compared to 2001.

Table 17: Total GHG emissions by sector

Categories	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Change between 2001 - 2018
Total	Gg CO_2-eq.	5,077.85	5,157.60	4,852.38	4,901.25	3,640.68	3,744.15	3,765.39	3,832.61	3,738.27	5,926.03	5,771.82	5,902.51	5,941.44	6,045.44	6,053.83	6,063.13	6,115.05	6,264.31	23.4%
1 – Energy	Gg CO_2-eq.	2,435.21	2,512.78	2,207.71	2,243.39	2,407.76	2,501.62	2,517.49	2,583.99	2,485.98	2,583.91	2,427.07	2,553.17	2,588.42	2,686.94	2,752.86	2,759.77	2,805.72	2,949.58	21.1%
2 – Industrial Processes and Product Use	Gg CO_2-eq.	3.75	8.43	2.84	2.84	3.42	4.17	3.25	3.59	3.09	3.17	1.42	1.08	1.75	1.00	1.00	1.00	1.17	1.08	-71.1%

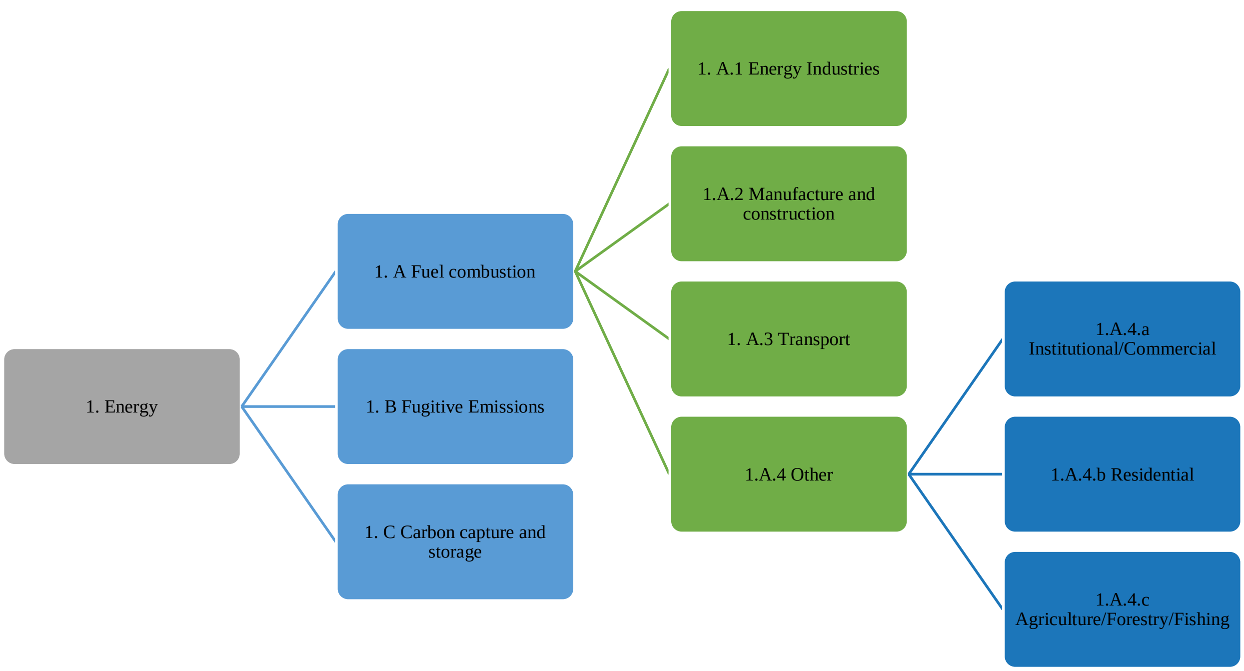
3 – Agriculture, Forestry, and Other Land Use	Gg CO_2-eq.	2,393.69	2,387.17	2,388.73	2,397.80	967.73	971.70	973.12	968.57	967.69	3,052.16	3,051.84	3,052.31	3,050.36	3,052.66	2,991.21	2,989.65	2,991.64	2,993.34	25.1%
4 – Waste	Gg CO_2-eq.	245.20	249.22	253.11	257.22	261.77	266.67	271.52	276.46	281.51	286.79	291.49	295.94	300.90	304.83	308.75	312.71	316.51	320.31	30.6%

2.7 Energy

The scope of the energy sector under the IPCC 2006 Guidelines for national GHG inventories covers a broad array of GHG emission sources. These include stationary fuel combustion (for power and heat generation, in the manufacture and construction sectors, in the residential sector, in the institutional and commercial sector as well as related to agriculture, fisheries, forestry) and fuel combustion in the transport sector. Furthermore, it includes fugitive GHG emissions from fuel production and distribution as well as GHG emissions from carbon capture and storage where such activities take place. Figure 24 provides a simplified overview of GHG emission categories in the energy sector.

In The Bahamas, most energy sector emissions stem from fuel combustion. Power generation is based on fuel oil and diesel. The Bahamas has only limited industrial activities, emissions from fuel consumption in the manufacture and industry sub-sector therefore focus on construction.

Figure 24: Categories in the IPCC sector energy



The transport sector is dominated by road transport, but also domestic aviation and domestic waterborne navigation play a role, with tourism being a strong driver for the subsector.

Emissions in the institutional/commercial subsector are also strongly influenced by tourism activity. Agriculture, fisheries and forestry only take place to a limited extent. Fuel production does not take place, however, fuel distribution does. Carbon capture and storage is not practiced.

On this basis, GHG emission estimates for the gases CO_2, CH_4, N_2O were compiled for the energy sector categories presented in
Table 18 below. These are the categories where relevant activities place in The Bahamas. Information about the activities relevant to each category (e.g., related to manufacture and construction) which are found in The Bahamas is provided from section 3.2.3.1 onwards.

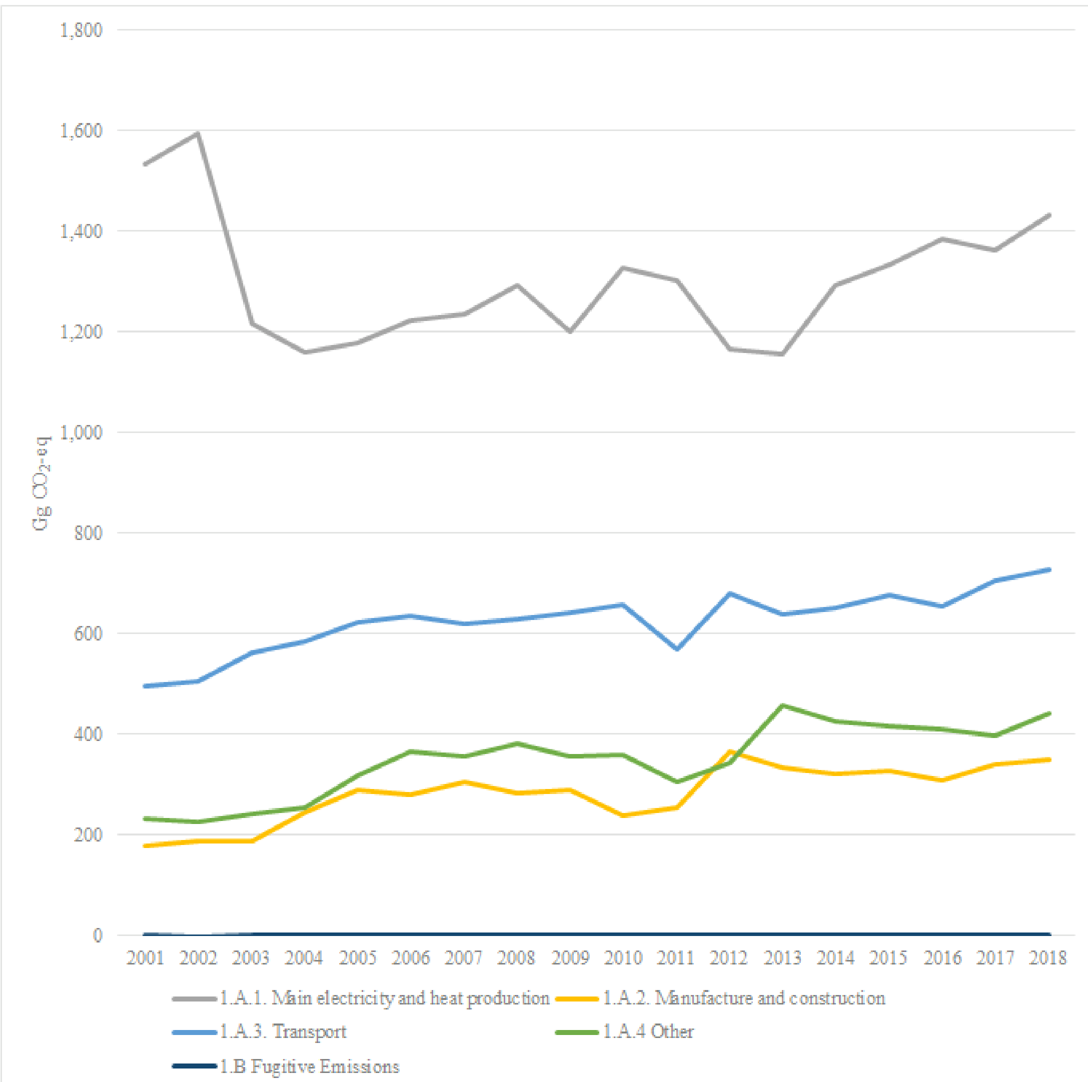
Table 18: GHG emission categories covered for the energy sector

IPCC Category	Category Name
1.A.1.a.1	Main electricity and heat production
1.A.2.	Manufacture and construction
1.A.2.k	Construction
1.A.2.m	Non-specified industry
1.A.3 Transport	
1.A.3.a. Aviation	• 1.A.3.a.i International Aviation • 1.A.3.a.i Domestic Aviation
1.A.3.b Road Transportation	• 1.A.3.b.i Cars • 1.A.3.b.i Light duty trucks • 1.A.3.b.i Heavy duty trucks and buses • 1.A.3.b.i Motorcycles
1.A.3.c. Navigation	• 1.A.3.c.i International Waterborne Navigation • 1.A.3.c.ii Domestic Waterborne Navigation
1.A.4	Other
1.A.4.a	Institutional/commercial
1.A.4.b	Residential

1.A.4.c	Agriculture/fisheries
1.B	Fugitive Emissions
1.B.2.A.iii.3	Natural Gas Liquids transport

An overview of GHG emissions in the Energy sector by category and by gas is presented in Table 19 below. Total GHG emissions in the energy sector amounted to 2435.21 Gg CO_2-eq in 2001 and 2949.58 Gg CO_2-eq in 2018, see Figure 25.

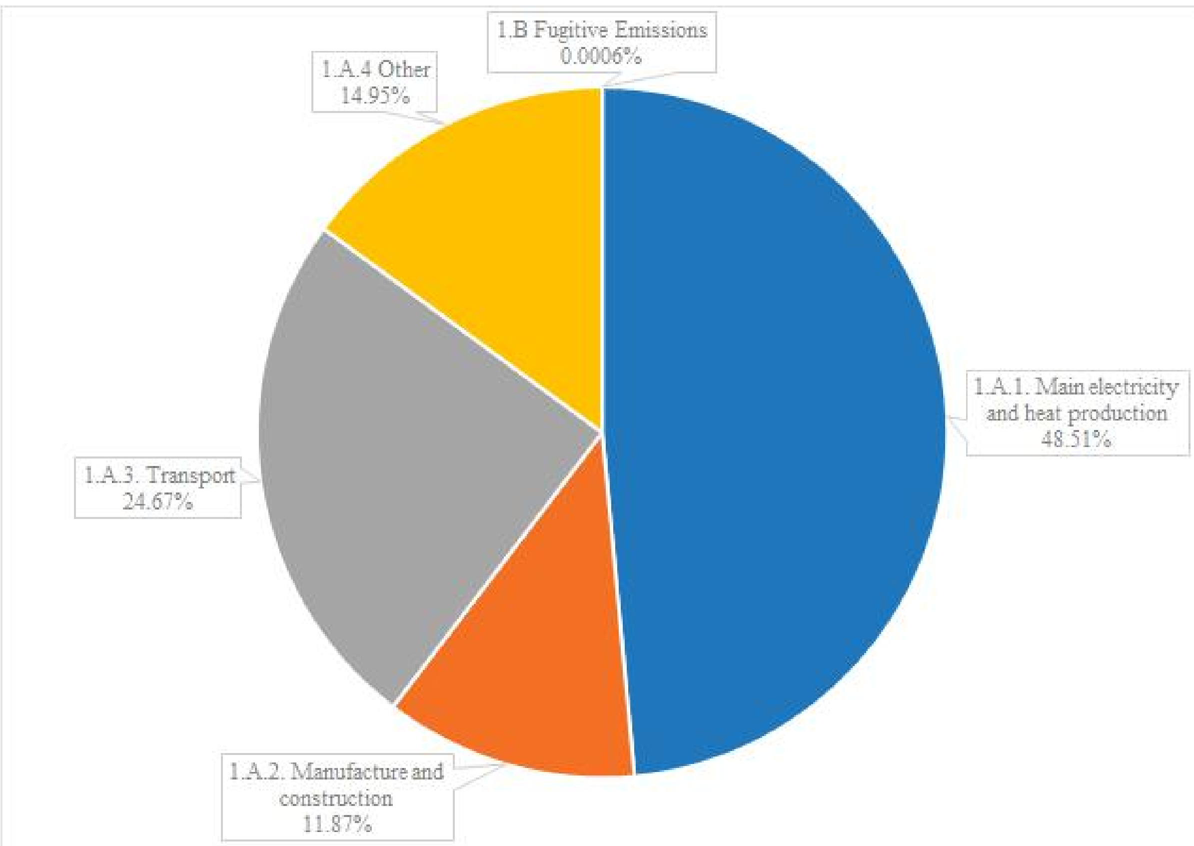
Figure 25: GHG emissions in the energy sector 2001-2018, by categories



The above information represents an increase by 21.1 per cent. In the same time frame, GDP has increased by over 60 per cent and population by nearly 30 per cent.

Main power and heat generation is the largest GHG emission source in the energy sector with 48.5 per cent of total emissions, followed by transport with 24.6 per cent. Manufacture and construction contributes 11.9 per cent and Other 15.0 per cent. The contribution of Fugitive Emissions category is minute with 0.0006 per cent.

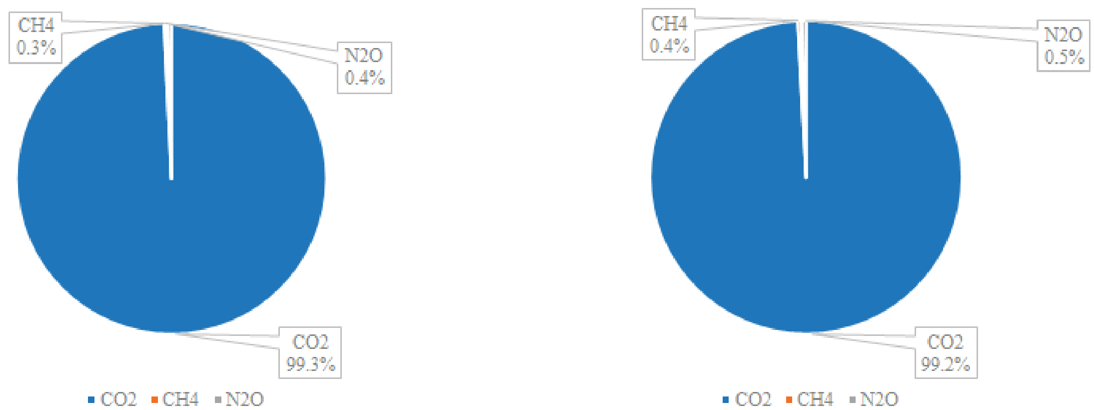
Figure 26: Contribution of categories to total GHG emissions in the energy sector in 2018



Shares of the gases in total emissions have remained similar over time, around 99 per cent for CO_2 and below 1 per cent for CH_4 as well as for N_2O.

Figure 27 shows the contribution of the three gases to total GHG emissions in the energy sector in 2001 as well as in 2018.

Figure 27: Contribution of gases to total GHG emissions in the energy sector in 2001 and 2018



GHG emissions for the subcategories 1.A.1 Main Electricity and Heat Production, 1.A.2 Manufacture and Construction, 1.A.3 Transport and 1.A.4 Other sector all show an increasing trend since 2011. Before, they had shown an overall slightly downward trend. For the energy sector as a whole, GHG emissions have increased by 21.1 per cent between 2001 and 2018. This includes a reduction of 6.6 per cent from Main Electricity and Heat Production, and an increase by 97.7 per cent in Manufacture and Industries, 90.8 per cent in Other and 47.2 per cent in Transport.

The increase in population as well as in GDP and related to that, tourism activity, can be deemed to have played a key role in the generally upwards moving trend since 2011. Technological change, e.g. the replacement of equipment for power generation, might potentially have played a role in reducing fuel consumption in earlier years of the time series. Data indicates that generation efficiency has considerably increased from 2003 onwards compared to 2001 and 2002. Furthermore, GDP has remained nearly stable between 2002-2004. A general decrease in fuel consumption in the sectors Transport and Other can be seen between 2009-2010. This might be related to the global financial crisis 2008-2010.

Table 19: GHG emissions in the Energy sector, by category

Category	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Difference 2018 vs 2001
1.Energy Total	Gg CO_2-eq	**2435.21**	**2512.78**	**2207.71**	**2243.39**	**2407.76**	**2427.07**	**2553.17**	**2588.42**	**2686.94**	**2752.86**	**2759.77**	**2805.72**	**2949.58**	**21.12%**	**2435.21**	**2512.78**	**2207.71**	**2243.39**	**21.1%**
1.A. Fuel combustion	Gg CO_2-eq	2435.20	2512.78	2207.70	2243.38	2407.75	2427.06	2553.16	2588.41	2686.93	2752.85	2759.76	2805.71	2949.56	21.12%	2435.20	2512.78	2207.70	2243.38	21.1%
1.A.1. Main electricity and heat production	Gg CO_2-eq	1532.51	1593.82	1217.35	1159.20	1177.49	1300.38	1165.09	1156.89	1291.53	1334.40	1383.86	1363.47	1430.77	-6.64%	1532.51	1593.82	1217.35	1159.20	-6.6%
1.A.2. Manufacture and construction	Gg CO_2-eq	177.18	188.55	187.28	245.98	290.65	253.17	365.38	335.03	320.99	327.69	309.69	339.29	350.19	97.65%	177.18	188.55	187.28	245.98	97.7%

1.A.3. Transport	Gg CO_2-eq	494.45	504.45	562.57	585.06	621.10	567.16	681.13	639.38	650.10	675.76	654.90	704.57	727.65	47.16%	494.45	504.45	562.57	585.06	47.2%
1.A.4 Other	Gg CO_2-eq	231.07	225.96	240.50	253.15	318.51	306.36	341.57	457.11	424.32	415.00	411.31	398.38	440.95	90.83%	231.07	225.96	240.50	253.15	90.9%
1.B Fugitive Emissions	Gg CO_2-eq	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02	64.29%	0.01	0.01	0.01	0.01	64.3%

Table 20: Total GHG emissions in the energy sector, by gas

Gas	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Difference 2018 vs 2001
Total	Gg CO_2-eq	2435.21	2512.78	2207.71	2243.39	2407.76	2427.07	2553.17	2588.42	2686.94	2752.86	2759.77	2805.72	2949.58	2435.21	2512.78	2207.71	2243.39	2407.76	21.1%
CO_2	Gg CO_2-eq	2417.27	2494.28	2188.64	2224.30	2387.62	2407.35	2531.11	2566.67	2664.81	2729.97	2737.12	2781.98	2924.86	21.00 %	2417.27	2494.28	2188.64	2224.30	21.0%
CH_4	Gg CO_2-eq	8.29	8.50	9.16	8.73	9.06	9.11	9.75	10.06	10.19	10.53	10.50	10.88	11.41	37.59 %	8.29	8.50	9.16	8.73	37.6%

N_2O	Gg CO_2-eq	9.64	10.00	9.91	10.37	11.08	10.62	12.32	11.69	11.95	12.36	12.15	12.85	13.31	38.01 %	9.64	10.00	9.91	10.37	38.01 %

2.8 IPPU

The industrial processes and product use sector covers a wide range of sources of GHG emissions. These include process (i.e., non-energy related) emissions from industrial production as well as emissions related to the use of certain products. GDP in The Bahamas focuses on the financial sector as well as on tourism, with only very limited industrial production taking place.

Data collection and consultation with experts indicates that no relevant industrial production, e.g., of cement clinker, glass, ceramics or steel takes place in The Bahamas at present. Moreover, a number of product use categories clearly occur or are likely to occur, while no data is available. These are presented in Table 21.

Table 21: Categories of the IPPU sector not estimated due to lack of data

Gas and IPCC category	**IPCC category code**	**Likelihood of occurrence**
CO_2 emissions from the use of paraffin waxes and solvent use	2.D.2, 2.D3	Likely
HFC emissions from the operation and discharge of refrigeration and air conditioning equipment	2.F.1	Emissions do occur
HFC emissions from the use of building foams, aerosols and solvents	2.F.2, 2.F.3, 2.F.4	Likely
SF_6 emissions from the operation of electrical equipment	2.G.1	Likely
N_2O emissions from the use of N_2O in hospitals	2.G.3	Likely

Due to the lack of data, GHG emissions from these categories could not be estimated. Particularly the HFC emissions from the operation and discharge of refrigeration and air conditioning equipment are likely to make a relevant contribution to The Bahamas total

GHG emissions. The collection of relevant data for the compilation of the next GHG inventory should thus be considered a priority. Annex II presents suggestions on how to retrieve relevant in the course of future GHG inventory compilations.

Emissions of product use which occur and for which data was available, relates to the use of lubricants. These emissions are presented in Table 22. This source only leads to emissions of CO_2. Emissions have decreased by over 70% over the time series, with a dip of over 50% happening between 2010 and 2011. Reasons for this development are presently unknown and should be researched as part of future GHG inventory compilations. A potential explanation could be structural changes after the economic crisis 2008-2010.

Table 22: Total GHG emissions in category 2.D.1 Lubricant use

Category	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	% Change 2018 vs 2001
2.D.1	Gg CO_2-eq	3.75	8.43	2.84	2.84	3.42	4.17	3.25	3.59	3.09	3.17	1.42	1.08	1.75	1.00	1.00	1.00	1.17	1.08	-71.11%

2.9 AFOLU

2.9.1 Agriculture

The agriculture sector covers a wide range of sources of GHG emissions including from livestock, crop production, fertilizer use, and soil management. The agriculture sector in The Bahamas remains a small percentage of the national GDP. These practices include small scale farming of food crops, limited livestock production throughout the islands, and more significantly, poultry egg and broiler production and soil enrichment from fertilizers. The addition of lime to agricultural soils was not estimated, as national soils are considered calcareous, and biomass burning was not estimated, as post-crop burning is not considered a common practice.

On this basis, GHG emission estimates for the gases CO_2, CH_4, N_2O were compiled for the agriculture sector categories presented in Table 23 below.

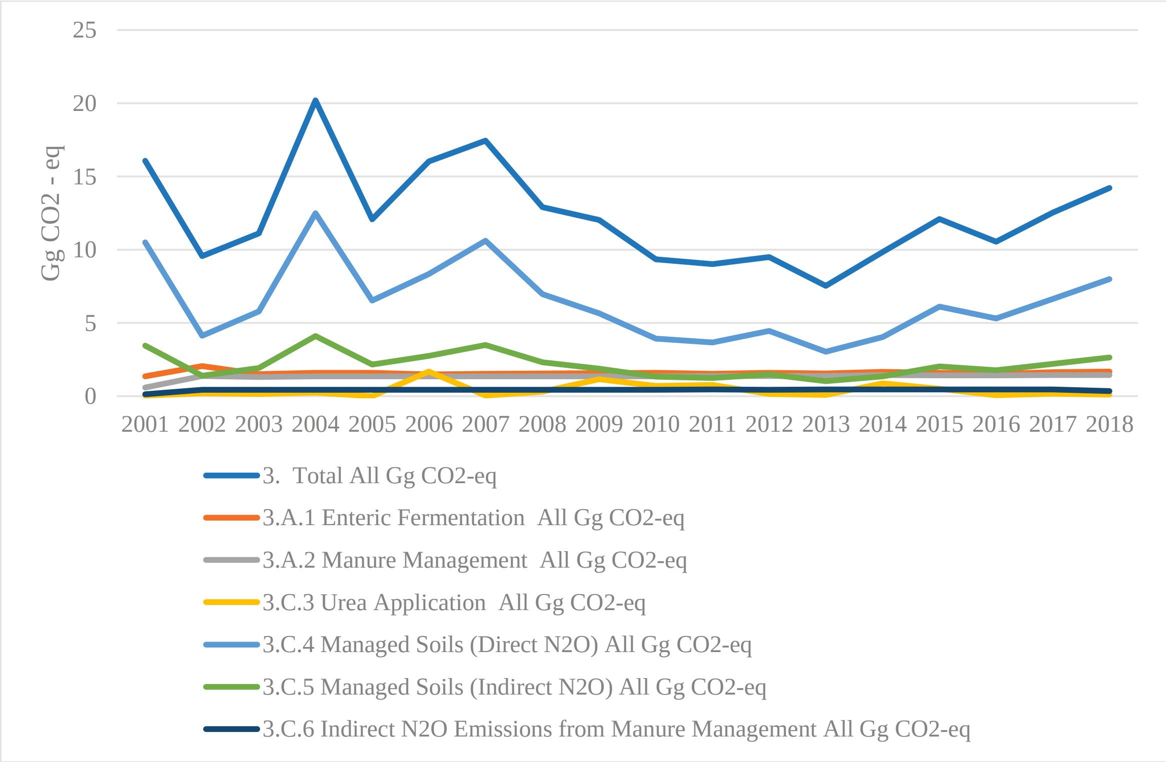
Table 23: IPCC 2006 GL categories for which Agriculture GHG emissions were estimated

IPCC Category	Category Name
3.A.1	Enteric Fermentation (CH_4)
3.A.2	Manure Management (CH_4 & Direct N_2O)
3.C.3	Urea Application (CO_2)
3.C.4	Managed Soils (Direct N_2O)
3.C.5	Managed Soils (Indirect N_2O)
3.C.6	Indirect N_2O Emissions from Manure Management

Total GHG emissions in the agriculture sector amounted to 16.08 Gg CO_2-eq in 2001 and 14.23 Gg CO_2-eq in 2018, see

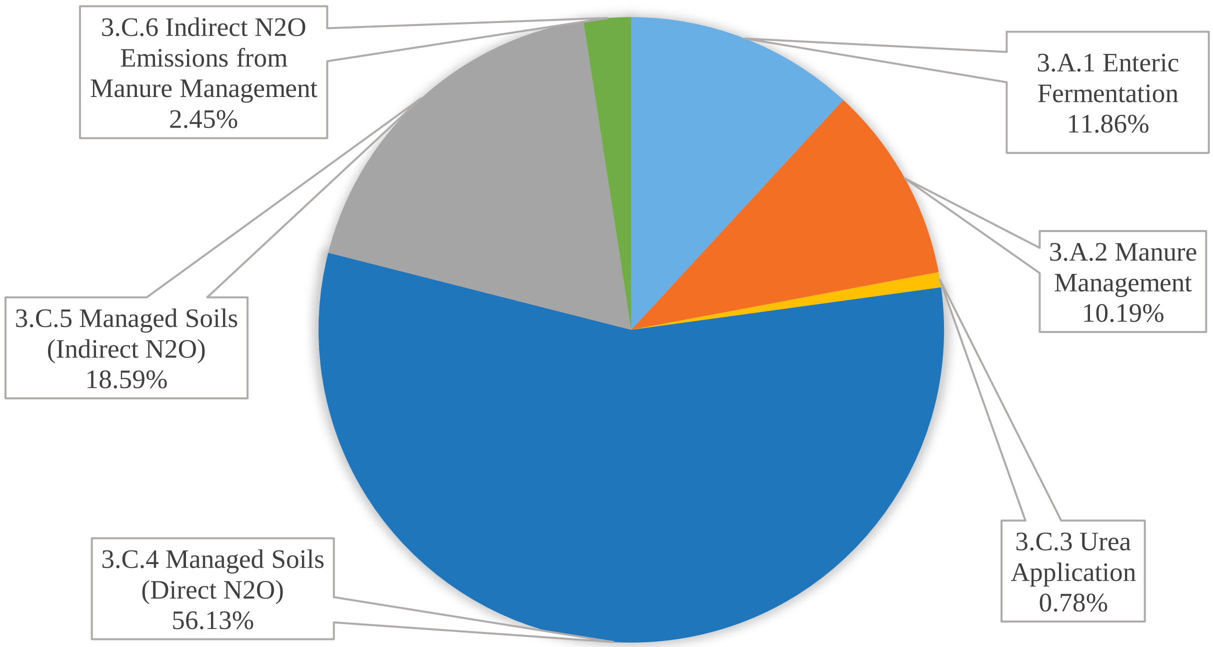
Figure 28 and Table 24. This represents a decrease by 11.54% per cent.

Figure 28: Total agriculture-sector category GHG emissions 2001-2018



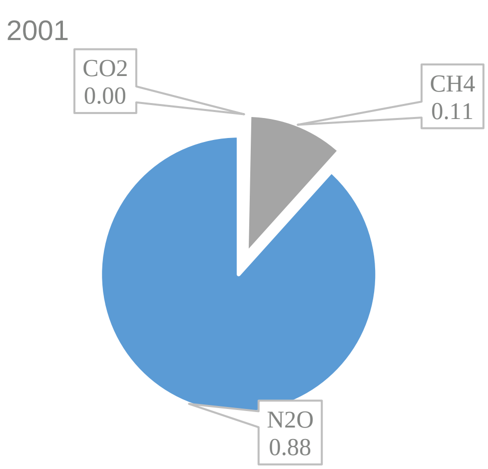
Total Direct N_2O emissions on managed soils, particularly from fertilizer, was the highest contributor to sector emissions (56.13 per cent), accounting for the importation of nitrogen based fertilizers over the time series. This is followed by indirect N_2O emissions to managed soils from leaching and atmospheric volatilization from fertilizers and managed animal waste, accounting for (18.59 per cent). Emissions from enteric fermentation (livestock), 11.86 per cent, and manure management (10.19 per cent) followed. Livestock is limited in the country, and was estimated from both national and international sources, from enteric fermentation, particularly for grazing animals. Indirect N_2O emissions from manure management and urea application jointly represented about 3 per cent of sector emissions.

Figure 29: Contribution of categories to total GHG emissions in the agriculture sector in 2018



Shares of the gases in total emissions have remained similar over time, with N_2O accounting for 88.3 and 95.9 per cent in 2001 and 2018 respectively, and 11.4 and 15.6 per cent for CH_4, and for CO_2, and 0.3 and 1 per cent each both in 2001 and 2018 (see Figure 30).

Figure 30: Contribution of gases to total agriculture sector emissions in 2001 and 2018



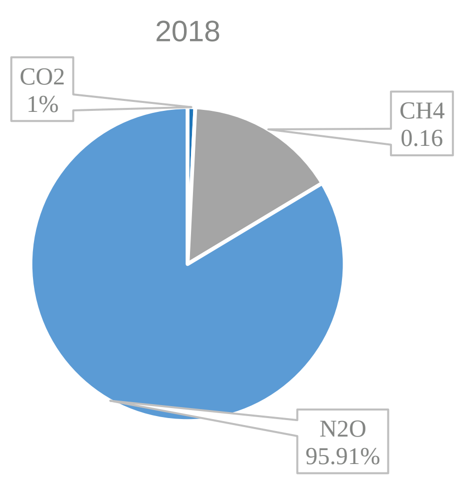


Table 24: GHG emissions in the agriculture sector, by category

IPCC Category	Gas	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	% Increase 2018 vs 2001
3. Total	All	Gg CO_2-eq	**16.08**	**9.57**	**11.12**	**20.20**	**12.07**	**16.04**	**17.46**	**12.91**	**12.03**	**9.34**	**9.02**	**9.49**	**7.54**	**9.84**	**12.11**	**10.54**	**12.54**	**14.23**	-11.54%
3.A.1	All	Gg CO_2-eq	1.36	2.06	1.51	1.59	1.60	1.48	1.53	1.55	1.56	1.60	1.53	1.60	1.55	1.66	1.60	1.54	1.64	1.69	24.34%
3.A.2	All	Gg CO_2-eq	0.58	1.37	1.31	1.34	1.34	1.34	1.35	1.35	1.35	1.36	1.37	1.37	1.38	1.44	1.41	1.41	1.43	1.45	151.17%
3.C.3	All	Gg CO_2-eq	0.05	0.19	0.15	0.23	0.00	1.68	0.04	0.31	1.15	0.69	0.76	0.15	0.09	0.88	0.49	0.06	0.18	0.11	114.08%
3.C.4	All	Gg CO_2-eq	10.51	4.12	5.79	12.49	6.53	8.33	10.61	6.96	5.65	3.93	3.67	4.44	3.04	4.04	6.12	5.30	6.64	7.99	-23.99%

3.C.5	All	Gg CO_2-eq	3.45	1.40	1.92	4.10	2.16	2.75	3.49	2.31	1.88	1.32	1.24	1.49	1.03	1.36	2.03	1.77	2.20	2.65	-23.36%
3.C.6	All	Gg CO_2-eq	0.14	0.43	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.46	0.44	0.45	0.46	0.45	0.46	0.45	0.35	151.36%

Table 25: GHG emissions in the agriculture sector, by gas

IPCC Category	Gas	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	% Increase 2018 vs 2001
3. Total	CO_2	Gg CO_2-eq	0.05	0.19	0.15	0.23	0.00	1.68	0.04	0.31	1.15	0.69	0.76	0.15	0.09	0.88	0.49	0.06	0.18	0.11	114.08%
3. Total	CH_4	Gg CO_2-eq	1.83	2.61	1.99	2.09	2.09	1.98	2.03	2.05	2.06	2.10	2.04	2.09	2.05	2.18	2.11	2.05	2.16	2.22	21.59%
3. Total	N_2O	Gg CO_2-eq	14.21	6.77	8.98	17.88	9.98	12.38	15.39	10.56	8.83	6.55	6.22	7.24	5.40	6.78	9.50	8.43	10.21	11.90	-16.25%

		Total	**16.08**	**9.57**	**11.12**	**20.20**	**12.07**	**16.04**	**17.46**	**12.91**	**12.03**	**9.34**	**9.02**	**9.49**	**7.54**	**9.84**	**12.11**	**10.54**	**12.54**	**14.23**	

2.9.2 Forestry and Other Land Uses

GHG emissions in the Forestry and Other Land Use sector typically come from a number of sources related to CO_2 emissions/removals from carbon stock changes in above and below-ground biomass pools of forest land, including forest land converted to other land uses such as cropland, grasslands, wetlands, and settlements. CH_4 and N_2O, and additional CO_2 emissions arise from fires and drainage of organic soils, however these emissions were not estimated due to unavailability of data on forest fires.

On this basis, GHG emission estimates for the gases CO_2 were compiled for the FOLU sector categories presented in Table 26 below.

Table 26: IPCC 2006 GL categories for which FOLU GHG emissions were estimated

IPCC Code	Category Name	
3.B.1	Forest land	3.B.1.a – Forest land Remaining Forest land 3.B.1.b – Land Converted to Forest land
3.B.2	Cropland	3.B.2.a – Cropland Remaining Cropland 3.B.2.b – Land Converted to Cropland
3.B.3	Grassland	3.B.3.a – Grassland Remaining Grassland 3.B.3.b – Land Converted to Grassland
3.B.4	Wetland	3.B.4.a – Wetlands Remaining Wetlands 3.B.4.b – Land Converted to Wetlands
3.B.5	Settlements	3.B.5.a – Settlements Remaining Settlements 3.B.5.b – Land Converted to Settlements
3.B.6	Other Land	3.B.6.a – Other land Remaining Other land 3.B.6.b – Land Converted to Other land

Total GHG emissions in the FOLU sector are dominated by the category Land conversion to Grassland in 2018, primarily from conversion from forest land to grassland. All emissions estimated from this sector were CO_2 emissions (Figure 31).

Figure 31: Contribution of categories to total FOLU GHG emissions in 2018

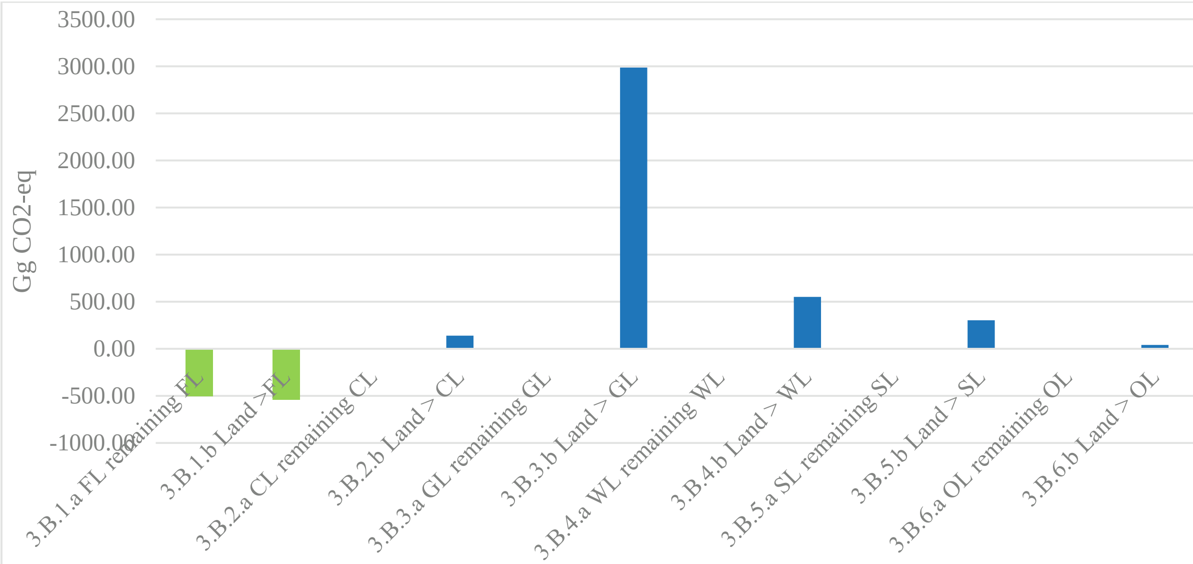
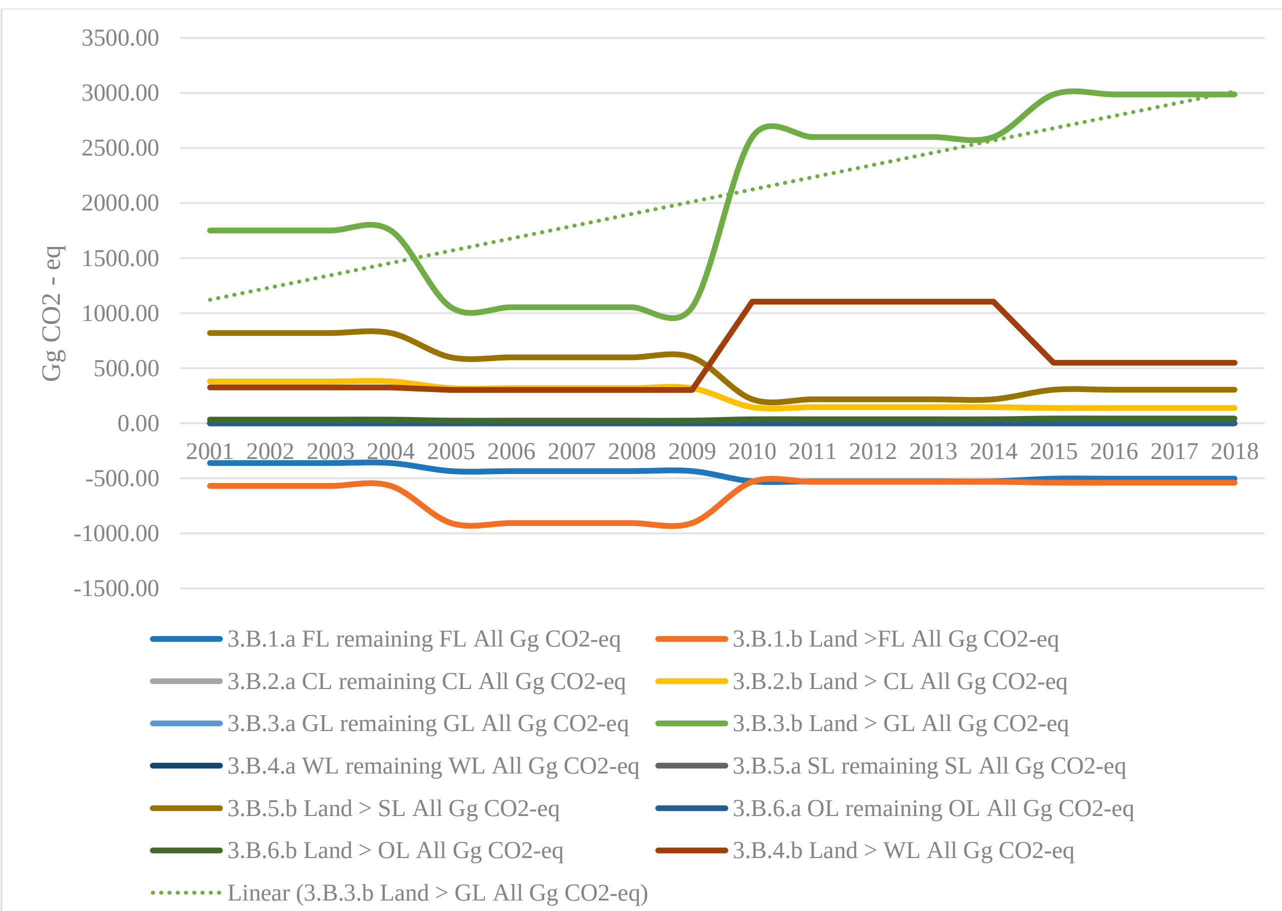


Figure 32: FOLU Sector Emissions by Category



Activity data generated from the land use change maps were multiplied with IPCC default emission factors to calculated emissions for each 5-year time interval. The yearly emissions estimated from land use change for each 5 year time interval (more information on methodology and approaches in Section 3.4.2) can be seen in Table 27 and Figure 32.

Over the time series, the trends that influence annual emissions are those with the most carbon stocks (i.e. Forest land, Grassland, and conversion to either). Lowest emissions were noted within the time period of 2005-2009 (955.66 Gg CO_2 eq yearly emissions) attributed to land conversion to forest land (more removals). This effect was noted after the passing of two hurricanes, Hurricanes Frances and Hurricane Jeanne, occurring two weeks apart in October of 2004, having severely impacted the north-western Bahamas, including Abaco, Andros, Berry, Bimini, Eleuthera, Exuma, Grand Bahama and New Providence islands (mainly forested islands). The pine forests of Grand Bahama were especially impacted with regeneration not comparable to its previous state. The effects of secondary foliage regrowth (and subsequently more removals) attributed to enhanced sinks and reduced emissions in the 2005-2010, with visual effects of this regrowth discernible by satellite imagery in the year 2010 on Grand Bahama and Abaco Islands (Figure 35).

In the following years, from 2010 to 2014 an increase in emissions in the area of 30% is noted, attributed to conversion from forestland to grassland and secondarily from a large conversion of forest land to wetlands (reduction in carbon stocks). The characteristics of these conversions require more land based studies, however the incidence of cyclical conversion of native shrubs and scrubs (classified as grasslands) to wetlands was identified as an area for future study. For more information on activity data see Section 3.4.2.

Furthermore, in more recent natural disasters, Hurricane Dorian in 2019 has demonstrated partial to severe destruction to mangroves, coral reefs, and forests of Abaco and Grand Bahama, particularly the eastern sides of Grand Bahama. Severe defoliation of pine forests on Grand Bahamas and Abaco, with moderate to severe tree uprooting and breakage in certain areas. Although previous assessments in The Bahamas indicate that ecosystems in the country have adapted over time to become resilient to tropical weather and extreme events, destruction to mangroves, coral reefs, seagrass beds and forests of Abaco and Grand Bahama, particularly the eastern sides of Grand Bahama were noted post Hurricane Dorian. Severe defoliation of pine forests on Grand Bahamas and Abaco, with moderate to severe tree uprooting and breakage in certain areas (IDB, 2019). This impact, particularly of the defoliation on Grand Bahama and Abaco can be seen on Figure 37 (Land Use Map of 2020), however the overall emissions from land use change between 2010 and 2020 were relatively constant.

Noteworthy for future improvements is the consideration of data gaps in activity data particularly from 2003 onward where Landsat 7 satellite images suffer from scan-line errors, resulting in less accurate activity data generated from Landsat 7 images.

Figure 33: Land Use Map 2000

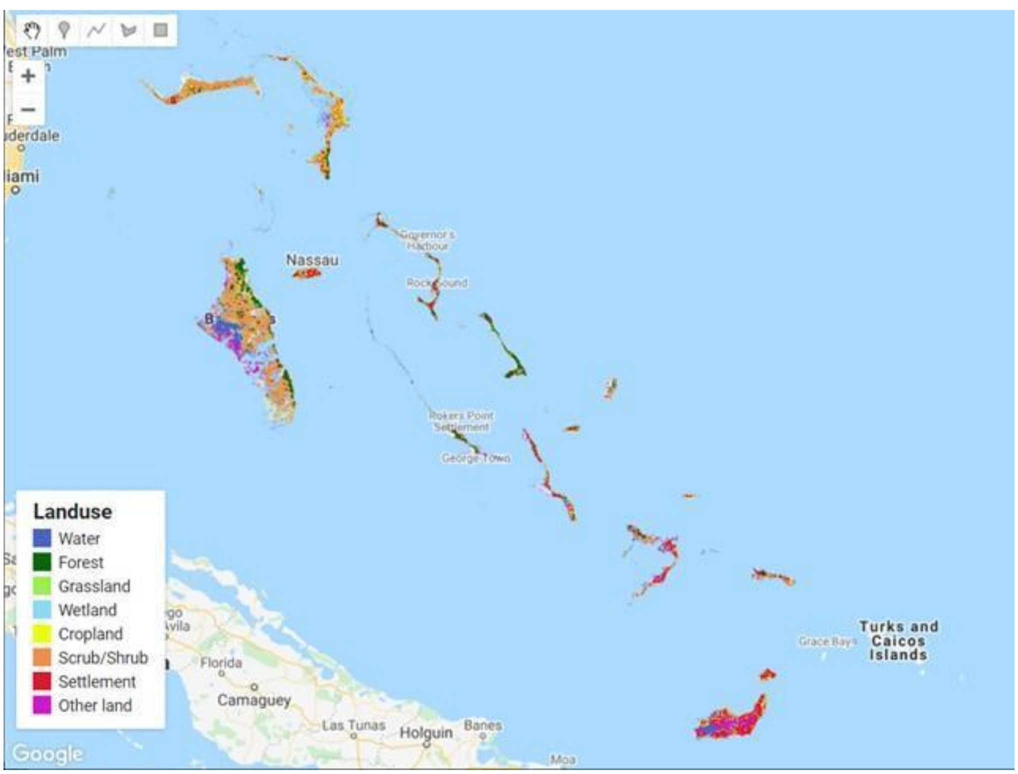


Figure 34: Land Use Map 2005

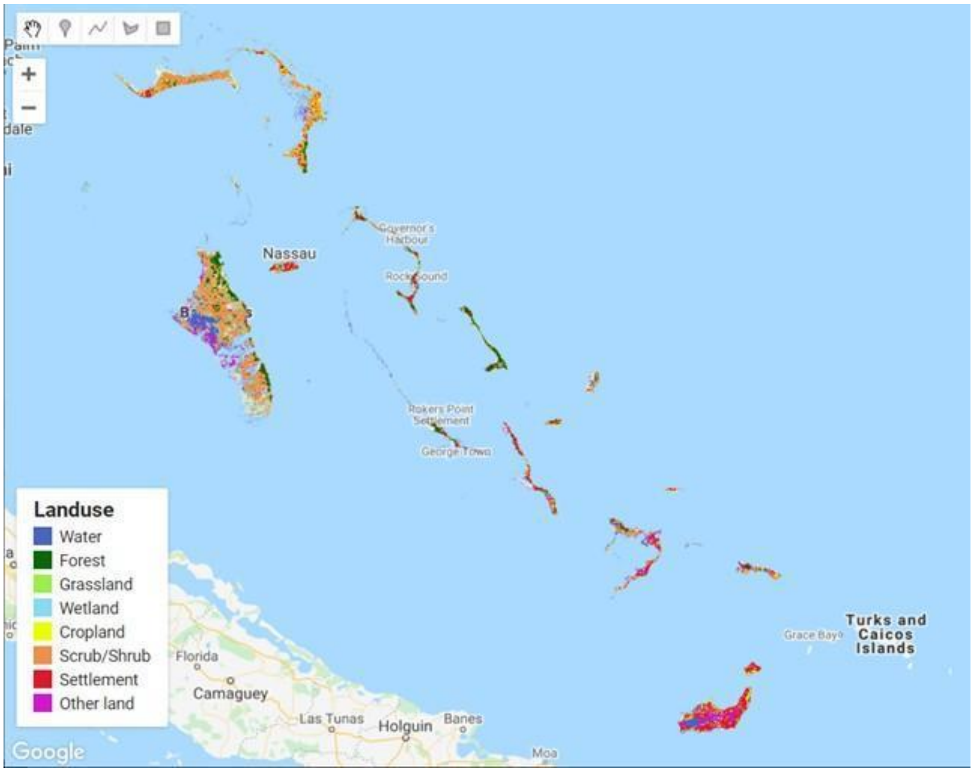


Figure 35: Land Use Map 2010

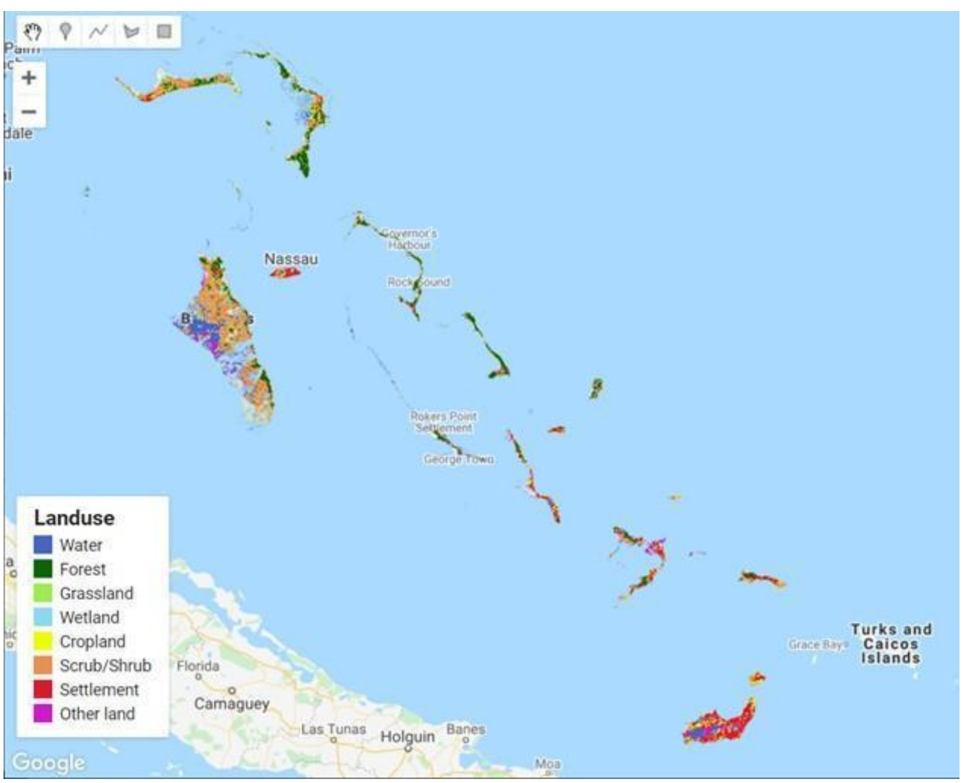


Figure 36: Land Use Map 2015

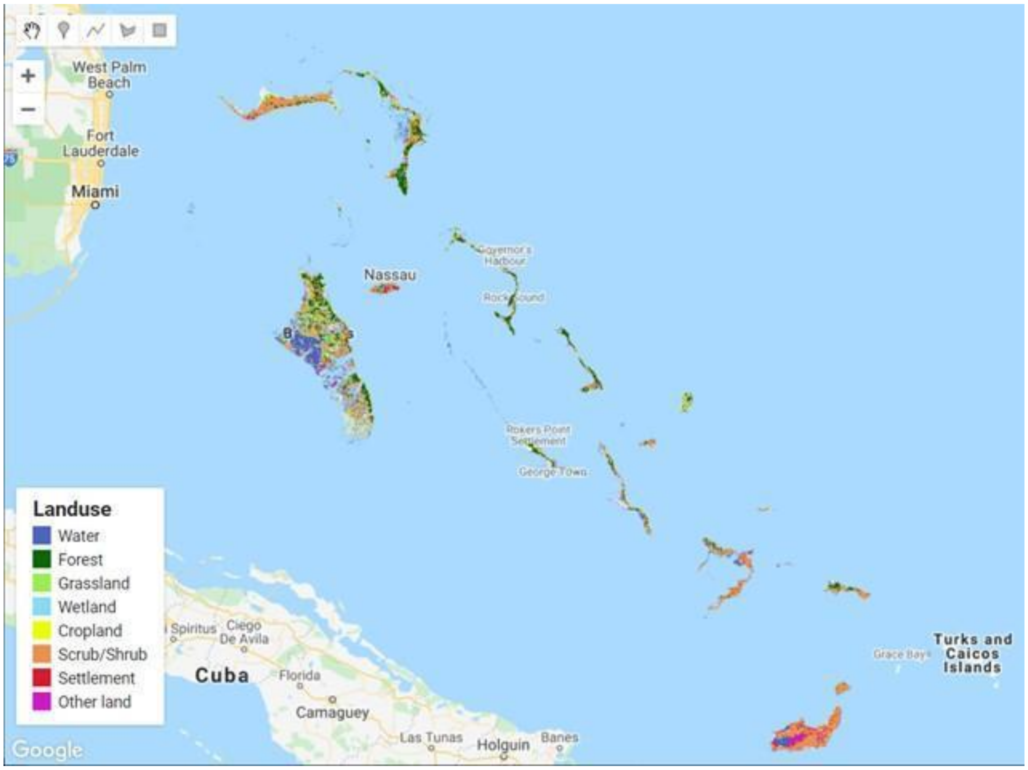


Figure 37: Land Use Map 2020

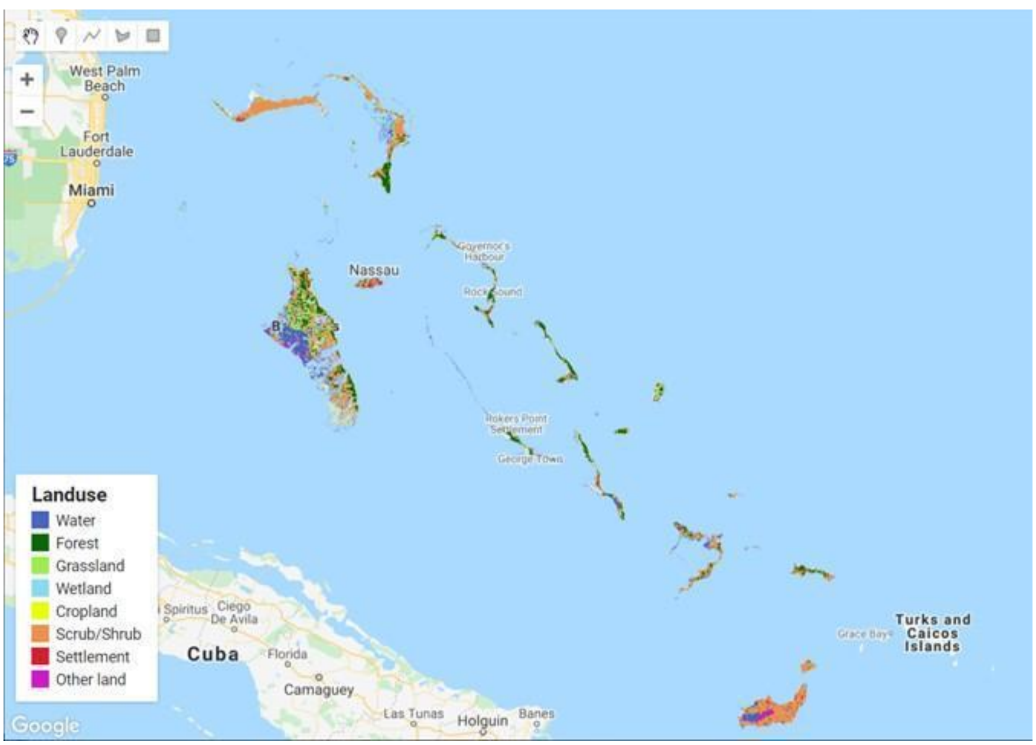


Table 27: GHG emissions in the Forestry and Other Land Use GHG sector, by category

IPCC Category	Gas	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	% Increase 2018 vs 2001
3. Total	All	Gg CO_2-eq	**2377.60**	**2377.60**	**2377.60**	**2377.60**	**955.66**	**955.66**	**955.66**	**955.66**	**955.66**	**3042.82**	**3042.82**	**3042.82**	**3042.82**	**3042.82**	**2979.11**	**2979.11**	**2979.11**	**2979.11**	25.30%
3.B.1.a	All	Gg CO_2-eq	-361.60	-361.60	-361.60	-361.60	-434.70	-434.70	-434.70	-434.70	-434.70	-527.69	-527.69	-527.69	-527.69	-527.69	-503.33	-503.33	-503.33	-503.33	39.20%
3.B.1.b	All	Gg CO_2-eq	-568.94	-568.94	-568.94	-568.94	-906.32	-906.32	-906.32	-906.32	-906.32	-531.80	-531.80	-531.80	-531.80	-531.80	-539.28	-539.28	-539.28	-539.28	-5.21%
3.B.2.a	All	Gg CO_2-eq	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
3.B.2.b	All	Gg CO_2-eq	380.16	380.16	380.16	380.16	318.55	318.55	318.55	318.55	318.55	146.16	146.16	146.16	146.16	146.16	138.31	138.31	138.31	138.31	-63.62%
3.B.3.a	All	Gg CO_2-eq	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
3.B.3.b	All	Gg CO_2-eq	1750.81	1750.81	1750.81	1750.81	1053.48	1053.48	1053.48	1053.48	1053.48	2599.54	2599.54	2599.54	2599.54	2599.54	2986.35	2986.35	2986.35	2986.35	70.57%

3.B.4.a	All	Gg CO_2-eq	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
3.B.4.b	All	Gg CO_2-eq	324.78	324.78	324.78	324.78	302.22	302.22	302.22	302.22	302.22	1103.24	1103.24	1103.24	1103.24	1103.24	550.03	550.03	550.03	550.03	69.36%
3.B.5.a	All	Gg CO_2-eq	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
3.B.5.b	All	Gg CO_2-eq	819.38	819.38	819.38	819.38	598.61	598.61	598.61	598.61	598.61	217.44	217.44	217.44	217.44	217.44	304.20	304.20	304.20	304.20	-62.87%
3.B.6.a	All	Gg CO_2-eq	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
3.B.6.b	All	Gg CO_2-eq	33.01	33.01	33.01	33.01	23.83	23.83	23.83	23.83	23.83	35.94	35.94	35.94	35.94	35.94	42.83	42.83	42.83	42.83	29.74%

Table 28: GHG emissions in the Forestry and Other Land Use GHG sector, by gas

IPCC Category	Gas	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	% Increase 2018 vs 2001
3. Total	CO_2	Gg CO_2-eq	2377.60	2377.60	2377.60	2377.60	955.66	955.66	955.66	955.66	955.66	3042.82	3042.82	3042.82	3042.82	3042.82	2979.11	2979.11	2979.11	2979.11	25.30%
3. Total	CH_4	Gg CO_2-eq	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
3. Total	N_2O	Gg CO_2-eq	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		Total	**2377.60**	**2377.60**	**2377.60**	**2377.60**	**955.66**	**955.66**	**955.66**	**955.66**	**955.66**	**3042.82**	**3042.82**	**3042.82**	**3042.82**	**3042.82**	**2979.11**	**2979.11**	**2979.11**	**2979.11**	

2.10 Waste

GHG emissions in the waste sector typically come from a number of sources related to the treatment of solid waste as well as the management of wastewater. With regards to solid waste, solid waste disposal (i.e., landfilling of solid waste) and, to a small extent, open burning of waste, take place in The Bahamas. One landfill is currently being converted to a managed form, while the remaining landfills are unmanaged. Biological treatment of solid waste does not take place. Large scale waste incineration does not take place in The Bahamas according to available information and expert judgement. The incineration of hazardous waste at smaller facilities, e.g. in hospitals, might take place according to expert judgement. Information on amounts of hazardous waste and treatment approaches could not be obtained, this is clearly an area for improvement.

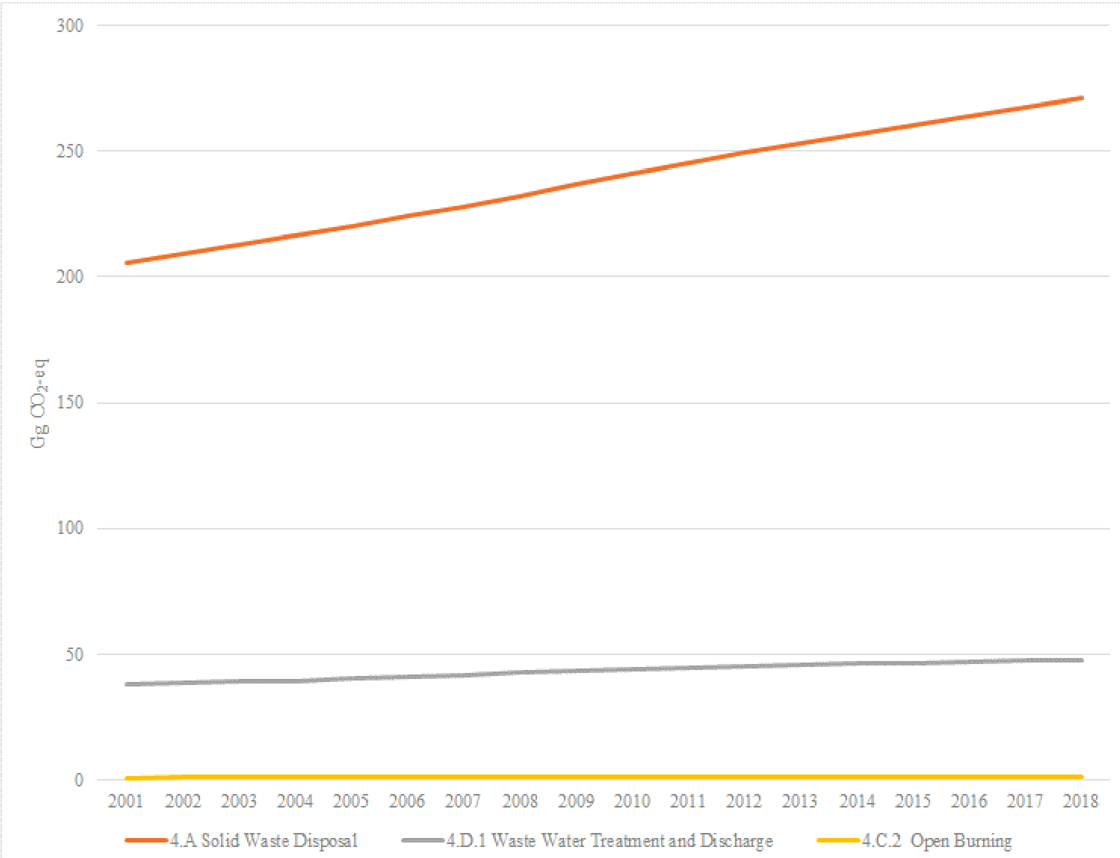
On this basis, GHG emission estimates for the gases CO_2, CH_4, N_2O were compiled for the waste sector categories presented in Table 29 below.

Table 29: IPCC 2006 GL categories for which Waste GHG emissions were estimated

IPCC Category	Category Name
4.A	Solid Waste Disposal
4.C.2	Open burning of waste
4.D.1	Domestic Wastewater Treatment and Discharge

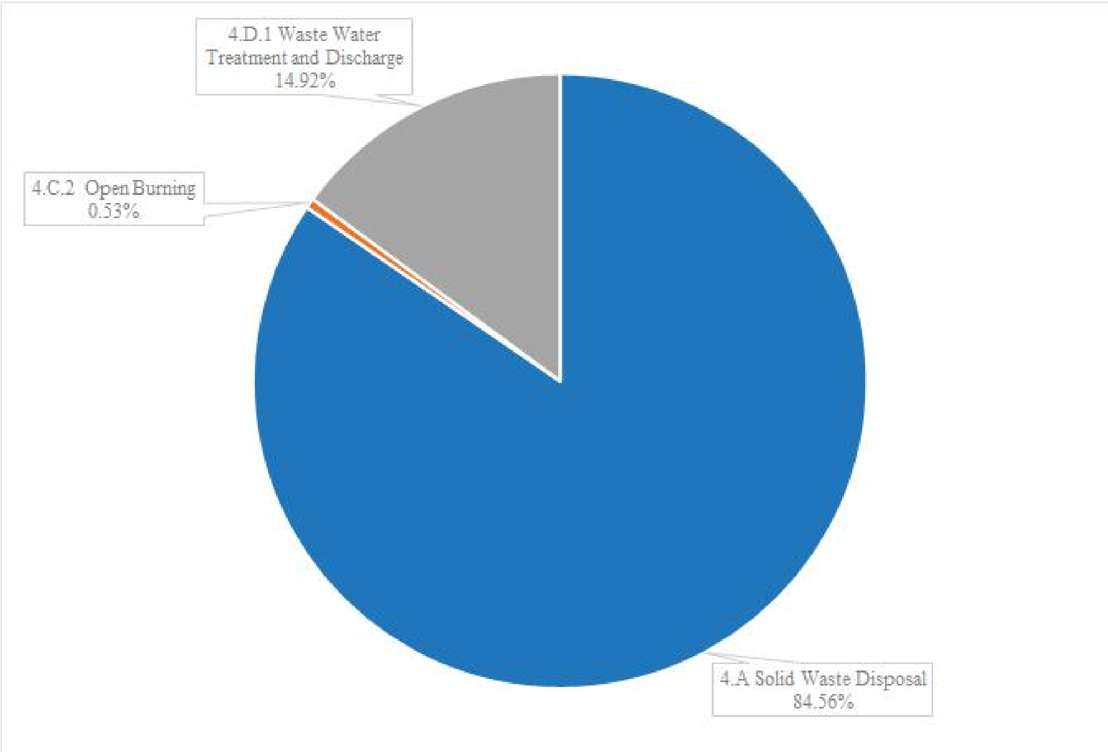
Total GHG emissions in the waste sector amounted to 245.20 Gg CO_2-eq in 2001 and 320.31 Gg CO_2-eq in 2018, see Figure 38 and Table 30. This represents an increase by 30.6 per cent. It is important to note that the calculation has heavily relied on IPCC default values and assumptions (e.g., waste generation rate, waste composition), so that the current estimations mainly reflect The Bahamas' population increase over the time series. Information indicating technological change and change in treatment approaches (e.g., moving from shallow to deep landfills over time) was not available. Generally, the increase in GDP and also tourism activity are likely to influence GHG emission developments in the waste sector, but are currently not reflected in the calculation. Annex II suggests improvements which would allow considering these drivers in the future.

Figure 38: Total GHG emissions in the waste sector 2001-2018, by categories



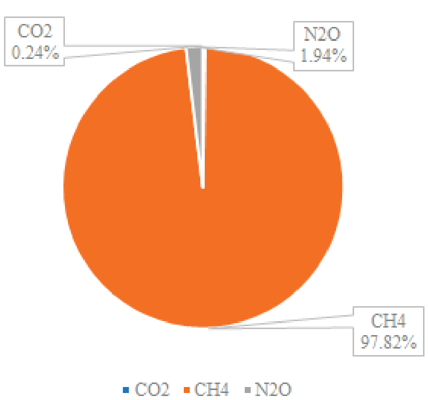
Total GHG emissions in the waste sector are dominated by the category solid waste disposal contributing 84.6 per cent in 2018. Wastewater treatment and discharge contribute 14.9 per cent and 0.5 per cent, see Figure 39. Between 2001 and 2018, the three subcategories show an upward trend with similar growth rates. GHG emissions from solid waste disposal grew by 31.6 per cent, from wastewater treatment and discharge by 27.4 cent and from open burning by 25.4 per cent.

Figure 39: Contribution of categories to total GHG emissions in 2018 in the waste sector



CH_4 dominates the waste sector with 98.1 per cent of sectoral emissions in 2018 and 97.8 in 2001. N_2O only contributes 1.7 per cent in 2018 and 1.9 per cent in 2001 and CO_2 only contributes 0.2 per cent in both years.

Figure 40: Contribution of gases to total waste sector emissions in 2001 and 2018



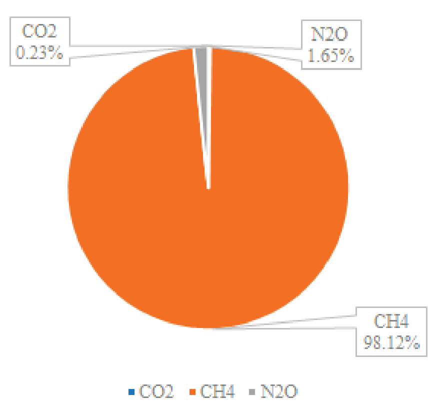


Table 30: GHG emissions in the waste sector 2001-2018, by category

IPCC Category	Gas	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	% Increase 2018 vs 2001
4. Total	All	Gg CO_2-eq	245.20	249.22	253.11	257.22	261.77	266.67	271.52	276.46	281.51	286.79	291.49	295.94	300.90	304.83	308.75	312.71	316.51	320.31	30.6%
4.A	All	Gg CO_2-eq	205.78	209.13	212.62	216.27	220.07	224.02	228.10	232.32	236.62	240.94	245.20	249.32	253.25	256.98	260.56	264.04	267.46	270.85	31.6%
4.C.2	All	Gg CO_2-eq	1.32	1.34	1.37	1.39	1.42	1.45	1.47	1.50	1.53	1.55	1.57	1.59	1.60	1.62	1.63	1.65	1.67	1.68	27.4%
4.D.1	All	Gg CO_2-eq	38.09	38.74	39.12	39.56	40.28	41.20	41.95	42.64	43.37	44.29	44.72	45.03	46.05	46.23	46.55	47.02	47.38	47.77	25.4%

Table 31: GHG emissions in the waste sector 2001-2018, by gas

IPCC Category	Gas	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	% Increase 2018 vs 2001
4. Total	All	Gg CO_2-eq	245.20	249.22	253.11	257.22	261.77	266.67	271.52	276.46	281.51	286.79	291.49	295.94	300.90	304.83	308.75	312.71	316.51	320.31	30.6%
4.A	CO_2	Gg CO_2-eq	0.58	0.59	0.60	0.61	0.62	0.63	0.65	0.66	0.67	0.68	0.69	0.70	0.70	0.71	0.72	0.72	0.73	0.74	27.4%
4.C.2	CH_4	Gg CO_2-eq	239.86	243.78	247.88	252.18	256.65	261.29	266.09	271.01	275.99	280.91	285.69	290.26	294.59	298.72	302.70	306.59	310.45	314.28	31.0%
4.D.1	N_2O	Gg CO_2-eq	4.76	4.85	4.63	4.43	4.50	4.74	4.78	4.79	4.86	5.20	5.11	4.98	5.60	5.40	5.33	5.39	5.33	5.30	11.3%

Approaches

2.11 Overview

Table 32 and Table 33 below present an overview on methodological tiers and data sources used for The Bahamas national GHG inventory. Generally, Tier 1 approaches were used. The Bahamas intends to move to Tier 2 over time for the categories identified as key (see section 2.3 . for the key category analysis and Annex III for the improvement plan)

Detailed information on activity data, data sources, emission and other calculation factors as well as assumptions are presented by IPCC category from section 3.2 onwards.

Table 32: Activity data and emission factor tiers used for The Bahamas national GHG inventory emission estimates

IPCC Category	Category Name	Specific IPCC Categories estimated for The Bahamas	Activity Data Tier	Emission Factor Tier
1.A.1	Energy Industries	1.A.1.a.1 Main electricity and heat production	1	D
1.A.2	Manufacture and construction	1.a.2.f Construction 1.A.2.m Non-specified Industries	1	D
1.A.3.	Transport	1.A.3.a.i International aviation 1.a.3.a.ii Domestic Aviation 1.A.3.b.i Cars 1.A.3.b.ii Light duty vehicles 1.a.3.b.iii Heavy duty vehicles and buses 1.a.3.b.iv Motorcycles	1	D

1.A.4.a	Other	1.A.4.a Institutional/Commercial 1.A.4.b Residential 1.A.4.c Agriculture/Fisheries/Forestry	1	D
1.B.	Fugitive emissions	1.B.2.a.iii.3 Natural gas liquids transport	1	D
3.A.1	Enteric Fermentation	3.A.1.a – Cattle 3.A.1.a.i – Dairy Cows 3.A.1.a.ii – Other Cattle 3.A.1.c – Sheep 3.A.1.d – Goats 3.A.1.f – Horses 3.A.1.g – Mules and Asses 3.A.1.h – Swine	1	D
3.A.2	Manure Management	3.A.2.a – Cattle 3.A.2.a.i – Dairy Cows 3.A.2.a.ii – Other Cattle 3.A.2.c – Sheep 3.A.2.d – Goats 3.A.2.f – Horses 3.A.2.g – Mules and Asses 3.A.2.h – Swine 3.A.2.j – Poultry	1	D
3.B.1	Forest land	3.B.1.a – Forest land Remaining Forest land 3.B.1.b – Land Converted to Forest land	1	D
3.B.2	Cropland	3.B.2.a – Cropland Remaining Cropland	1	D

		3.B.2.b – Land Converted to Cropland		
3.B.3	Grassland	3.B.3.a – Grassland Remaining Grassland 3.B.3.b – Land Converted to Grassland	1	D
3.B.4	Wetland	3.B.4.a – Wetlands Remaining Wetlands 3.B.4.b – Land Converted to Wetlands	1	D
3.B.5	Settlements	3.B.5.a – Settlements Remaining Settlements 3.B.5.b – Land Converted to Settlements	1	D
3.B.6	Other Land	3.B.6.a – Other land Remaining Other land 3.B.6.b – Land Converted to Other land	1	D
3.C.3	Urea Application		1	D
3.C.4	Direct N_2O Emissions from managed soils		1	D
3.C.5	Indirect N_2O Emissions from managed soils (3)		1	D

3.C.6	Indirect N_2O Emissions from Manure Management		1	D
4.A.	Municipal Solid Waste		1	D
4.C	Incineration and open burning	4.C.2 Open burning	1	D
4.D.1	Domestic Wastewater Treatment and Discharge		1	CS, D

Table 33: Overview of key data sources used for The Bahamas national GHG inventory estimates

IPCC Category	Key sources of activity data	Key sources of emission factors and other calculation factors
1. A. Energy	• Central Bank of The Bahamas • Energy Balance (2010-2012) • Power generators: Bahamas Power and Light, Company Ltd. Grand Bahamas Power Company • Fuel Distributors: Rubis	IPCC 2006 Guidelines
2. Industrial Processes and Product Use	• Central Bank of The Bahamas	IPCC 2006 Guidelines

3. AFOLU	• FAO Livestock data • Customs import data on livestock • Customs import data on urea and fertilizers • Landsat 7 and 8 satellite data from Google Earth • ESRI Land Cover Map 2020	IPCC 2006 Guidelines
4.A Waste	• UN Population data • FAO protein consumption data • Regional Sanitation Study (PAHO, 2012) • IPCC 2006 waste generation default data and waste composition default data	IPCC 2006 Guidelines

2.12 Energy

2.12.1 Overview - Activity data and emission factors

Table 34 presents the key data sources available for the estimation of energy sector emissions in The Bahamas.

Table 34: Key data sources and information covered by each source

Source	Fuels	Years covered	Scope	Reference

Central Bank of The Bahamas	propane, motor gasoline, aviation gasoline, Kerosene, Bunker C (a type of fuel oil), gas oil (also referred to as diesel), lubricants and others	1990-2021	Total national consumption of each fuel	Bahamas Central Bank, Quarterly Statistical Digests[14]
Energy Balance	Firewood, LPG, Gasoline Alcohol, Jet Fuel Kerosene, Diesel Oil, Fuel Oil, Charcoal, Non-Energy	2010-2012	Total national consumption of each fuel	OLADE (Latin American Energy Organisation) (2015); The Bahamas. Energy Balances 2010-2012; http://biblioteca.olade.org/opac-tmpl/Documentos/old0348.pdf
Bahamas Power and Light Company Ltd.	Fuel oil, diesel	2000-2020	Consumption of fuels for power generation in The Bahamas excluding Grand Bahama.	Private communication from Rochelle McKinney, Bahamas Power and Light

[14] The Quarterly Statistical Digests prepared by the CBB can be found here: https://www.centralbankbahamas.com/publications/qsd.

Grand Bahamas Power Company	CO_2 emissions from fuel oil as well as from diesel consumption	2016-2020	Power generation for Grand Bahama	Private communication from Garelle Hudson, Grand Bahamas Power Company
Rubis (a fuel distributor) [15]	Sales of Aviation gasoline, aviation jet fuel, unleaded gasoline, diesel, kerosene. Unleaded gasoline and diesel were differentiated by sales to retail clients and to commercial/industrial clients	2010-2019		Private communication from Kirk Johnson , Rubis

The Central Bank of The Bahamas (CBB) compiles a quarterly overview of oil imports for domestic consumption, including international bunkers (the fuels not consumed by The Bahamas themselves, but consumed for international aviation and international waterborne navigation). Such information covered the whole time series 2001-2018 and includes the following fuels: propane, motor gasoline, aviation gasoline, Kerosene, Bunker C (a type of fuel oil), gas oil (also referred to as diesel), lubricants and others. International bunkers are not differentiated by fuel type. The CBB data does not differentiate by fuel use, e.g., whether diesel is consumed for road transport or for diesel generators used by commercial ventures like hotels.

[15] Further fuel distributors exist, e.g. SOL Group, Freeport Oil Company, from which no data was available at the time of compiling this document.

OLADE has prepared an energy balance for the years 2010-2012. The energy balance (EB) presents fuel consumption by activity. These activities show good alignment with the categories of the IPCC 2006 Guidelines. Annex III shows how the fuels and activities in the energy balance were mapped against the categories in the IPCC 2006 Guidelines.

Comparing CBB and EB fuel consumption values, the CBB data values were often lower than EB values for the timeframe 2010-2012. While potential reasons for this discrepancy were assessed, it was not possible to find evidence pointing to specific reasons, e.g., data used and assumptions made in compiling the EB or completeness of the CBB dataset. Only for the particular case of fuel oil the EB mentions that a fuel distributor indicated that the CBB data does not consider data from all fuel distributors and might thus be lower than the real consumption. Of course, this situation related to 2010-2012, and there was no data available allowing to understand whether the situation might have changed today.

Disaggregated (bottom-up) fuel consumption at category level was available only to a limited extent, e.g., information related to fuel consumption for power generation from BPL and GBPC, fuel sales to retail as well as commercial industrial clients from Rubis.

In order to estimate total fuel consumption, the data sources which are of national origin and cover the whole time series were preferred. These are CBB and BPL. Only where these were not sufficient or seemed incomplete, EB data was used to fill gaps. Table 35 presents the approaches used to estimate overall fuel consumption for each fuel.

Allocation of fuel consumption to the various IPCC categories was performed using the average shares of each activity in total fuel consumption for the years 2010-2012 from the EB.

Table 35: Approaches for the estimation of fuel consumption

Fuel	Estimation of overall consumption	Clarifications
Aviation Gasoline	Value presented by the CBB statistics	EB presents gasoline and aviation gasoline aggregated into one

		category, while CB statistics present them separately
LPG	Value presented by the CBB statistics	The CB statistics present no LPG but "propane", while the EB mentions "LPG", which is in most cases a mix of propane and butane. Based on experience in the region it was assumed the CB data related to LPG as well.
Gasoline	Value presented by the CBB statistics	
Diesel	EB data was used for 2010-2012 and extrapolated for 2001-2009 and 2013-2018 using The Bahamas' GDP as driver	CBB diesel consumption fluctuates strongly and in no relation to GDP or population over the time series. Additionally, in 2010-2015 the CBB diesel consumption is slightly lower than the consumption reported by BPL, which only accounts for the consumption for power generation, but not for consumption under the other activities like transport. This indicates that the data might be incomplete.
Fuel oil	BPL fuel oil consumption values were scaled up by the average difference between BPL and EB values (2010-2012) in %.	CBB fuel oil consumption fluctuates strongly and in no relation to GDP or population over the time series, frequently being considerably lower than the fuel oil consumption reported by BPL, which accounts for the consumption for power generation, but not other activities like transport

		and industry. However, according to the EB, consumption for power generation accounts for over 98 per cent of total fuel oil consumption.
Firewood	Average consumption for the timeframe 2010-2012 in TJ/ capita rural population is calculated using EB 2010-2012 values, total population numbers (UN projections) and the share of rural population (World Bank). This value is extrapolated over the remainder of the timeframe using rural population as driver.	CBB statistics do not include firewood consumption, only the EB provides this value.
Charcoal	Total consumption from the EB 2010-2012, for the remainder of the time series GDP is used as driver for the charcoal consumption in the institutional/commercial sector and population for the charcoal consumption in the residential sector.	CBB statistics do not include charcoal consumption. The EB contains charcoal consumption and indicates the consumption takes place in the residential as well as in the institutional/commercial sector.
Kerosene	CBB data	

Table 36 presents the fuels allocated to the various IPCC categories based on information in the CBB and the EB.

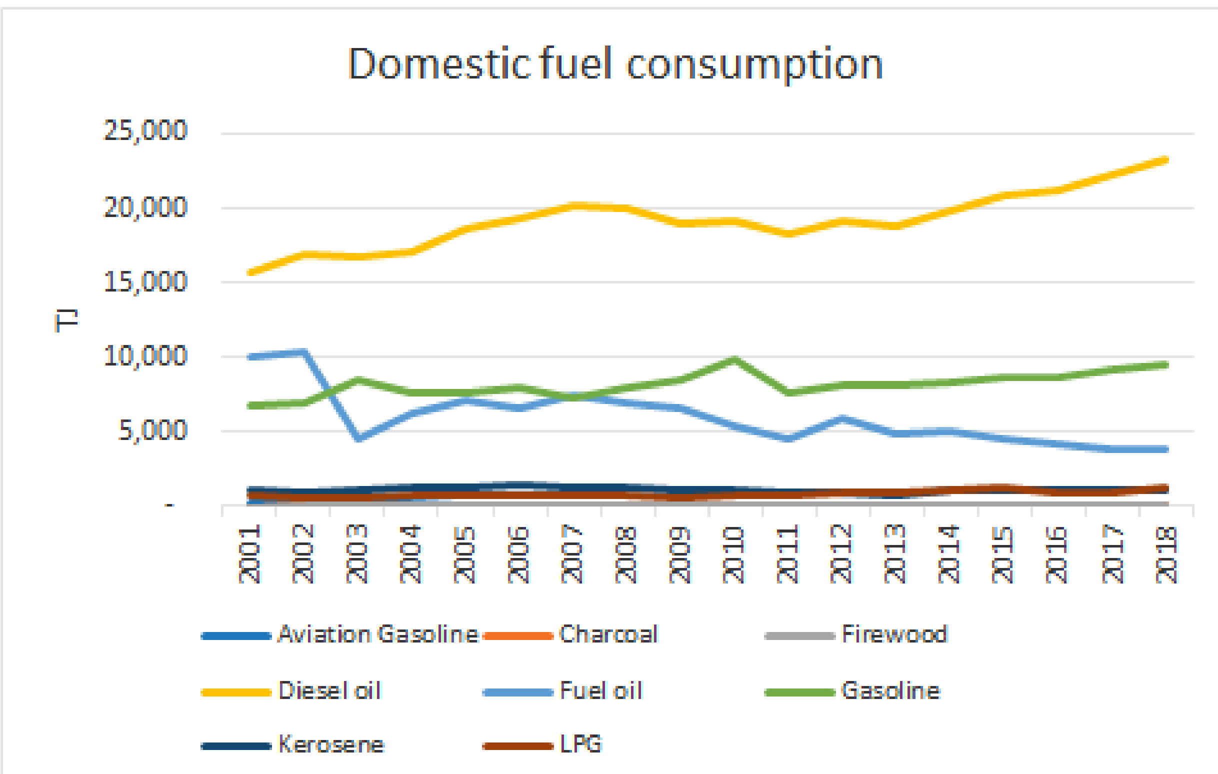
Table 36: Matching of fuels and activities in the energy balance to the categories in the IPCC 2006 Guidelines

	Firewood	LPG	Aviation Gasoline	Gaso line	Jet Fuel /Kerosene	Diesel Oil	Fuel Oil	Charcoal
1.A.1.a.1 Main electricity and heat production						X	X	
1.A.2. Manufacture and construction		X		X		X	X	
1.A.3.a. Aviation		X			X			
1.A.3.b Road Transportati on				X		X		
1.A.3.c. Navigation							X	

1.A.4.a Institutional/ commercial	**-**	**X**		**X**	**-**	**X**	**-**	**X**
1.A.4.b Residential	**X**	**X**		**X**	**X**	**X**	**-**	**X**
1.A.4.c Agriculture/fisheries	**-**	**-**		**X**	**-**	**X**	**-**	**-**

Estimated domestic fuel consumption is presented in Figure 41.

Figure 41: Domestic fuel consumption 2001-2018



The following chapters provide additional information on the national circumstances relevant for each category, data available and used as well as assumptions made with regards to the GHG estimations. The estimated GHG emissions by category in CO_2-eq. are presented in Annex I, fuel consumption by category in Annex II.

Emissions of CO_2, CH_4 and N_2O in the energy sector were estimated by using a Tier 1 approach. Activity data (fuel consumption by fuel type) was multiplied by fuel-specific default emission factors taken from the IPCC 2006 GL.

Table 37 below presents the sources of the emission factors used for the estimations. The specific emission factors used for each IPCC category are presented in the subchapters on the specific IPCC categories.

Table 37: Sources of emission factors used for The Bahamas national GHG inventory

IPCC Category	Category Name	Source of CO_2 emission factors (IPCC 2006 GL)	Source of CH_4 and N_2O emission factors (IPCC 2006 GL)
1.A.1.a.1	Main electricity and heat production	Volume 2, chapter 2, Table 2.2	Volume 2, chapter 2, Table 2.2
1.A.1.k	Construction		Volume 2, chapter 2, Table 2.3
1.A.2.m	Non-specified industry		Volume 2, chapter 2, Table 2.3
1.A.3.a.	Aviation		Volume 2, chapter 2, Table 3.6.5
1.A.3.b	Road transport		Volume 2, chapter 3, Table 3.2.2
1.A.3.c	Navigation		Volume 2, chapter 3, Table 3.5.4

1.A.4.a	Institutional/commercial		Volume 2, chapter 2, Table 2.4
1.A.4.b	Residential		Volume 2, chapter 2, Table 2.5
1.A.4.c	Agriculture/fisheries		Volume 2, chapter 2, Table 2.5
1.B.2.a.iii.3	Natural gas liquids transport	Volume 2, chapter 4, Table 4.24, Table 4.2.4	Volume 2, chapter 4, Table 4.24, Table 4.2.4 (N_2O only)

2.12.2 Reference approach

The Reference Approach is a top-down approach, using a country's energy supply data to calculate the emissions of CO_2 from combustion of mainly fossil fuels. The IPCC 2006 GL states that is good practice to apply both a sectoral approach and the reference approach to estimate a country's CO_2 emissions from fuel combustion and to compare the results of these two independent estimates. The detailed approach to calculating the Reference approach can be found in Vol. 2 Chapter 6 of the IPCC 2006 Guidelines[16].
In the case of The Bahamas, the reference approach does not provide an estimate which is independent from the estimate of the sectoral approach.

This is because the sectoral approach was not calculated based on real category-specific demands, but overall fuel consumption per fuel type, allocated to IPCC categories based on the information available. Therefore, the reference approach and the sectoral approach are both based on the same total fuel consumption per fuel. The calculation of the reference approach and the sectoral approach was nevertheless carried out as a quality control measure.

Table 38 below shows the emission levels in Gg CO_2 in the reference and the sectoral approach yield the same results.

[16] See https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_6_Ch6_Reference_Approach.pdf.

Table 38: Results of the Reference approach and comparison with sectoral approach

Item	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Aviation Gasoline	Gg CO_2-eq	11	9	10	6	6	2	0	3	3	3	3	5	4	4	3	4	3	3
Charcoal	Gg CO_2-eq	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Firewood	Gg CO_2-eq	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4
Diesel oil	Gg CO_2-eq	967	1,033	1,032	1,053	1,144	1,182	1,235	1,224	1,161	1,174	1,352	1,416	1,396	1,468	1,547	1,576	1,650	1,720
Fuel oil	Gg CO_2-eq	772	803	353	480	547	506	568	540	511	412	351	454	376	387	347	324	293	296

Gasoline	Gg CO_2-eq	566	578	701	635	626	657	605	660	703	818	624	672	665	680	716	711	755	786
Kerosene	Gg CO_2-eq	65	58	66	75	79	89	81	77	65	67	61	62	50	64	69	63	69	71
LPG	Gg CO_2-eq	31	21	23	30	27	28	29	31	23	29	27	33	38	40	47	36	36	52
Total CO_2 emissions – Reference approach	Gg CO_2-eq	2,412	2,502	2,183	2,279	2,429	2,464	2,518	2,534	2,466	2,503	2,416	2,641	2,529	2,644	2,730	2,714	2,807	2,928
Total CO_2 emissions – Sectoral approach (incl. biomass – related	Gg CO_2-eq	2,417	2,508	2,188	2,284	2,435	2,469	2,523	2,540	2,472	2,509	2,422	2,647	2,535	2,650	2,736	2,720	2,813	2,934

memo items)																			
Difference between Reference approach and sectoral approach	Gg CO_2 -eq	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Difference between Reference approach and sectoral approach (incl. biomass-related memo items)	Gg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

2.12.3 Category-specific information

2.12.3.1 Main electricity and heat production – Category 1.A.1.a.i

Power generation in The Bahamas is in the hand of two power supply companies: The state-owned Bahamas Power and Light (Company Ltd. BPL) and The Grand Bahamas Power Company. The latter services Grand Bahama Island only, whereas BPL services the remaining major islands, (with the exception of Spanish Wells, Eleuthera and Inagua). Both companies generate electricity using fuel oil and diesel. Total power generation for The Bahamas is not available other than for the years 2010-2012 from the energy balance. From BPL, power generation was available for the years 2001-2013 only.[17] While it is known that autoproducers of power exist in The Bahamas, for example using diesel-fueled generators, no data was available to estimate emissions from the related fuel consumption under category 1.A.1.a.i. It is understood that emissions from this fuel consumption are included under category 1.A.4. Other.

Fuel consumption was available for BPL over the whole time series, but only from 2016 onwards from The Grand Bahamas Power Company. Activity data is presented in Table 41 further below.

Table 39: Emission factors used for category 1.A.1.a.i Main electricity and heat production

Fuel Type	Unit	CO_2	CH_4	N_2O
Diesel oil	kg gas /TJ	74,100	3	0.6
Fuel oil	kg gas /TJ	77,400	3	0.6

2.12.4 Manufacturing Industries and Construction (Category – 1.A.2)

With the large focus on financial services and tourism, industrial activity in The Bahamas is limited. Examples include mining (actually quarrying of aragonite, a type of limestone), construction and mixing of cement. Production of clinker does however not take place.

[17] Power generation from the IEA database (https://www.eia.gov) was compared to available power generation and found to differ strongly, e.g. IEA generation values were 45.2 per cent below reported BPL generation in 2001, 33.6 per cent in 2008 and 6.5 per cent in 2013.

The energy balance provides information on fuel consumption related to the two activities "industry" and "construction". Under Category 1.A.2 Manufacturing Industries and Construction, the IPCC 2006 Guidelines include a list of subcategories. One of the subcategories is construction (1.A.2.f); the list does however not include a category named "industry" (as listed in the EB). It is our understanding that "industry" as described in the EB could in theory include fuel consumption from any of the categories under 1.A.2 applicable for The Bahamas, except for construction. The decision was thus taken to allocate the fuel consumption under the activity "industry" in the EB to the IPCC category 1.A.2.m Non-specified industry.

Information in the EB on fuel consumption from mining is included in the activity "agriculture, fishing, mining" and could not be disaggregated due to lack of information. Emissions from fuel combustion from mining are therefore reported as part of category 1.A.4.c.

Activity data is presented in Table 42 for construction and Table 43 for non-specified industries further below.

Table 40: Emission factors used for category 1.A.2 Manufacturing and construction

Fuel Type	Unit	CO_2	CH_4	N_2O
Diesel oil	kg gas /TJ	74,100	3	0.6
Fuel oil	kg gas /TJ	77,400	3	0.6
Gasoline	kg gas /TJ	69,300	3	0.6
Kerosene	kg gas /TJ	71,500	3	0.6
LPG	kg gas /TJ	63,100	1	0.1

Table 41: Activity data for category 1.A.1.a.i Main electricity and heat production

Fuel type	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Diesel oil	TJ	10,425	10,843	11,719	9,259	8,625	9,790	9,122	10,258	9,408	12,416	12,861	9,682	10,601	12,262	13,375	14,340	14,471	15,339
Fuel oil	TJ	9,754	10,144	4,456	6,063	6,905	6,386	7,168	6,816	6,457	5,209	4,432	5,735	4,749	4,892	4,379	4,092	3,704	3,739

Table 42: Activity data for category 1.A.2.f Construction

Fuel type	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Diesel oil	TJ	169	199	142	319	438	397	485	403	403	221	346	607	530	486	483	446	502	507
Gasoline	TJ	280	286	345	312	307	320	294	322	343	399	305	329	325	333	350	347	369	384
LPG	TJ	22	14	16	20	19	19	20	21	16	20	18	22	26	28	33	25	25	35

Table 43: Activity data for category 1.A.2.m Non-specified industry

Fuel Type	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Diesel oil	TJ	719	847	602	1354	1863	1686	2063	1712	1711	938	1471	2578	2253	2063	2051	1893	2132	2153
Fuel oil	TJ	22	23	10	14	16	15	16	16	15	12	10	13	11	11	10	9	8	9
Gasoline	TJ	1191	1214	1467	1324	1305	1362	1251	1369	1459	1696	1295	1398	1381	1414	1487	1477	1567	1630
LPG	TJ	91	61	66	87	80	81	85	90	66	84	77	95	110	117	138	105	105	150

2.12.5 Transport (Category 1.A.3)

2.12.5.1 Domestic Aviation (Category – 1. A. 3.a.ii)

Both domestic as well as international flights take place in / from The Bahamas. This category covers only domestic flights, i.e., flights which both start and land in The Bahamas. International flights are covered in section 3.2.6.2.

Flight data could not be obtained for domestic flights. The CBB dataset lists the consumption of aviation gasoline as well as Kerosene for domestic uses. It was assumed that all domestic aviation gasoline consumption takes place in the aviation sector. The EB, which only covers domestic use, indicates Kerosene consumption in the transport sector, which was assumed to be for domestic flights, and further use in the residential sector, which was assumed to be for lighting purposes. Consumption of aviation gasoline was taken from the CBB data. Kerosene for domestic flights was calculated by taking total Kerosene consumption from the CBB dataset and allocating the total consumption to the activities “transport” and “residential” as in the EB.

Table 44: Emission factors used for category 1.A.3.a.i domestic aviation

Fuel Type	Unit	CO_2	CH_4	N_2O
Aviation gas	kg gas /TJ	70,000	0.5	2
Kerosene	kg gas /TJ	71,500	0.5	2

2.12.6 Road Transport (Category – 1. A. 3.b)

Gasoline and diesel are the fuels consumed under this category. While a small amount of biodiesel is currently produced and consumed in the transport sector in The Bahamas, this activity has only started in 2019.

Gasoline consumption data was estimated using the CBB dataset. Registration of data for road vehicles was obtained from The Bahamas’ Department of Transport and compared with data from the energy balance for the year 2012. The Department of Transport has started digitizing registration data from 2016 onwards. Not all islands have digitized their systems. The islands which have to date, however, cover about 95% of The Bahamas' inhabitants. Registration numbers in 2016 and 2017 are considerably higher than in 2018-2021, however considerably lower than in 2012, see Table 45 below. While the general difference between 2016-2021 values to the 2012 value might indicate that the datasets provided contain only new registrations, this does not explain the differences between values for 2016/2017 and 2018-2021. On this basis, total numbers of vehicles and numbers per vehicle type could not be calculated.

Table 45: Vehicle registration numbers

Source	Year	Passenger cars	Light duty trucks	Heavy duty trucks / buses	Motorcycles	Total number of vehicles
EB	2012	134,039	4,578	841	877	140,335
Department of Transport	2016	43,439	3,875	90	25	47,429[18]
	2017	56,629	5,612	2,581	1,207	66,029
	2018	16,807	1,094	557	459	18,917
	2019	14,001	752	483	199	15,435
	2020	13,321	853	927	256	15,357
	2021	16,041	1,248	1,170	583	19,040[11]

For the time being, fuel consumption per vehicle type (cars, light duty trucks, heavy duty vehicles, motorcycles) was calculated using a total number of vehicles obtained from CEIC Data[19], standard distances driven per vehicle type and standard fuel efficiencies per vehicle type, typical fuels used. Only the average shares of vehicle types was derived from the vehicle registration numbers presented in Table 45. The assumptions used for the allocation of fuel consumption to the vehicle types

[18] Data from 2016 and 2021 did not cover the whole year, but only October 20-December 31 for 2016, and January 1-May 1 for 2021. Numbers presented have been scaled up assuming an equal activity in registration for the remainder of the year as during the time period for which data was available.
[19] https://www.ceicdata.com/en/indicator/bahamas/motor-vehicle-registered

are presented in Table 46. The resulting fuel consumption per vehicle type over the time series are presented in Table 50, Table 51,

Table 52, and Table 53 further below. The emission factors used are presented in Table 47. For gasoline, CH4 and N2O emission factors in the IPCC 2006 Guideline are related to vehicle technologies. No information on vehicle technologies per vehicle type was available for cars, LDV and motorcycles using gasoline. As CH4 and N2O emissions from these vehicle categories are not key categories, these emissions were calculated using the emission factors for “gasoline uncontrolled”, as a conservative approach in line with Figure 3.2.3 of Volume 2, Chapter 3 of the IPCC 2006 Guidelines.

Table 46: Assumptions used for the allocation of fuel consumption to the subcategories

Information	Unit	Passenger cars	Light duty trucks	Heavy duty trucks / buses	Motorcycles
Share of vehicle type	%	87.9%	7.4%	3.2%	1.5%
Fuel used	N/A	Gasoline	80% Gasoline 20% Diesel	Diesel	Gasoline
Distance driven per year	km	15500	35000	20000	1000

Table 47: Emission factors used for category 1.A.3.b Road Transport

			Default Emission Factor [kg/TJ]		
Fuel type	Representative vehicle category	Subcategory	CO_2	CH_4	N_2O

Motor Gasoline	Uncontrolled	Cars	69300	33	3.2
Motor Gasoline	Uncontrolled	LDV	69300	33	3.2
Motor Gasoline	Uncontrolled	Motorcycles	69300	10	0.96
Gas/Diesel Oil			74100	3.9	3.9

2.12.6.1 Domestic Waterborne Navigation (Category – 1. A. 3.c.ii)

Detailed data about The Bahamas fleet of waterborne vessels (e.g., mailboats, tourism, private cruising) was not available. It was assumed that smaller vessels consume gasoline, larger vessels diesel or fuel oil and that thus a share of the overall gasoline, diesel and fuel oil consumption might be attributable to domestic waterborne navigation. There was however no information available allowing to split fuel consumption for domestic waterborne navigation from total gasoline and total diesel consumption in The Bahamas. Such consumption could thus not be allocated to domestic waterborne navigation and is reported under road transport.

The amount of fuel oil in domestic waterborne navigation was estimated based on data obtained from BPL and the allocation of fuel oil consumption to activities in the EB. According to the EB, about 98% of fuel oil consumption is related to power generation, while the remainder is related to transport. It was assumed any consumption of fuel oil under the transport activity in the EB is for domestic waterborne navigation.

Activity data is presented in
Table 57 further below. Emission factors are presented in Table 48.

Table 48: Emission factors used for the category 1.A.3.c.ii domestic waterborne navigation

Fuel Type	Unit	CO_2	CH_4	N_2O
Fuel oil	kg gas /TJ	77400	7	2

Table 49: Activity data for category 1.A.3.a.ii Domestic Aviation

Fuel Type	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Aviation Gasoline	TJ	153	133	138	92	87	31	5	41	41	41	41	66	56	61	46	56	46	41
Kerosene	TJ	902	807	913	1047	1102	1231	1119	1069	902	930	841	857	696	891	963	880	958	991

Table 50: Activity data for category 1.a.3.b.i Cars

Fuel Type	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gasoline	TJ	3,912	4,007	4,861	4,413	4,353	4,588	4,235	4,607	4,909	5,715	4,355	4,685	4,635	4,742	5,000	4,958	5,274	5,490

Table 51: Activity data for category 1.A.3.b.ii Light duty trucks

Fuel Type	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Diesel oil	TJ	145	171	122	273	376	340	416	346	345	189	297	521	455	417	414	382	430	435
Gasoline	TJ	1026	1051	1275	1157	1142	1203	1110	1208	1287	1499	1142	1228	1215	1243	1311	1300	1383	1440

Table 52: Activity data for category 1.A.3.b.iii heavy duty vehicles and buses

Fuel Type	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Diesel oil	TJ	538	634	451	1014	1395	1263	1545	1283	1282	702	1102	1931	1688	1546	1536	1418	1597	1613

Table 53: Activity data for category 1.A.3.b.iv Motorcycles

Fuel Type	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gasoline	TJ	3	3	4	4	4	4	3	4	4	5	4	4	4	4	4	4	4	4

Table 54: Activity data for category 1.A.3.c.ii Domestic waterborne navigation

Fuel Type	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Fuel oil	TJ	201	209	92	125	142	132	148	141	133	107	91	118	98	101	90	84	76	77

2.12.6.2 International Bunkers (Categories – 1. A. 3.a.ii and 1. A. 3.c.i)

The CB statistical data provides information on foreign bunkers throughout the whole time series. The data is presented in barrels and not disaggregated by fuel type. The Bahamas' Second national communication as submitted to the UNFCCC (2NC) indicates that a statistical assessment was conducted for 1990, 1994 and 2000 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. While no detailed overview of international flights could be obtained at the time, there is a general understanding, that there is international air traffic involving small aircraft using aviation gasoline between The Bahamas and other countries, e.g., the US. The international bunkers fuel consumption should thus likely also include aviation gasoline from international flights. GHG emissions from the consumption of aviation gasoline for such international flights could not be estimated due to lack of data.

The 2NC does present CO_2 emissions for the categories international aviation and international navigation, but does not provide insight into the shares of gasoline and fuel oil consumed under international navigation. As a conservative approach, it was thus assumed that CO_2 emissions from international navigation resulted solely from fuel oil. This means, overestimating the consumption of fuel oil and underestimating the consumption of gasoline in international waterborne navigation.

Using IPCC default factors and the CO_2 emissions from international aviation and international navigation for the years 1990, 1994 and 2000 in the 2NC, fuel consumption of kerosene and fuel oil were estimated. The average share of each fuel type in the total fuel consumption in energy units was calculated, amounting to 56% for Kerosene and 44% for fuel oil. These shares were multiplied by the CB statistical data for international bunkers to estimate kerosene and fuel oil consumption for international bunkers over the time series. Activity data are shown in Table 56 and Table 57 below.

Table 55: GHG emission factors (defaults) used for international bunkers

			International aviation		International navigation	
Fuel Type	Unit	CO_2	CH_4	N_2O	CH_4	N_2O
Fuel oil	kg gas /TJ	77,400			7	2
Kerosene	kg gas /TJ	71,500	0.5	2		

Table 56: Activity data for category 1.A.3.a.i International aviation

Fuel Type	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Kerosene	TJ	14999	15043	7207	8689	7934	10480	12711	10439	8548	8463	9467	12743	10877	9690	7720	7849	8774	9473

Table 57: Activity data for category 1.A.3.c.i International waterborne navigation

Fuel Type	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Fuel oil	TJ	12496	12533	6004	7239	6610	8731	10590	8697	7121	7050	7887	10616	9061	8073	6431	6539	7310	7892

2.12.6.3 Other transportation (Category 1.A.3.e)

Emissions from pipeline transport do not occur in The Bahamas. Emissions from the Off-road use of vehicles are included in the emissions under road transport (category 1.A.3.e.ii). Emissions from mobile combustion related to fishing are very likely to occur, however, fuel consumption (e.g. diesel, gasoline) for this specific activity was not available. This fuel consumption is included in the fuel consumption for road transport.

2.12.6.4 Other (Category 1.A.4.)

The IPCC category Other contains three subcategories:

- 1.A.4.a Institutional/Commercial
- 1.A.4.b Residential
- 1.A.4.c Agriculture, Forestry, Fisheries.

Fuel consumption per subcategory and type was, with the exception of firewood and charcoal, calculated by calculating total consumption for each fuel as indicated in section 3.2.1 above and allocating fuel use to categories as indicated in the EB.

Consumption of firewood and charcoal was not available from the CBB dataset, however from the EB. The EB indicates a small amount of firewood is used in the residential sector. It was assumed that this is a practice typical for rural areas. On this basis, average firewood consumption per capita of rural population was calculated for 2010-2012 and extrapolated over the time series using rural population as driver.

For charcoal, EB 2010-2012 values were split over the categories institutional / commercial and residential based on the information in the EB. Charcoal use in the category institutional commercial, which is assumed to take place mainly in the services and tourism sector, was extrapolated over the timeline using GDP. Charcoal use in the category residential was extrapolated over the timeline using population development.

GHG emission factors used for the three sub-categories are presented in Table 58.

Table 58: Emission factors used for the categories institutional/commercial, residential, agriculture/fisheries/forestry

Fuel Type	Unit	CO_2	CH_4	N_2O
Charcoal	kg gas /TJ	112,000	200	1
Firewood	kg gas /TJ	112,000	300	4
Diesel oil	kg gas /TJ	74,100	10	0.6
Gasoline	kg gas /TJ	69,300	10	0.6
Kerosene	kg gas /TJ	71,500	10	0.6
LPG	kg gas /TJ	63,100	5	0.1

Activity data are shown below in Table 59 for Commercial / Institutional, Table 60 for Residential and Table 61 for Agriculture / Forestry / Fisheries.

Table 59: Activity data for category 1.A.4.a Commercial /institutional

Fuel Type	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Charcoal	TJ	9	10	10	10	11	11	11	11	11	11	11	11	11	11	12	12	12	12
Firewood	TJ	29	29	30	30	31	31	32	32	33	33	34	34	34	34	34	35	35	35
Diesel oil	TJ	930	1096	779	1753	2411	2182	2669	2216	2215	1213	1904	3337	2916	2670	2654	2450	2759	2787
Gasoline	TJ	1541	1571	1899	1713	1689	1762	1619	1772	1888	2195	1676	1810	1787	1830	1924	1911	2028	2109
LPG	TJ	54	36	39	51	47	48	50	53	39	49	45	56	65	69	81	62	62	88

Table 60: Activity data for category 1.a.4.b Residential

Fuel Type	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Charcoal	TJ	6	6	6	6	7	7	7	7	7	7	7	7	8	8	8	8	8	8
Diesel oil	TJ	42	50	35	80	110	99	121	101	101	55	87	152	133	121	121	111	125	127
Gasoline	TJ	70	71	86	78	77	80	74	81	86	100	76	82	81	83	87	87	92	96
Kerosene	TJ	7	6	7	8	8	9	8	8	7	7	6	6	5	7	7	6	7	7
LPG	TJ	331	219	238	314	288	294	307	324	241	303	279	344	400	423	501	380	380	543

Table 61: Activity data for the category 1.A.4.c Agriculture/Fisheries/Forestry

Fuel Type	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Diesel oil	TJ	85	100	71	159	219	198	243	201	201	110	173	303	265	243	241	223	251	253
Gasoline	TJ	140	143	173	156	154	160	147	161	172	200	152	165	162	166	175	174	184	192

2.12.7 Fugitive Emissions (Category 1.B)

2.12.7.1 Natural Gas liquids transport (Category 1.B.2.a.iii.3)

Fuel production does not take place in The Bahamas. Fuel distribution of oil products and LPG however does. The IPCC 2006 guidelines indicate that low levels of emissions from CO_2 and N_2O might occur from the distribution of LPG, but that no emissions might occur from the distribution of oil products. Emissions from the distribution of LPG were estimated based on total LPG consumption for The Bahamas, based on the CBB dataset. The GHG emission factors used for this category are presented in Table 62.

Table 62 Emission factors used for category 1.B.2.a.iii.3 Natural Gas liquids transport

Gas	Unit	Value
CO_2	Gg per 1000 m3 LPG	0.00043
N_2O	Gg per 1000 m3 LPG	0.0000000022

Table 63: Activity data for the category 1.B.2.a.iii.3 Natural Gas liquids transport

Fuel Type	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
LPG	1000 barrels	154	102	111	146	134	137	143	151	112	141	130	160	186	197	233	177	177	253

2.13 IPPU

2.13.1. Lubricant use (category 2.D.1)

The Central Bank of The Bahamas (CBB) compiles a quarterly overview of oil imports for domestic consumption which includes the category “lubricants and other” and provides a time series from 2001-2018.

The IPCC 2006 GL indicate that only CO_2 emissions occur from lubricant use, but not N_2O or CH_4 emissions. The CO_2 emissions arise from the oxidation of the lubricants during use. Emissions were estimated using the carbon content of the lubricants and a default factor for oxidation during use provided by the IPCC 2006 GL.

Table 64: Factors used for the estimation of GHG emissions under category 2.D.1 Lubricant use

Factor	Unit	Value	Source
Carbon content of lubricants	t/TJ	20	V3, Ch5, Table 5.2
Oxidation during use (ODU) factor	N/A	0.2	V2, Ch1, table 1.4

Lubricant consumption in 2001-2018 is presented in Table 65

Table 65: Lubricant consumption, activity data for category 2.1 Lubricant use

Activity data	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Lubricant consumption	TJ	255.97	574.51	193.40	193.40	233.22	284.41	221.84	244.59	210.47	216.15	96.70	73.95	119.45	68.26	68.26	68.26	79.64	73.95

2.14 AFOLU

2.14.1. Agriculture

2.14.1.1. 3.A.1 and 3.A.2 Enteric Fermentation and Manure Management

The livestock values were obtained from both National Customs Imports report for livestock, in addition to FAOStat. Cattle (meat)[20], swine, sheep, goats and poultry data[21] were obtained from FAOStat, and horses, mules and asses were obtained from national sources in annual customs reports. Livestock production is generally limited in The Bahamas, with the exception of poultry[22].Livestock activity data can be seen in Table 67.

Some of the assumptions[23] applied to these categories include:

- Cattle population was assumed to be 5% dairy cow, 95% other (meat)
- Manure management practices for population of cattle, sheep, goats, horses, asses and mules is 98%open range/paddock, 2% dry lot
- Manure management practices for population of swine is 90% dry lot and 10% liquid slurry
- Manure management practices for population of poultry is 100% poultry manure with litter

Table 66 shows the default values from Volume 4, Chapter 10 of the IPCC 2006 Guidelines with regards to enteric fermentation and manure management.

[20] Cattle production is not a large industry in the Bahamas, therefore values for meat production were used, which represents the majority of the industry according to expert judgement. Future data validation of this sector was prioritized.
[21] Poultry livestock includes eggs and laying hens, however further assessments should prioritize obtaining national figures for broiler production, which has an established industry.
[22] Generally, livestock production data is not readily available at the national level, therefore there was a heavy reliance on the use of international data from FAOStat.
[23] Assumptions applied were collected based on expert judgement from agricultural experts from the Ministry of Agriculture

Table 66: Factors used for the estimation of GHG emissions under category 3.A.1 and 3.A.2 Enteric Fermentation and Manure Management

Species/Livestock category	Emission factor for Enteric Fermentation ((kg head-1 yr-1)	Emission factor for Manure Management (kg head-1 yr-1)
Dairy Cows	72	2
Other Cattle	56	1
Sheep	5	0.2
Goats	5	0.22
Horses	18	2.19
Mules and Asses	10	1.2
Swine	1	2
Poultry	0	0.02
Source	IPCC 2006 GL, Vol 4, Tables 10.10 and 10.11	IPCC 2006 GL, Vol 4, Tables 10.14 – 10.16

Table 67: Livestock Activity Data, 2001-2018

Species/ Livestock category	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Dairy Cows	6	8	8	8	8	5	5	6	6	5	5	6	6	6	6	5	5	5
Other Cattle	114	143	152	157	157	100	95	107	106	95	100	107	108	106	105	103	102	101
Sheep	1600	1830	1950	2000	2000	1700	2000	2000	2000	2000	2000	2024	2042	2045	2063	2091	2120	2142
Goats	5300	5450	5550	5700	5700	5800	6000	6000	6000	6000	6000	6172	6173	6103	6127	6089	6113	6147
Horses	15	1216	12	2	8	50	28	27	45	162	7	49	24	152	107	6	13	264
Mules and Asses[24]	59	0	0	255	255	0	0	0	0	0	0	0	65	229	97	75	390	100
Swine	6300	6250	6400	6500	6500	6500	6600	6600	6600	6600	6600	6680	6802	7046	6919	6966	7023	7059
Poultry (laying hens, eggs, in shell)	120000	123000	125000	128000	128000	130000	113000	113000	113000	113000	140000	113000	114000	113000	115000	115000	109000	114000

[24] The fluctuation of mules and asses over the time series requires detailed assessment of historical data which was not feasible for the preparation of this GHG Inventory, and is a noted improvement for subsequent reports.

2.14.1.2. 3.C.3 Urea Application

Activity data is derived from annual imports of urea fertilizer from the Customs Annual report. This can be seen in Table 68. The emission factor CO_2 emissions for urea fertilization, which is equivalent to the carbon content of urea on an atomic basis (20% for $CO(NH_2)_2$) in Table 69.

Table 68: Annual Urea Import[25], 2001-2018

Year	Urea Data- Customs Imports (tonnes)
2001	71
2002	261
2003	210
2004	314
2005	0
2006	2297
2007	54
2008	416
2009	1563
2010	946
2011	1040
2012	207
2013	116
2014	1200
2015	674
2016	83
2017	239
2018	152

[25] The fluctuations in urea import data (e.g. 0 tonne in 2005) requires detailed assessment of historical data, which was not feasible for the preparation of this GHG Inventory. It is a noted improvement for subsequent reports.

Table 69: Factors used for the estimation of GHG emissions under category 3.C.3 Urea Application

Emission factor ([tonnes of C (tonne of urea)$^{-1}$])
0.2

2.14.1.3. 3.C.4 and 3.C.5 Managed Soils (Direct and Indirect N2O)

This subcategory accounts for direct N_2O emissions from synthetic fertilizer, dung and urine from manure on grazed soils, as well as indirect N_2O emissions from leaching/runoff and atmospheric deposition of volatilised nitrogen from managed soils. The activity data for livestock, and assumptions for the fraction of total manure deposited on soils are those referred to in Section 3.4.1.1 (Enteric Fermentation and Manure Management) and Table 67. The activity data of nitrogen based fertilizer was obtained from national Customs import data, see Table 70.

The emission factors for direct N_2O emissions from synthetic fertilizer as well as from urine and dung N deposited on pasture, range and paddock can be seen in Table 71. The emission factors for indirect N_2O emissions from N_2O emission from N leaching and runoff and atmospheric volatilization can be seen in Table 72.

Table 70: Activity Data for Nutrient Nitrogen from Fertilizer for Agriculture (tonnes)

Year	Nutrient Nitrogen N from Fertilizer for Agriculture (tonnes)
2001	14,566
2002	4,548
2003	7,561
2004	17,341
2005	8,029

2006	10,288
2007	13,087
2008	8,282
2009	6,093
2010	3,770
2011	3,712
2012	4,851
2013	2,997
2014	3,907
2015	6,858
2016	5,516
2017	6,697
2018	8,747

Table 71: Emission factors for 3.C.4 direct N_2O emissions from synthetic fertilizer and urine and dung on grazed soils

Anthropogenic N input type	Emission factor for N_2O emissions from urine and dung N deposited on pasture, range and paddock by grazing animals [kg N_2O-N (kg N input)-1]	Emission factor for N_2O emissions from N inputs [kg N_2O-N (kg N input)-1]
Cattle, Poultry and Pigs, and Sheep	0.02	-
Sheep and Other Animals	0.01	-
Synthetic Fertilizers	0.01	0.01
Source	IPCC 2006 GL, Vol 4, Chapt 11, Table 11.1	

Table 72: Emission factors for 3.C.5 indirect N_2O emissions on managed soils

Fraction of all N additions to managed soils that is lost through leaching and runoff	Emission factor for N_2O emission from N leaching and runoff	Fraction of applied organic N fertilizer materials (F_{ON}) and of urine and dung N deposited by grazing animals (F_{PRP}) that volatilizes	Emission factor for N_2O emission from atmospheric deposition of N on soils and water surfaces
[kg N (kg of N additions)$^{-1}$]	[kg N_2O-N (kg N leaching and runoff)$^{-1}$]	(kg NH_3-N + NO_x-N) (kg of N applied or deposited)$^{-1}$	(kg N_2O-N) (kg NH_3-N + NO_x-N volatilized)$^{-1}$
$Frac_{LEACH-(H)}$	**EF**	**$Frac_{GASM}$**	**EF**
0.3	0.0075	0.2	0.01
Source	IPCC 2006 GL, Vol 4, Chapt 11, Table 11.3		

2.14.1.4. 3.C.6 Indirect N2O Emissions from Manure Management

This category involves the determination of indirect N_2O emissions from manure management. Emissions reported under category concern only the N_2O emissions from manure produced in animal houses, and then stored temporarily and/or processed before being transported elsewhere. The source categories include swine and poultry. The emission factors used for this category as seen in Table 73 below. Activity data for this sector for livestock can be seen in Table 67 further above.

Table 73: Emission Factors for Indirect N_2O Emissions from Manure Management

Species/Livestock category 2	Total nitrogen excretion for the MMS (kg N yr-1)	Emission factor for N_2O emissions from atmospheric deposition of nitrogen on soils and water surfaces [kg N_2O-N (kg NH3-N + Nox-N volatilised)-1]
Swine	0.48	0.01
Poultry	0.4	0.01
Source	IPCC 2006 GL, Vol 4, Table 10.22	IPCC 2006 GL, Vol 4, Table 11.3

2.14.2. Forestry and Other Land Uses (Category 3.C)

Methodology used for time series analysis of satellite data to generate activity data

The Bahamas, like many developing countries, does not have a regular forest inventory data or land use mapping necessary to generate activity data for calculating GHG emissions from the FOLU sector. To address this issue Landsat satellite data was used to generate activity data using Google Earth Engine platform for the inventory period 2000 to 2020. Landsat images from 2000, 2005, 2010, 2015 and 2020 were classified into six IPCC land use classes, Forestland, Grassland, Cropland, Wetland, Settlement and Other land. IPCC default emission factors were used to calculate GHG emission for each of four time periods: 2000-2005, 2005-2010, 2010-2015 and 2015-2020. For this inventory, all lands were considered as managed land, classified as crown lands.

Classification of Satellite Imagery

It is a challenge to obtain cloud free satellite images over the Caribbean countries, The Bahamas is no exception. Therefore, cloud filtering and masking functions were used to mask out (remove) cloud and cloud shadows. Only cloudless composite images covering the country were used in this analysis. For this reason, the total land area varies for each

5 year period because of unclassified pixels which may be due to cloud and cloud shadows or absence of satellite data for a portion of the country. Activity data for Landsat images 2000 to 2010 were collected using Landsat 7 satellite and images from 2010 to 2020 were collected using Landsat 8 satellite. These two satellites have slightly different band combinations, therefore, separate classification models were developed for Landsat 7 and Landsat 8 to generate classified maps. The training points for each of six IPCC land classes were collected by sampling a global map of land use/land cover (LULC) published by ESRI[26]. The forest definition is same as the training data which came from ESRI Land Cover 2020, whereby forest is captured as trees >= 15 m.

The global land cover map was derived from ESA Sentinel-2 imagery at 10m resolution. It is a composite of LULC predictions for 10 classes throughout the year in order to generate a representative snapshot of 2020. A stratified random sampling was used to collect training data for 8 classes[27]: 1) Water, 2) Forest, 3) Grassland, 4) Wetland, 5) Cropland, 6) Scrub/Shrub, 7) Settlement and 8) Other land.

A total of 809 training points were collected, 70% of points were randomly selected from each land use type to train classification model using "Random Forest" algorithm in the

[26] https://www.arcgis.com/home/item.html?id=d6642f8a4f6d4685a24ae2dc0c73d4ac

[27] Definitions: 1. Water- Areas where water was predominantly present throughout the year; may not cover areas with sporadic or ephemeral water; contains little to no sparse vegetation, no rock outcrop nor built up features like docks; examples: rivers, ponds, lakes, oceans, flooded salt plains.

2. Trees- Any significant clustering of tall (~15-m or higher) dense vegetation, typically with a closed or dense canopy; examples: wooded vegetation, clusters of dense tall vegetation within savannas, plantations, swamp or mangroves (dense/tall vegetation with ephemeral water or canopy too thick to detect water underneath).

3. Grassland - Open areas covered in homogenous grasses with little to no taller vegetation; wild cereals and grasses with no obvious human plotting (i.e., not a plotted field);
4. Flooded vegetation
Areas of any type of vegetation with obvious intermixing of water throughout a majority of the year; seasonally flooded area that is a mix of grass/shrub/trees/bare ground; examples: flooded mangroves, emergent vegetation, rice paddies and other heavily irrigated and inundated agriculture.

5. Cropland - Human planted/plotted cereals, grasses, and crops not at tree height; examples: corn, wheat, soy, fallow plots of structured land.

6. Scrub/shrub - Mix of small clusters of plants or single plants dispersed on a landscape that shows exposed soil or rock; scrub-filled clearings within dense forests that are clearly not taller than trees; examples: moderate to sparse cover of bushes, shrubs and tufts of grass, savannas with very sparse grasses, trees or other plants
7. Settlement - Human made structures; major road and rail networks; large homogenous impervious surfaces including parking structures, office buildings and residential housing; examples: houses, dense villages / towns / cities, paved roads, asphalt
8. Other land - Areas of rock or soil with very sparse to no vegetation for the entire year; large areas of sand and deserts with no to little vegetation; examples: exposed rock or soil, desert and sand dunes, dry salt flats/pans, dried lake beds, mines.

Google Earth Engine. Remaining 30% points were used to validate the model. The model developed using Landsat 7 satellite data from 2020 was applied to Landsat 7 images from 2000, 2005 and 2010 to generate land use maps for 2000, 2005 and 2010. The same training data and procedure was used to build and validate Landsat 8 classification model using Landsat 8 satellite data from 2020. The model was then applied to 2015 to generate land use maps for 2015 and 2020. Table 74 below outlines the activity data from land use classifications from 2000 to 2020. A more detailed breakdown of land use between individual land use categories (land use matrices) for each 5 year interval from 2000-2020 can be seen in Annex V.

The CO_2 emission factors used for this category are presented in Table 75.

Table 74: Activity data for Land Use Classifications, 2000-2020 (ha).

Land Use (ha)	2000-2005	2005-2010	2010-2015	2015-2020
Forest remaining Forest	174,695	210,014	254,936	243,171
Land converted to Forest	87,564	144,763	80,390	88,664
Grassland remaining Grassland	304,151	269,032	278,697	374,237
Land converted to Grassland	142,646	107,834	220,502	139,809
Cropland remaining Cropland	16,657	16,832	3,333	2,976
Land converted to Cropland	56,364	51,321	14,665	15,507
Wetland remaining Wetland	15,502	17,064	13,051	27,961
Land converted to Wetland	52,713	47,258	66,044	47,017
Settlement remaining Settlement[28]	63,590	59,560	25,517	17,702
Land converted to Settlement	66,370	66,339	21,407	24,394
Other land remaining Other land	54,111	43,985	28,451	32,929

[28] It seems unlikely that this land use decreased over time. This might be attributable to limited resolution of the satellite imagery and has been identified as an area of improvement, see Annex III.

Land converted to Other land	22,180	12,987	22,449	16,575
Unclassified Area	331,456	341,010	358,558	357,059
Total Area (ha)	**1,388,000**	**1,388,000**	**1,388,000**	**1,388,000**

Figure 42 below shows the total land area for each land use classification for the period of 2000 to 2020. Each land use represents the sum of land use type remaining and the area converted to each land use type (e.g.: Forestland = Forestland remaining Forestland + Land Converted to Forestland). Over the time series, The Bahamas highest land use category was grassland accounting for 50% of classified land, including both pastureland and shrubland/scrubland (prevalent native species being low-scrubby coppice), followed by Forest Land which represented 32%of total area.

Figure 42: Land Use Types in 2015-2020

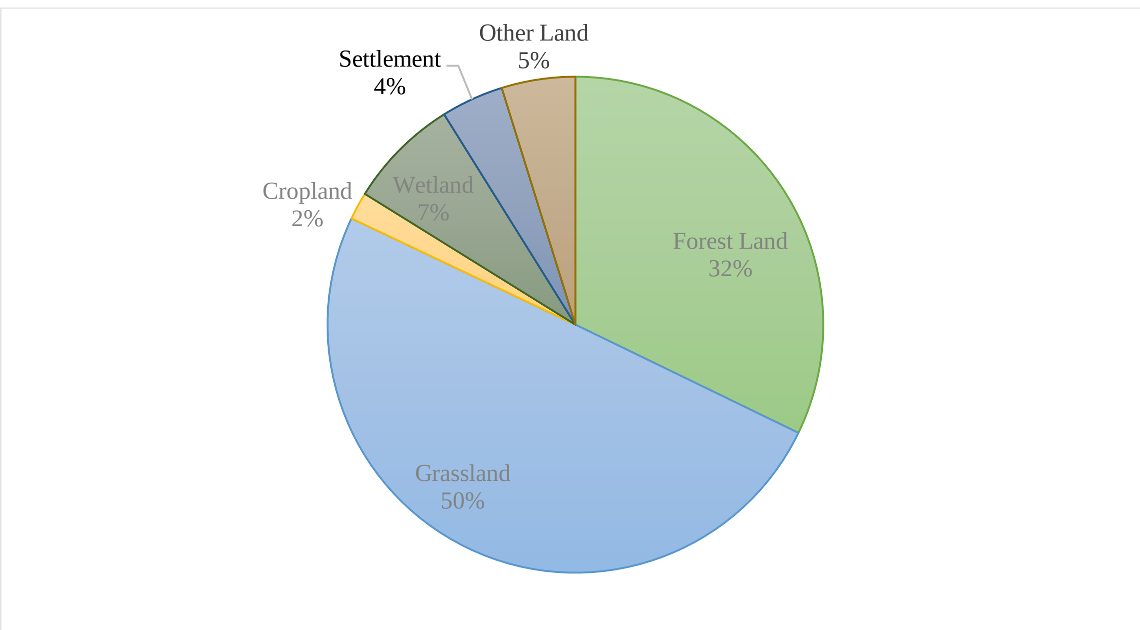


Table 75: Emission factors used for Land Use (Category 3.C)

Land use category	Carbon stock (tC/ha)	Source
Forest land[29] [Table 4.7, (AGB+BGB)*0.47]	62.04	IPCC 2006, GL, Vol. 4, Table 4.7 (above ground biomass)
Non-forest land		IPCC 2006, GL, Vol. 4, Table 6.4 (biomass stocks present on grassland, after conversion from other land use)
Grassland (Table 6.4)	4.09	
Cropland	0.00	
Wetland	0.00	
Settlement	0.00	
Other land	0.00	
Land Converted to Forest Land (Table 4.9)		
Forest growth in 5 years for trees <20 yrs		IPCC 2006, GL, Vol. 4, Table 4.9 (above-ground net biomass growth in natural forests)
Land converted to forest (2.26 tC/ha/yr)	11.28	
Forest Land Remaining Forest Land (Table 4.9)		
Forest growth in 5 years for trees >=20 yrs		
Forest Land Remaining Forest Land 0.56 tC/ha/yr)	2.82	

[29] Dominant forest type in the Bahamas is pine forest

2.15 Waste

2.15.1 Solid Waste (Category 4.A)

Over the duration of the time series, solid waste was collected and landfilled in unmanaged landfills (open dumps) with a depth of generally more than 5 meters, according to expert judgement. The landfill on New Providence, now called New Providence Ecology Park – NPEP was converted into a managed landfill from 2019, the process was finalised in early 2020. At the time data collection took place (Q2 2021) methane capture was planned to start later the same year, once a critical mass of methane capture had been reached. From 2015-2019 landfill fires were reported, which could be extinguished by mid-2019. Open burning of waste is practiced on smaller islands, where no waste collection system exists. Detailed information on which islands these are, were not available.

Only limited waste management data is available in The Bahamas at present. For the NPEP amounts landfilled of roughly 250-300 kt waste per year were estimated for the timeframe March 2019 – March 2020 based on truck numbers and loading volumes, as scales were to be installed only from roughly mid-2021 onwards. Considering New Providence's population at the time, this amount of waste is largely in line with the default value for MSW generation per capita for The Bahamas provided in the IPCC 2006 Guidelines.

Source separation of waste does not take place in The Bahamas. NPEP started diverting gardening waste as well as construction debris for the purposes of recycling from mid-2020 onwards. Since that time, composting of gardening waste takes place. In the future, diversion of food waste for composting is planned. Generally, waste composition data is not available for The Bahamas.

Methane emissions from landfilling were estimated using a Tier 1 approach which uses the first order decay model [reference to IPCC 2006 GL providing more information on the model]. Waste generation was calculated using 1950-2018 population data[30] and a waste generation default value of 950 kg / cap and year (see Volume 5, Chapter 2, Table 2A.1 of the IPCC 2006 GL).[31] In line with IPCC default, it was assumed that 70% of this waste is landfilled (see Volume 5, Chapter 2, Table 2A.1 of the IPCC 2006 GL). Table 82 further below shows the estimated waste amounts landfilled in 2001-2018. Default values from table 2.3 of Volume 5, Chapter 2 of the IPCC 2006 Guidelines were used with regards to waste composition, see Table 76.

Table 76: Assumptions for waste composition

Food	Garden	Paper	Wood	Textile	Nappies	Plastics, other inert	Total
%	%	%	%	%	%	%	(=100%)
47%	0%	17%	2%	5%	0%	29%	100%

Potentially landfilling of sludge from wastewater treatment plants also takes place in The Bahamas. Information on sludge was, however, not available.
Industrial waste is assumed to be collected and processed as part of municipal solid waste.

2.15.2 Open burning (Category A.C.2)

No information was available on the share of waste openly burned and the islands where such open burning might be a common practice. Based on expert judgement, 2% of total population is assumed to use open burning as waste management measure. This level of open burning is also assumed to cover landfill fires as reported for NPEP. The waste amounts assumed to be openly burned are presented further down in Table 83. It was

[30] Taken from UN World Population prospects, https://population.un.org/wpp/Download/Files/1_Indicators%20(Standard)/EXCEL_FILES/1_Population/WPP2019_POP_F01_1_TOTAL_POPULATION_BOTH_SEXES.xlsx

[31] Population numbers used do not include tourism. Waste generation might therefore potentially be underestimated.

assumed that the composition of the waste burned is the same as for the waste landfilled, see section 2.15.1 .

CO_2, CH_4 and N_2O emissions from open burning were estimated using a Tier 1 methodology whereby the amount of waste openly burned is multiplied by an emission factor (CH_4, N_2O) or a combination of factors (CO_2) specific to each gas (see Volume 5, Chapter 5 of the IPCC 2006 Guidelines for national GHG inventories). The estimation approach for N_2O and CO_2 requires the amount of waste openly burned on a dry matter basis, while the one for CH_4 refers to wet matter. Table 77 presents the dry matter content for different waste types.

Table 77: Waste composition default data and default factors for the estimation of CO_2 emissions from fossil carbon in open burning and sources of default data in the IPCC 2006 Guidelines.

Source of factor	**table 2.3 of Volume 5, Chapter 2 of the IPCC 2006 Guidelines**	**Volume 5, Chapter 2, Table 2.4**			**Volume 5, chapter section 5, Table 5.2**	**Volume 5, chapter 5.2.1.1**
Type of waste	Share in MSW	Dry matter content	Fraction of carbon in dry matter	Fraction of fossil carbon in total carbon	Oxidation factor	Conversion factor 44/12
		%	%	%	%	
Food	47%	40	38	0	58	3.666667
Paper	17%	90	46	1	58	3.666667

wood	2%	85	50	0	58	3.666667
textile	5%	80	50	20	58	3.666667
plastics	29%	100	75	100	58	3.666667

Table 78: Open burning default factors for CH_4 and N_2O from open burning

Gas	CH_4 emission factor data	N_2O emission factor data
Source of default factor	EF taken from V5, Ch5, p. 5.20	EF taken from V5, Ch5, table 5.6
Unit	g CH_4 / t MSW (wet matter)	g N_2O/t waste (dry matter)
Value	6500	150

2.15.3 Domestic wastewater treatment and discharge (Category 4.D.1)

Domestic wastewater management across 700 islands and cays of The Bahamas is challenging. For this reason, The Bahamas has the highest usage of septic tanks in the region, accounting for 81% of its population (PAHO, 2012). Other domestic wastewater is managed through access to a centralized sewerage system (16%), and through pit latrines ~5%).

At present, industrial sources of wastewater are not accounted for due to limited knowledge of production values in the country for the rum and beer production sector, as well as fish and conch processing and packaging facilities.

Emissions of CO_2, CH_4 and N_2O were estimated for the category 4.D.1 Domestic Wastewater and were based on a Tier 1 approach. CH_4 emissions from domestic wastewater were estimated using a Tier 1 methodology using a combination of both default values for EFs and AD, and country specific activity data, see Table 79 and Table 80. CH_4 production depends primarily on the amount of degradable organic material in the wastewater, the temperature and the type of treatment system. Activity data includes the total amount of organically degradable material in the wastewater estimated from population data, biological oxygen demand EFs, and correction factor for industrial BOD into sewers (see Table 79). N_2O emissions were estimated using Tier 1 methods for total amount of nitrogen in effluent, accounted from annual per capita protein consumption (see Table 81).

Table 79: Domestic Wastewater Defaults for CH_4 emissions from domestic wastewater and for estimation of Organically Degradable Material in Domestic Wastewater.

Type of treatment or discharge	Maximum methane producing capacity (kg$_4$/kgBOD)	Methane correction factor for each treatment system (MCF)	EF (kg CH_4/ kg BOD)		Degradable organic component (kg BOD/cap/yr)	Correction factor for industrial BOD discharged in sewers' (I)
Latrine	0.6	0.1	0.06		14.6	1
Centralized, aerobic treatment plant (overloaded)	0.6	0.3	0.18			
Septic System	0.6	0.5	0.3			
Sea, River and Lake Discharge	0.6	0.1	0.06			

Table 80: Values for Urbanisation and Degree of Utilisation of Domestic Wastewater Treatment, discharge or Pathway for CH_4 emissions from domestic wastewater

Urbanization (Fraction of Population)			**Degree of utilization of Discharge Pathway by income group**		
Rural	Urban-high	Urban-low	Rural, Urban-high and Urban low income		
			Septic Tank	Sewer (Centralized, aerobic treatment plant)	Latrine
0.16	0.25	0.59	0.81	0.13	0.06
Source: IPCC 2006 Defaults, Table 6.5 (LAC, Brazil)[32]			**Source: National Data, PAHO (2012)**		

Table 81: Emission Factors to estimate indirect N_2O from Wastewater

Nitrogen in Effluent EF	**Fraction of nitrogen in protein**	**Fraction of non-consumption protein**
(kg N_2O-N/kg N)	(kg N/kg protein)	(-)
0.005	0.16	1.1
Source: IPCC 2006 Defaults		

[32] This default was closest to characteristics of urbanization distribution in the Bahamas than other regional defaults

Table 82: Amounts of solid waste deposited, activity data for category 4.A Solid Waste

Activity data	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Solid waste deposited	Gg	201.24	204.59	208.23	212.06	216.03	220.14	224.36	228.55	232.49	236.04	239.12	241.78	244.17	246.47	248.85	251.32	253.87	256.45

Table 83: Solid waste openly burned, activity data for category 4.C Open Burning

Activity data	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Solid waste openly burned	Gg	287.49	292.28	297.47	302.95	308.62	314.48	320.52	326.50	332.12	337.19	341.60	345.40	348.81	352.10	355.50	359.03	362.67	366.36

Table 84: Amounts of organically degradable material in wastewater, activity data for category 4.D.1 Domestic Wastewater

Activity data	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Organically degradable material in wastewater	kg BOD/yr	4418222.8	4491836	4571683.4	4655852.4	4742941	4833082	4925879	5017743	5104218	5182153	5249839	5308326	5360667	5411242	5463408	5517778	5573623	5630300

Chapter 3 – Measures to Facilitate Adequate Adaptation to Climate Change

Introduction

This chapter provides a comprehensive assessment of the vulnerability and adaptive capacity of various socioeconomic sectors of The Bahamas. This assessment was done based on consultations made with key stakeholders from distinctive sectors and an extensive review of (i) the latest available information on climate scenarios and projections for The Bahamas in the short, medium, and longer terms, (ii) the main climate hazards currently affecting the country, and (iii) current and potential future vulnerability of key areas and socioeconomic sectors under different climate scenarios and associated impacts.

The results of the assessment served as basis for the identification of appropriate adaptation actions that will contribute to enhancing The Bahamas capacity to adapt to climate change impacts and increase the country's resilience to climate hazards in the short, medium, and long term.

3.1 Basic Concepts

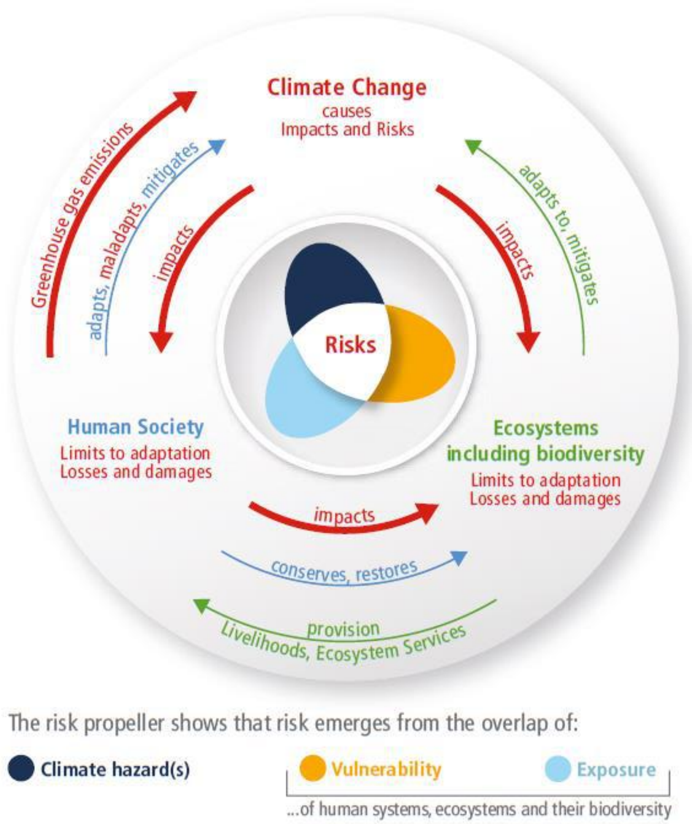
The concept of *climate risk* forms the basis of state-of-the-art analyses on the impacts of climate change and adaptation measures and replaces the concept of *vulnerability* which for a long time expressed the degree to which climate change potentially affects socio-ecological systems.

According to the Intergovernmental Panel on Climate Change (IPCC), *risk* is defined "as the potential for adverse consequences for human or ecological systems, recognising the diversity of values and objectives associated with such systems".

Risk results from the interactions among climate-related *hazards, vulnerability* and *exposure* of human systems, ecosystems and their biodiversity (IPCC, 2022), which concepts defined by the IPCC (2022) as follows:

- *Vulnerability:* The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (…), where:
    - *Sensitivity***:** Susceptibility to negative or positive effects caused by climate variability or change.
    - *Adaptation capacity***:** Ability to respond effectively to climate hazards and reduce damage.
- *Exposure:* The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.
- *Hazards***:** The potential occurrence of a (…) physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources (…).

Figure 43: Main interactions and trends among climate change causes, impacts and risks.



- *Vulnerability* and *exposure* to climate hazards depend on a number of socioeconomic factors, such as income and education, governance and access to public goods and services, and adaptation measures that have been adopted to reduce exposure and vulnerability. Climate *hazards* may stem from gradual changes in climate variables such as precipitation and temperature, as well as extreme events such as floods and droughts. Notably, anthropogenic climate change adds to already existing natural climate variability and can lead to both a de-/increase in gradual changes and/or extreme events, and thus *climate risks*.

Importantly, without hazards, there is no exposure, and without exposure, there is no vulnerability.

3.2 Methodology

Overall, the assessment focused on the sectors of Agriculture, Coastal and marine resources, Disaster management, Energy, Forestry, Human health, Human settlements and infrastructure, Terrestrial biodiversity, Tourism, Transport, and Water resources, and was based on the following components and approaches:

- <u>Hazards</u>

  An initial step was to identify the hazards could have a significant impact on the country and on each priority sector and analyse past and future climate trends for these hazards associated with different emission scenarios, e.g., a light scenario such as RCP[33] 4.5 (IPCC AR5) or SSP2 (IPCC AR6), and a severe scenario such as RCP 8.5 (IPCC AR5) or SSP5 (IPCC AR6). Further details on Section 3.5.

- <u>Impacts</u>

  The climate change impacts in The Bahamas were assessed from an extensive literature review and focused on economic and non-economic climate-change loss and damage, displacement, impacts on natural resources, and impacts on socioeconomic conditions. The results (see Section 3.8) were summarized for the

[33] Representative Concentration Pathways

priority sectors and translated into graphic representations - impact chains – that allow the identification of:

- Socioeconomic vulnerability and exposure factors of the population, goods and services.
- Climate vulnerability and exposure factors of natural resources.
- Key vulnerable and exposed groups and areas, which appear in several impact chains (e.g., low-income households, the coastline and heavily populated New Providence).

➢ Exposure, Sensitivity and Adaptive Capacity

  - Exposure: Sectoral exposure to climate change-related hazards was established analysing the greater or lesser presence of elements of each sector in the geographical area of analysis.
  - Sensitivity: The sectoral sensitivity was assessed through a descriptive analysis of the sectoral characteristics that may imply an increase in climate risk:
    - The elements of the sector present intrinsic weaknesses that make them more sensitive to climate impacts.
    - The sector's own elements present dependence on climatic variables.
    - The elements of the sector currently have other threats or pressures other than climate change that make their baseline situation more sensitive to changes in climate (e.g., pollution).
- Adaptive capacity: To assess each sector's adaptive capacity, the sectoral characteristics that may contribute to a reduction of climate risk were identified. These include:
  - Previous studies in the sector on climate change impacts on the sector and typologies of adaptation measures to address them.
  - Access to the necessary technology to address climate change impacts in the sector.
  - Economic capacity to cope with climate change impacts in the sector.

Once these variables were assessed, they were categorized given a category between low, medium or high and the following evaluation matrices were applied (see Section 1. 3.7).

Table 85: Evaluation Matrices Assessing Vulnerability and Risk

VULNERABILITY		**Sensitivity**		
		Low	**Medium**	**High**
Adaptive Capacity	**High**	Low	Low	Medium
	Medium	Low	Medium	High
	Low	Medium	High	High

RISK		**Vulnerability**		
		Low	**Medium**	**High**
Exposure	**Low**	Negligible	Low	Moderate
	Medium	Low	Moderate	High
	High	Moderate	High	Extreme

➢ <u>Adaptation</u>

The results from the previous components of the assessment were the basis for the definition and identification of sectoral recommendations and adaptation measures to be implemented in the short, medium and long term in The Bahamas (see Section 3.9).

3.3 The Bahamas national circumstances, institutional arrangements, and legal frameworks

The Bahamas is distributed in an archipelago of over 700 islands and more than 2000 cays, islets, and rocks in the western Atlantic Ocean. Its land surface covers 5,382 square miles, and it is one of the countries with the biggest ocean surface, approximately 100,000 square miles, with a total area of 105,382 square miles located north of Cuba and Hispaniola (Haiti and the Dominican Republic), northwest of the Turks and Caicos Islands, southeast of the U.S. state of Florida and east of the Florida Keys.

The major contributor to The Bahamas GDP is tourism, mainly concentrated in Nassau and Grand Bahama, and financial services sectors, like foreign exchange earnings. Besides the services sector, the island of Grand Bahama contains most of the industry sector, with small facilities of crude oil storage for trans-shipment. On the other hand, the island of New Providence has brewing, distilling and light manufacturing. The agriculture, forestry and fisheries sectors are some of the smaller contributors to the country's GDP, accounting only for 0.5% to it in 2021 (The Government of The Bahamas, 2014; The World Bank, 2021).

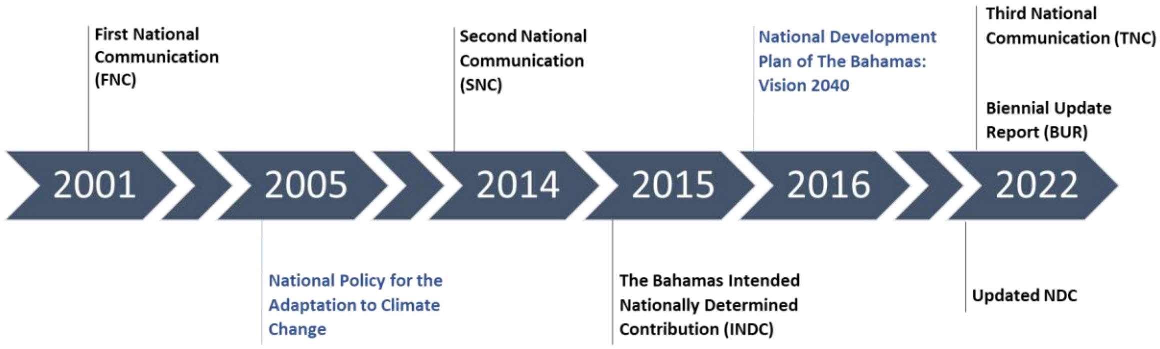
Concerning climate change framework, The Bahamas has always been sensitized to climate change and its impacts, and in response to these challenges in 2006 the country developed its National Climate Adaption Policy, which provided a plan of action for addressing impacts of climate change. In this report, the Government of The Bahamas elaborated an assessment that gave an account of the degree of vulnerability of the country to the possible impacts of climate change. The assessment was made by sectors, pointing out their capacity for adaption to climate change and proposed strategies for anticipating the negative impacts.

As part of its response the country has also ratified the Kyoto Protocol in 1999, which was in force from 2005 to 2020. This protocol included legally binding obligations aimed, among many other international commitments, to reduce the worldwide emission of greenhouse gas and at facilitating the development and establishment of technologies that can help increase resilience to the impacts of climate change (UNFCCC, 2022). Under the umbrella of this protocol, all non-Annex 1 parties, such as The Bahamas, were required to submit to the United Nations Framework Convention on Climate Change (UNFCCC) Biennial Update Reports (BURs) containing updates of national GHG inventories and information on mitigation actions, and National Communications (NC) that should include a national inventory of anthropogenic emissions by sources, a general description of steps taken or envisaged by the non-Annex I Party to implement the Convention, and any other information that the countries consider relevant to the achievement of the objective of the Convention. In this context, in 2001 The Bahamas developed its First National Communication (FNC) (Commonwealth of The Bahamas, 2001); in 2015 its Second National Communication (SNC), in 2022 its BUR and in 2024 its Third National Communication, which corresponds to this present document.

With the goal of ensuring the continuity of the work initiated by the Kyoto Protocol after 2020, a new protocol was ratified by countries at the 2015 Conference of Parties (COP21): the Paris Agreement. Its main objective is to reduce greenhouse gas emissions to prevent mean global temperature to rise over 1.5ºC compared to pre-industrial levels. Additionally, this agreement requires each Party to report the long-term goals to reduce national emissions and adapt to the impacts of climate change and commits each signing country to regularly report its contributions to the Agreement, through National Determined Contributions (NDCs). The Bahamas ratified the treaty in 2016 and submitted its intended NDC that aimed at strengthening the national capacities for addressing climate change through long-term adaption and mitigation commitments for the country's key sectors. As part of this international commitments, the country also updated its NDC for submission ahead of COP27 in November 2022.

A summary of The Bahamas main adaptation-related framework at national and international levels from 2001 to the present is described on Figure 44.

Figure 44. Main adaptation-related framework at national level (in blue) and reporting to the UNFCCC (in black).



3.4 Historical climate and evidence of climate change in The Bahamas

According to the Köppen-Geiger climate classification, practically the entire territory of The Bahamas has a tropical savannah climate (The World Bank, 2022) separated in two distinct seasons: warm but dry winter season from November to April and a hot wet summer season from May to October. Precipitation is more common in the northern islands, showing a gradient from the dry south to the humid north (Commonwealth of The Bahamas, 2001).

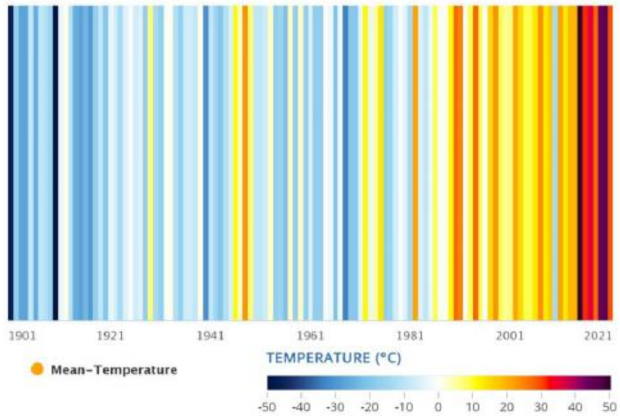
Annual mean temperature in The Bahamas has been increasing (

Figure 45), with historical records showing that in the past century, annual mean temperatures have increased by 0.5ºC since 1960 with an average rate of 0.11ºC per decade. Further analysed data show that the mean daily maximum temperature for July has increased an average of 2ºC in 100 years, and, with the more recent data, at a rate of 2.6ºC per 100 year. There is also seasonal variation between the islands, with the northern islands having a more rapid rate of warming than southwestern islands (The World Bank Group, 2021). Climate change models used during the process of the First National Communication predicted a mean temperature rise of 1.7ºC in 50 years (Commonwealth of The Bahamas, 2001) and according to the Global Facility for Disaster Reduction and Recovery (GFDRR) tool *ThinkHazard!*[34] there is more than a 25% chance that at least one period of prolonged exposure to extreme heat will occur in the next five years in The Bahamas. Moreover, warmer sea surface temperatures are likely increasing the formation of hurricanes which the country is highly exposed and vulnerable to, due to its geographic location in a hurricane hazard prone area (hurricane belt region) (Taylor, 2021).

Figure 45. Observed Annual Mean-Temperature, 1901-2021 for The Bahamas.

Source: Climate Change Knowledge Portal (The World Bank Group, 2021).

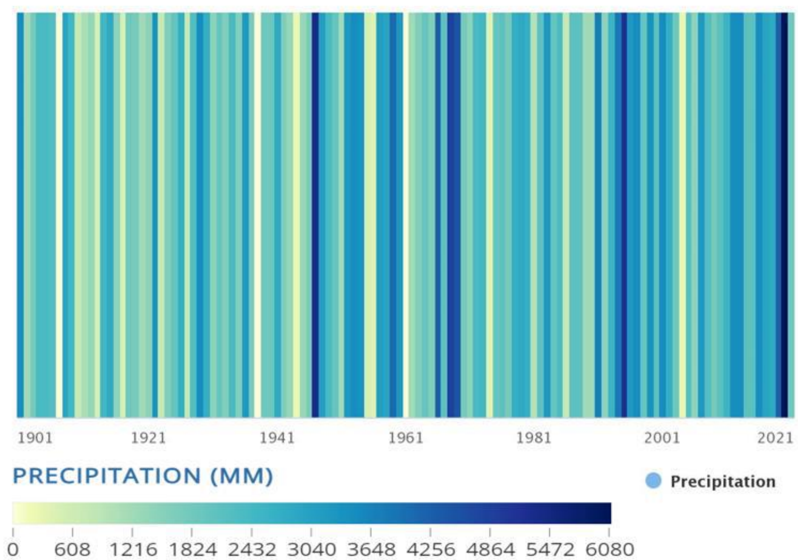
[34] ThinkHazard! is a web-based tool that aims to enable non-specialists to consider the impacts of disasters on new development projects highlighting the hazards present in a project area and how each hazard may change in the future as a result of climate.



In terms of precipitation, mean annual rainfall in the country ranges from about 865 mm to about 1470 mm (Figure 46) and there have been no significant or consistent changes observed for mean precipitation since 1960. However, particularly dry periods have occurred in the years 2004, 2005 and 2006 (The World Bank Group, 2021).

Figure 46. Observed Annual Mean-Temperature, 1901-2021 for The Bahamas.

Source: Climate Change Knowledge Portal (The World Bank Group, 2021).



Inter-annual variability in the Bahamian climate is strongly influenced by the El Niño Southern Oscillation (ENSO), with El Niño episodes bringing warmer and drier conditions between June and August.

Located in the heart of the Atlantic hurricane belt, The Bahamas is also subject to tropical cyclones and has experienced many direct hits by Major Hurricanes[35] especially during the August – November period. Records from NOAA and The Bahamas Department of Meteorology indicate that and historically, the country has experienced direct hits by twenty-four Major Hurricanes in the past century (1922-2021), (Table 86). On average, that is about one Major Hurricane every four years, combined with categories one and two hurricanes and tropical storms. All of these systems inflict catastrophic damages through strong winds, storm surges and excessive rainfalls, resulting in significant negative impacts on the country's economy. For example, in 2019 Hurricane Dorian, a category 5 hurricane, hit Grand Bahama and the Abaco Islands with a 295 km/h wind speed and storm surges in excess of 6 meters causing about 3.4 billion US dollars in damages (one-quarter of The Bahama's GDP) and hundreds of dead or missing persons (IDB, 2020b).

Table 86. List of Major Hurricanes that made a direct hit on at least one island in The Bahamas during the past century (1922 – 2021). Source: Bahamas Department of Meteorology.

Year	Date	Hurricane	Category
1926	July 25 - 27	Unnamed	3
1926	Sept. 16 - 17	Unnamed	3
1926	Oct. 20 - 21	Unnamed	3
1928	Sept. 15 - 16	Unnamed	4
1929	Sept. 25 - 26	Unnamed	4
1932	Sept. 5	The Great Abaco	4
1932	Nov. 10	Unnamed	4
1933	Sept. 3	Unnamed	3
1933	Oct. 5	Unnamed	4
1935	Sept. 29	Unnamed	3
1945	Sept. 14 - 15	Unnamed	3
1947	Sept. 16	Unnamed	3
1949	Aug. 26	Unnamed	3
1965	Sept. 6 -7	Betsy	4
1992	Aug. 23	Andrew	4
1999	Sept. 14	Floyd	4
2004	Sept. 1 - 3	Frances	3
2004	Sept. 25	Jeanne	3
2011	Aug. 24 -25	Irene	3

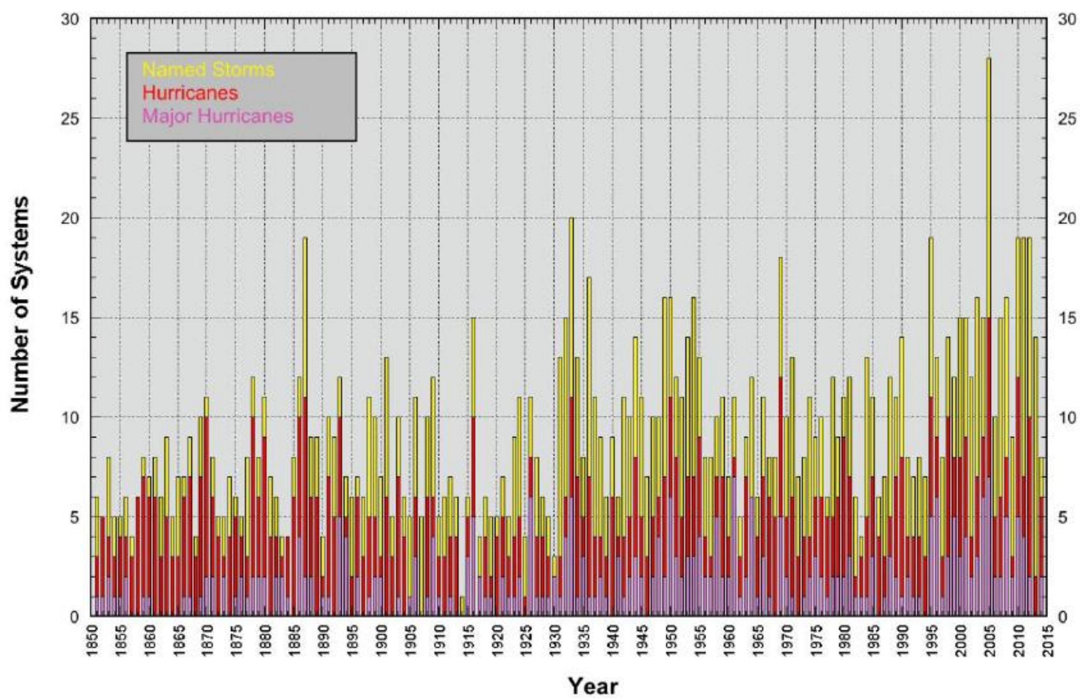
[35] Hurricanes of category 3 or higher

2012	Oct. 25 - 26	Sandy	3
2015	Oct 1 – 2	Joaquin	4
2016	Oct 4 - 6	Matthew	5
2017	Sept. 7 - 8	Irma	5
2019	Sept. 1 - 3	Dorian	5

Some models suggest that the severity of tropical cyclones may increase in tropical zones or latitudes due to changes on El Niño pattern and increased heatwaves, clear evidence of the changing climate. And effectively, since 1990 it has been observed that there has been an increase in the frequency of tropical storms on the Atlantic Basin[36] (Figure 47) (Collins et al., 2019; Walsh & Pittock, 1998).

Figure 47. Number of named storms, hurricanes, and hurricanes of category 3 or greater, on the Atlantic Basin (1850-2014)

Source: NOAA.



Finally, most of the islands in the archipelago are low-lying, with an average altitude of 1 meter above sea level which creates a high vulnerability of the country to sea level rise (SLR) and historical hydrological records show that over the past century sea level has risen 0.3 meters (The Government of The Bahamas, 2015).

[36] The Atlantic basin includes the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico.

3.5 Climate scenarios and projections for The Bahamas

To assess climate change impacts and plan appropriate response actions that will help minimize and cope with these impacts in the future, it is important to analyse the behaviour of key climate variables such as temperature and precipitation.

Earth systems models allow us to understand the Earth's system and to project future climate by analysing a set of climate-related variables. The World Climate Research Program (WCRP) Coupled Model Intercomparison Project (CMIP) involves more than a thousand scientists all over the planet and allows them to share, compare and analyse the outcomes of different global climate models. CMIP outcomes are used for understanding climate change impacts and serves as the basis for climate assessments and negotiations around the world such as the Intergovernmental Panel on Climate Change (IPCC) Assessment Reports (AR) (The Commonwealth of The Bahamas, 2005).

The overall results of the IPCC's last report (AR6) of the regional analysis for the Caribbean using different climate model ensembles project with high confidence decreases on mean precipitation, and increases on mean surface temperature and extreme heat, relative sea level, costal flood and erosion, marine heatwaves, and ocean acidity. Additionally, the 2019 IPCC Special Report on Ocean and Cryosphere in a Changing Climate, attributed with medium confidence the assertion of human contribution to an increase in Atlantic hurricane activity since the 1970s and tropical cyclones are also projected to increase with medium confidence in the region[37,38].

Scientific research has indicated that these climate events will most likely be more frequent in the future in The Bahamas and will include (The Commonwealth of The Bahamas, 2005):

- *SLR:* immersion of coral reefs and flooding of low-lying lands.
- *Rise in sea surface temperature*: changes in marine biodiversity, bleaching of coral reefs and loss in fisheries productivity.
- *Intense hurricanes*: changes in terrestrial biodiversity, coastal erosion, and infrastructure damage.
- *Salinization* (influenced by SLR): contamination of potable ground water supplies and loss of agricultural land due to soil contamination.
- *Higher temperatures:* introduction of vector-borne diseases like dengue or malaria.

[37] http://interactive-atlas.ipcc.ch/
[38] https://github.com/IPCC-WG1/Atlas

3.5.1 Temperature and Precipitation

Climate projections for temperature and precipitation in The Bahamas were obtained from the global climate model compilations of the CMIP6 that supports the IPCC's AR6[39] and while for the AR5, the scenarios used for the projections were based on different greenhouse gas concentration trajectories (Representative Concentration Pathways, RCP), for the AR6 these scenarios were based on five different narratives describing possible socioeconomic developments that could shape our future society (Shared Socioeconomic Pathways, SSP), and set the stage on which reductions in emissions will – or will not – be achieved. These are:

Table 87. IPCC AR6 Shared Socioeconomic Pathways (SSP). Source: (O'Neill et al., 2017).

Scenario	Description
SSP1-1.9	The most optimistic scenario. Global CO_2 emissions are cut to net zero by mid-century with a switch to more sustainable practices. It meets the Paris Agreement's goal of keeping global warming to around 1.5ºC above preindustrial temperatures by 2100.
SSP1-2.6	The next best scenario. Global CO_2 emissions are cut severely, but not as fast, reaching net-zero after 2050. Temperatures stabilize around 1.8ºC above pre-industrial levels by 2100.
SSP2-4.5	"Middle of the road" scenario. Global CO_2 emissions do not reach net-zero by 2100. Low progress towards sustainability. Temperatures rise 2.7ºC by the end of the century.
SSP3-7.0	Regional rivalry and inequality scenario. Emissions and temperatures rise steadily and global CO_2 emissions roughly double from current levels by 2100. Countries become more competitive shifting towards national security and ensuring their own food supplies. Temperatures rise 3.6ºC by 2100.
SSP5-8.5	Fossil-fuelled development. A dark future. Global CO_2 emissions levels double by 2050. Economy growth based on intensive fossil fuel exploitation and energy-intensive lifestyles. Temperatures rise 4.4ºC by the end of the century.

Figure 48 and Figure 49 show the IPCC projections of CO_2 emissions under the different SSP scenarios and of mean temperatures and precipitations for The Bahamas under each scenario.

[39] Bahamas, The - Mean Projections | Climate Change Knowledge Portal (worldbank.org)

Figure 48. Future annual emissions of CO_2: Shared Socioeconomic Pathway (SSP) Scenarios.

Source: (IPCC, 2021).

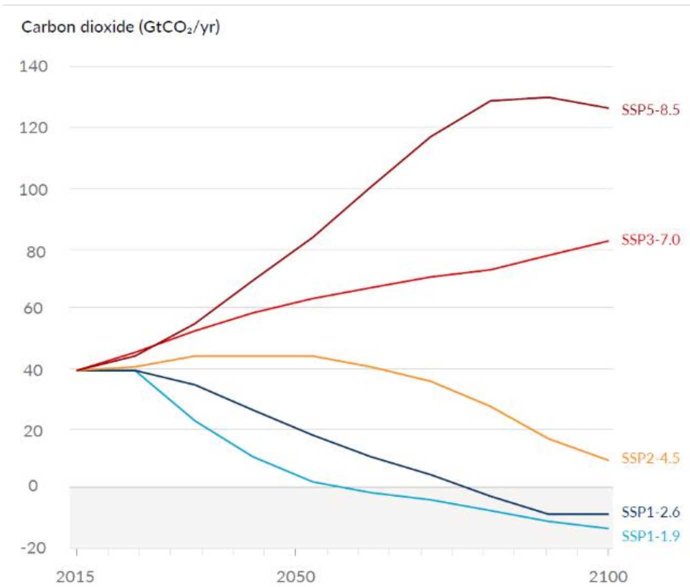
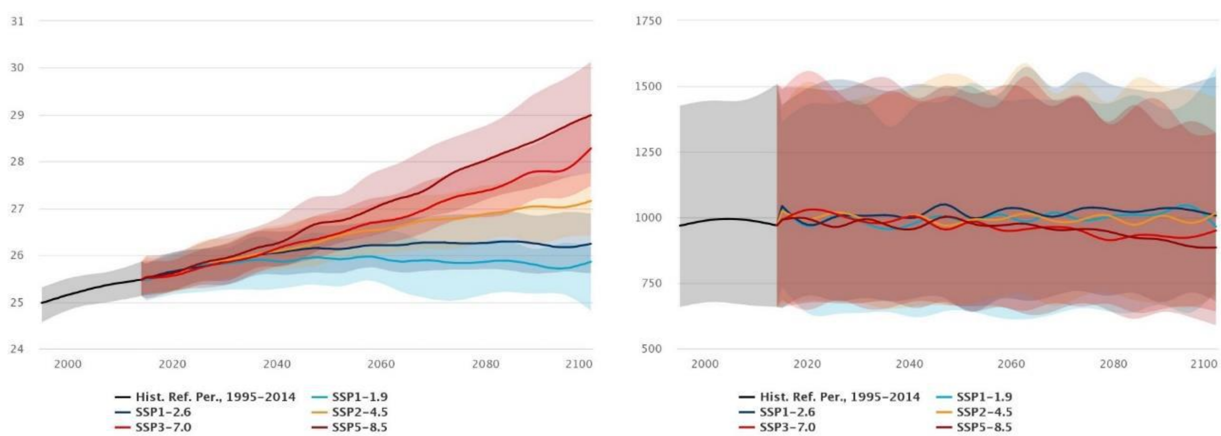


Figure 49. Projected Mean Temperature (left) and Precipitation (right) for The Bahamas (Ref. Period: 1995-2014), Multi-Model Ensemble.

Source: World Bank Climate Change Knowledge Portal.



This new emissions scenarios with different socioeconomic assumptions and mitigation levels of aerosols and other GHG, conclude that, for The Bahamas, the following climate change-related mid- and end of the century impacts are expected:

Table 88. Temperature and precipitation projections for The Bahamas.

Source: World Bank Climate Change Knowledge Portal.

Temperature	Precipitation
• Increase of the mean annual temperature by 0.8-2.3°C by mid-century, and 1.2-2.5°C by the end of the century. • Most rapid rate of warming in the summer from June-August and September-November. • Substantial increases in the frequency of 'hot' days occurring on 24-47% of days by mid-century and 26-67% by the end of the century and decreases in the frequency of 'cold' days and nights occurring on 0-4% days per year.	• Decreases in rainfall, particularly in the months from March to August partly offset by overall increases in the September-November period. • Decrease on the proportion of total rainfall that falls in heavy events during the March-August period.

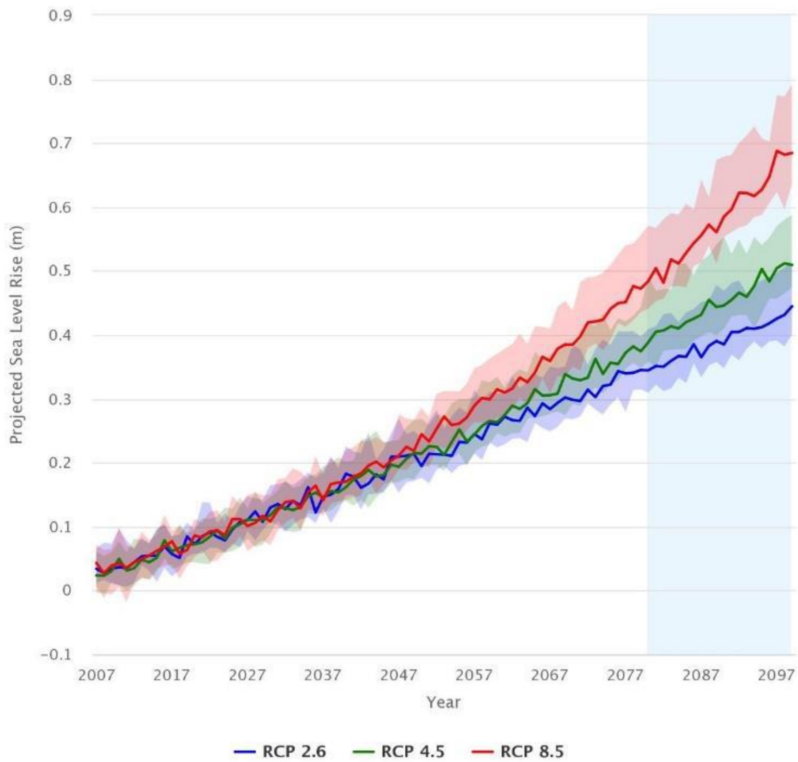
3.5.2 Sea Level Rise and Coastal Flooding

As a result of global warming, global sea levels are rising due to the melting of land-based ice sheets and glaciers, and to seawater expansion (as the ocean warms, seawater becomes less dense and expands). According to data derived from the CMIP5 collection[40] that supported IPCC's AR5 (2014), sea-level in The Bahamas might increase by the end of the 21st century ranging from 0.4m under an optimistic scenario with low carbon emissions, high renewables, and strong international cooperation (RCP 2.6) to nearly 0.7m under a pessimistic (business as usual) scenario (RCP 8.5) (Figure 50). Additionally, a 2018 report from the Inter-American Development Bank (IDB)[41] based on two different sea-level models that build on top of the IPCC's work[42], provides local projections for Settlement Point tide gauge and describes further increases of median seal-level projections relative to the year 2000 ranging between 0.27m by mid-century and 0.61m by the end of the century under a low (RCP 2.6) emission scenario, and between 0.32m by 2050 and 1.63m by 2100 under a high emission scenario (RCP 8.5).

[40] https://climateknowledgeportal.worldbank.org/country/bahamas/impacts-sea-level-rise
[41] https://sealevel.climatecentral.org/uploads/ssrf/Sea-level-rise-threats-in-the-Caribbean.pdf
[42] Koop *et al.* 2014 and Koop *et al.* 2017

Figure 50. Projected Sea-Level Rise for The Bahamas (2080-2090).

Source: World Bank Climate Change Knowledge Portal.



Due to its low topography, an increase of 1m in seal level in The Bahamas could submerge a large part of the country. Figure 51 provides a visual example on the impact such increase would have in the island of New Providence.

Figure 51. Screenshots from Surging Seas Risk Zone Map (ss2.climatecentral.org), showing (in grey) (a) land above the current coast; (b) land less than 1m above the local high tide line in Nassau (New Providence), The Bahamas.

Source: Climate Central Surging Seas Risk Mapping Tool: https://ss2.climatecentral.org/.

(a)

(b)

3.5.3 Hurricanes and other Extreme Weather Events

The number of hurricanes in the Caribbean is influenced by the El Niño/La Niña (El Niño Southern Oscillation -ENSO) cycle in the Pacific Ocean and, among other factors, they depend upon warmer sea surface temperatures which, due to climate change, are likely increasing their formation (The World Bank Group, 2022). Hurricane activity in the Caribbean has been subject of many studies with climate models suggesting that the severity and frequency of these events may increase due to climate change (Walsh & Pittock, 1998). In the past 30 years there has been an increase in the frequency of North Atlantic hurricanes and tropical storms in the Caribbean region which may be caused by changes on El Niño pattern and increased heatwaves, clear evidence of the changing climate (Collins et al., 2019; Simpson et al., 2012). Additionally, hurricane intensity also appears to be increasing and the IPCC AR6 concludes with medium confidence that tropical cyclones and severe storms are expected to become more extreme in the Caribbean (Magnan et al., 2019).

3.6 Climate risk and adaptation in The Bahamas

3.6.1 Vulnerability in The Bahamas

Similarly to other Small Island Developing States (SIDS), The Bahamas geographic conditions makes it an extremely vulnerable country to climate change-related events. While impacts in the islands of New Providence, Grand Bahama and Abaco may be strongly felt by a larger number of people (as 90% of the country's population live in these islands), the Family Islands face challenges related with higher costs for development and post disaster recovery. Settlements in these islands are dispersed and with small populations and the provision of public utilities and the development of infrastructure needs to be extended for long distances to supply communities. In addition, the dispersion of population contributes to an inequitable access to social services (IDB, 2021; Taylor, 2021).

The country is distributed in a large archipelago of over 700 islands and it is one of the countries with the biggest ocean surface (The Government of The Bahamas, 2014) that hosts five percent of the world's coral reefs which makes for shallow, clear water, ideal for snorkelling and fishing (Simpson et al., 2009; The Government of The Bahamas, 2014). Reefs play a vital role in The Bahamas' economy as reef diving and snorkelling are an important part of the country's tourism industry, which accounts for more than 45% of GDP and employs directly and indirectly more than 50% of the country's labour force (The Government of The Bahamas, 2020). Hurricanes and extreme weather events can cause significant damage and loss of these marine life forms which can be exacerbated by climate change-related stressors such as, increases in sea surface temperatures that are already causing coral bleaching in the country's reefs (The Commonwealth of The Bahamas, 2005; The Government of The Bahamas, 2014). Other impacts also include changes in marine biodiversity and losses in fisheries productivity.

The islands of The Bahamas are low and flat with an average altitude of 1 meter above sea level for the majority of the islands (~80%), rising to the greatest elevation at Mount Alvernia on Cat Island (63m) making the country particularly vulnerable to sea-level rise (SLR). According to a study by Simpson et al. (2009), even a 1m (3.28 ft) increase in seal level can affect as much as 10% of the land area and 5% of the country's population[43]. SLR pose a threat to The Bahamas population as it can increase the risk of flooding and coastal erosion causing damages to infrastructure. The location of vital transportation infrastructure such as road networks and airports near the coastline poses a threat to the transportation sector, with 2% of the road networks and 13% of airports affected by a 1m (3.28 ft) SLR increase. Furthermore, 15% of Bahamian wetlands and 9% of major tourism resorts are also at risk to a 1m (3.28 ft) rise in sea level. Impacts of 1m (3.28 ft) SLR to

[43] Based on 2010 projections

the Bahamian GDP are also important to note and will be primarily from losses in agricultural productivity and tourism leading to a 4% loss in GDP[44], or US$ 421,488,795.00 (Simpson et al., 2009). In addition, SLR can lead to saltwater intrusion causing the contamination of potable ground water supplies and loss of agricultural land due to soil contamination.

Moreover, freshwater resources are finite in The Bahamas and the country is also particularly prone to *water shortages* specifically in the dry season, when demand is also highest. Considering that due to climate change temperatures are expected to increase and precipitation is projected to decrease, particularly in this season, the availability of freshwater is expected to decline in the future posing a risk not only to the Bahamian population but also to its natural capital. Higher temperatures can also lead to the introduction of vector-borne diseases such as dengue or malaria and a decline in precipitation levels would reduce the level of groundwater recharge that, coupled with increases in SLR, could increase the risk of saltwater intrusion (Simpson et al., 2009) directly affecting water supply availability.

Additionally, an increase on the frequency and intensity of *hurricanes and extreme weather events*, as projected, can have a devastating impact in the country by leading to significant losses and damages. Storm surges associated with hurricanes can also cause significant damage and flooding as they precede the arrival of hurricanes and continue during the hurricane, sometimes affecting larger areas (Simpson et al., 2009).

3.7 Sectoral Exposure, Sensitivity and Adaptive Capacity

3.7.1. Agriculture

In The Bahamas the agricultural sector makes a small contribution to the country's wealth and economic drivers, (FAOAquastat, 2015). In 2015, agriculture accounted for only 0.7% of GDP (together with fisheries, it accounted for 1.6% of GDP) and its share in total employment is rather moderate with only 3% of the active population in The Bahamas being employed in agriculture, with 90% of the agricultural land in the country being government property and managed by the Ministry of Agriculture and Fisheries (Shik et al., 2018).

Crop farming consists mainly of tropical fruits and vegetables whereas livestock farming is mainly sheep, goat and swine production with a small recovering poultry industry. Livestock production and crops have been increasing over the past years and in the 2000's both agricultural and food production increased overall in the country, however nearly 90% of the Bahamian food products is imported, 80% of which come from the United States (International Trade Administration, n.d.; Shik et al., 2018). Imported

[44] At 2008 levels

products include meats (including poultry), dairy, eggs, fruits and vegetables, beverages and convenience foods. Presently, there is no export of fruits or vegetables.

In addition, transportation of agricultural production between islands is a serious issue as transportation costs remain extremely high (FAO, 2009). Moreover, the availability of transportation is scarce (once weekly boat schedule).

In accordance with the 2018 report by the Inter-American Development Bank *Analysis of Agricultural and Fisheries Policy in The Bahamas,* in 2018 the agricultural land surface represented 0.8% of the total country land area, being mostly concentrated on New Providence, Abaco, Andros and Grand Bahama islands, with large-scale mechanized crop production carried out mainly in Abaco, Andros and Grand Bahama. However even though the land is available, the soil requires fertilization as the soils have a low organic matter content and its nature is highly alkaline. Abaco, Andros and Grand Bahama have fresh water for irrigation available (Shik et al., 2018) but other narrower islands are prone to have more brackish water lenses and the soil is interspersed with hard rocks and that makes land preparation difficult and more expensive.

The islands of the northern Bahamas are the primary centres of production for a wide range of perishable vegetable crops, while the south-eastern islands are more suited to the production of the hardier, non-perishable staple crops (FAO, 2009) often using traditional methods of crop production. In terms of livestock, presently, Abaco is the single island with the largest poultry operation. Sheep, goats and pigs are farmed throughout all the islands.

According to the country profile of the Bahamas elaborated by the FAO in 2015, the total agricultural land in the Bahamas was estimated to be 14,000 ha, representing 1% of the territory (Table 89).

Table 89. Agricultural statistics for The Bahamas.

Source:(FAOAquastat, 2015)

	Area	Area (%)
Agricultural land (permanent meadows and pasture + cultivated land)	14000 ha	1%
Permanent meadows and pasture	2000 ha	0.14%
Cultivated area (arable land + area under permanent crops)	12000 ha	0.857%
Arable land (temp. crops + temp. fallow + temp. meadows)	8000 ha	0.57%
Area under permanent crops	4000 ha	0.28%

However, in 2019, the impact of Hurricane Dorian on the agriculture and fisheries sector of Abaco and Grand Bahama was significant and generalized. Several farms and green houses were destroyed, and the wind and saltwater intrusion also destroyed many perennial crops. According to the Department of Agriculture (DoA) assessments and the former Minister's budget speech/briefing on loss and damage to the sector, the impact of hurricane Dorian resulted in losses of $16 million to the agriculture sector.

The main agricultural lands on islands such as Abaco, Grand Bahama and Andros are not located very close to the coast. However, due to the low elevation of all islands and the erosion of the coast line make the islands very susceptible to saltwater intrusion caused by storm surges. Given the size of the sector; rising sea levels; loss of arable land; loss and damage caused by extreme weather events; and the difficulty for farmers to rebound after such catastrophic devastation, it is considered that this sector presents a **HIGH** exposure to climate-related hazards.

In the future climate change scenario, The Bahamas, which by its nature has always been sensitive to climate change and its impacts, will be highly vulnerable due to its low land elevations, among other reasons. This condition particularly implies a high vulnerability to SLR (mainly in almost all islands) which can cause flooding events that can damage crops and agricultural land, as well as other infrastructure and facilities in the agricultural sector. In addition, sea level rise can also lead to the contamination of freshwater resources due to saltwater intrusion including aquifers, a very important source of freshwater for the agricultural activity of the islands. In addition, climate change will also expose the sector to a higher frequency of extreme weather events like hurricanes and extreme winds, which are also becoming stronger in intensity. All of this leads to losses in the productive capacity of the land and available resources to crop farmers and livestock farmers, who are often unable to cope with the losses caused by these extreme events. Therefore, the sensitivity of the sector to climate change-related hazards is considered to be **HIGH**.

Regarding adaptation capacity, there is a lack of proper regulatory framework to promote sustainable land and natural resource management. Also considering future climate change scenarios, there is also a lack of emergency preparedness to heat waves and droughts, and even a lack of knowledge about soil management techniques and climate-resilient crops (The Government of The Bahamas, 2015). Together with the lack of available arable land, the adaptive capacity of the sector is considered to be **LOW**.

3.7.2. Natural Resources

A third of the Caribbean's coral reefs are located in The Bahamas and these ecosystems are valuable biological and economic resources for the country, as they provide food security, support fisheries livelihoods and are a major source of marine biodiversity with high cultural and tourism attraction value (Deleveaux et al., 2013). In addition, coral reefs are natural breakwaters and form a natural coast protection against erosion and storm action while generating new sand through natural erosion of the coral skeletons (The Government of The Bahamas, 2014).

The most extensive reef systems in The Bahamas are found along the northern and eastern coasts or the windward side of the islands (Bahamas Reef Environment Educational Foundation (BREEF), 2016) with the longest reef system located along Andros Island extending more than 200 km (

Figure 52).

Figure 52. Coral reefs in The Bahamas.

Source:(Deleveaux et al., 2013).

Likewise, The Bahamas has natural forest resources comprising pine forests, coppice hardwoods and mangrove forests. Terrestrial forests can be divided in three main categories: Northern Bahamas Pine Forests, Central Bahamas Broadleaf Hardwood Forest and Southern Bahamas Drought-Resistant Woodland. The majority (80%) of these resources are located on state (crown) lands, with the remaining on private lands (Bahamas Environment Science and Technology (BEST) Commission, 2005).

Forests are valuable habitats for native Bahamas fauna and flora, presenting a high biodiversity including indigenous and important endangered species. They also provide protection of soil and freshwater resources, which has a high value due to the scarcity of water resources in the country (Bahamas Environment Science and Technology (BEST) Commission, 2005).

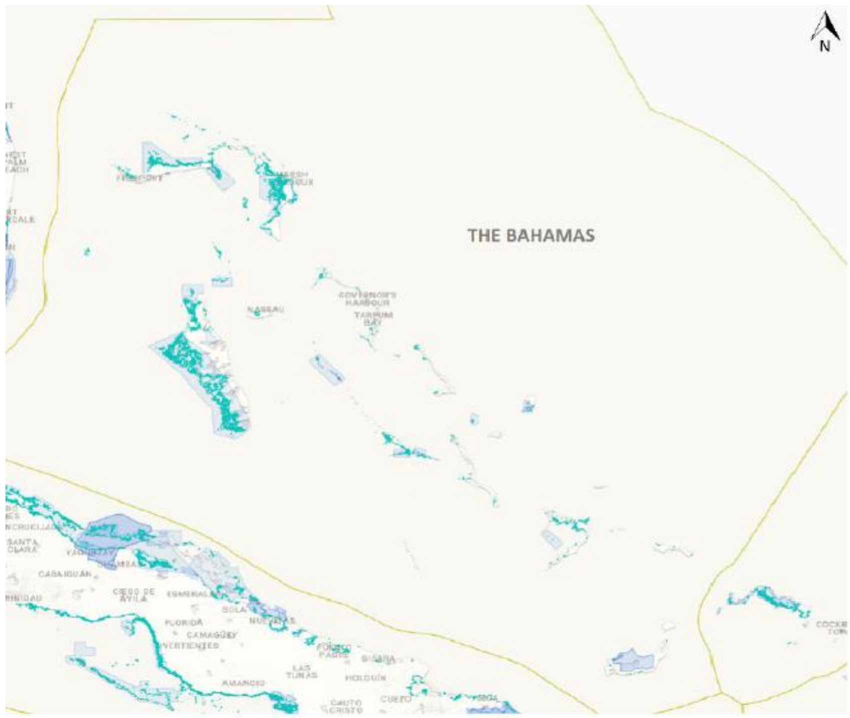
As per 2005 data, Bahamian forest resources occupy approximately 50.9% of the country's area, however, according to Global Forest Watch, since 2001 there was an 8.7% decrease in tree cover in The Bahamas, mainly due to deforestation and shifting agriculture activities and, in 2010, the country had 344k ha of tree cover (defined as any vegetation greater than 5 meters in height), extending over 26% of its land area (Global Forest Watch, n.d.).

The top 5 forested regions that were responsible for 51% of all tree cover loss between 2001 and 2021 include North Andros, Cat Island, East and West Grand Bahama's and South Abaco. North Andros had the most tree cover at 47.9 kha compared to an average of 10.8 kha (Global Forest Watch, n.d.). Notably, in 2019 the impact of Hurricane Dorian on the Bahamian ecosystem was enormous. According to the IDB, an overall estimate of 44.1 kha of forests in public lands and 122.8 kha of National Reserves have been damaged (IDB, 2021).

Mangrove forests dominate on the leeward shores of most islands representing approximately 49.22% of the coastline in 2020 (Figure 53).These ecosystems are nursery areas for key fisheries species, along sea grass beds, and also play an important role in the country as they protect inland forests and natural communities from storms and erosions (The Commonwealth of The Bahamas, 2005; The Government of The Bahamas, 2014).

Figure 53. Mangrove extent in The Bahamas (2020).

Source:(Global Mangrove Watch, n.d.)



Additionally, blue holes which are important ecosystems for ecoturism and of great scientific value, occur in forest areas (The Commonwealth of The Bahamas, 2005; The Government of The Bahamas, 2014). All the major islands of The Bahamas have blue holes, but Andros has the greatest amount with 178 documented blue holes on land and at least 50 in the sea (Bahamas National Trust, n.d.).

Regarding the islands' faunal biodiversity, nearly 9% (121 taxa) of plant species found in The Bahamas are endemic. 1,111 higher plants, 57 breeding birds, 53 reptiles, 5 amphibians and 248 fish has been identified in The Bahamas. Additionally, 24 species of marine mammals are also known to occur in The Bahamas. There are also 46 species of native herpetofauna and two bird species which are endemic of The Bahamas (Ministry of Environment, 2011).

Based on the elements described above, it is considered that the exposure of this sector to climate change hazards is considered to be **HIGH.**

In terms of sensitivity, coastal and marine zones and also inland ecosystems are very vulnerable to changes in temperature and storm surges and are under great risk from climate change-related impacts. About 30% of the 4,000 mi^2 of coral reefs in The Bahamas is under threat from overfishing and coastal impacts (The Government of The Bahamas, 2014). Reefs play a vital role in The Bahamas' economy as reef diving and snorkeling are an important part of the country's tourism industry, which accounts for more than 45% of GDP and employs directly and indirectly more than 50% of the country's labor force (The Government of The Bahamas, 2020). In addition, there are recreational and tourism values derived from coral reefs, but not linked to activities that take place on the reefs themselves (coral-adjacent values). These include values associated with the beaches and coastal waters protected by the reefs, such as: white sand, brightly colored views of the crystal-clear nearshore waters, activities such as swimming or small boats that require calm waters, and obtaining local fish and shellfish associated with the reefs (Spalding et al., 2018).

Additionally, sea level rise, will also impact and affect numerous ecosystems, as well as other assets and infrastructure located in coastal zones as well. The main threats include flooding, inundation of mangrove swamps and wetlands, as well as erosion of beaches and coastal lands and some of the smaller cays primarily due to hurricanes and storm surges, though sea level rise and changing coastal processes may also play a role. Increased sea water temperature from climate change is expected to cause a significant loss in fisheries production. This is due to its negative impacts on coastal ecosystems, habitats for numerous fish and other marine life forms. For example, fish movement patterns and populations might migrate to colder latitudes or even die (The Government of The Bahamas, 2014).

Forests and woodlands in The Bahamas will be affected by the negative impacts of climate change. This may manifest with changes in growth patterns and species composition, as a result of soil salinization, rising water tables and an increased risk of soil erosion – which would contribute to loss of woodland (The Government of The Bahamas, 2014).

Hence, the sensitivity of the overall sector is considered to be **HIGH.**

Protected areas with high biodiversity levels maintain essential ecosystem services which can increase resistance, resilience and reduce the vulnerability of livelihoods against climate change. Therefore, the islands with the highest number and percentage of their surface area (e.g., Andros) classified as a protected area will be more protected against climate change impacts and will also be less vulnerable and more resilient to future changes (e.g., sea rise level, higher temperatures, droughts). Additionally, islands that present a high percentage of their coastal area with coral reef or mangrove ecosystems, have an additional and very effective defence system against flooding and help to slow down the effects of sea level rise. Protected areas are often the source of both pure water and increased water flow, improving the availability and quality of water resources. The surface area occupied by the protected areas in the different islands is shown in the following table:

Table 90. Protected areas per island (ha).

Source:(Bahamas Protected Areas Fund, 2020).

Island	Protected areas (ha)
Abaco	182.33
Acklins & Crooked Island	24.86
Andros	839012.01
Andros/ Exuma	1.09
Berry Islands	25,498.46
Bimini	-
Cat Island	194.25
Cay Sal	1,684,432.23
Crooked Island	3.24
Crooked Island/ Acklins/ Mayaguana	2,449,568.4
Eleuthera	29.95
Exuma	95,157.06
Grand Bahama	173,116.172
Inagua	116,934.02
Inagua/ Acklins	4,986.54
Long Island	-
Mayaguana	48.967006
Moore's Island	-
New Providence	11,215.06
Ragged Island	-
Run Cay	-
San Salvador	10,420.66

In 2021, the Government of The Bahamas significantly strengthened the fight against biodiversity loss and climate change by adding 2,144 kha (5.3 million acres) to the Bahamas' marine protected areas (MPAs). In doing so, the Bahamas has protected 20% of its marine and coastal habitat. This goal was announced by the Bahamas when it joined the inaugural Caribbean Challenge in 2010 (Bahamas National Trust, n.d.).

It should be mentioned that some challenges do exist regarding the implementation of regulatory frameworks[45] to promote sustainable land and natural resource management and in addition to complete datasets to support robust monitoring and tacking systems to assess climate change impacts on the sector. Efforts to adapt and conserve natural elements and forest ecosystems are considered to be very important (Commonwealth of The Bahamas, 2001). Aside from the need to update some of the regulatory framework (e.g., The Coastal Protection Act (1968), • The National Biodiversity Strategy and Action Plan (1999)) to ensure the climate variable is included in the management dissemination regarding the role of biodiversity, natural resources and ecosystems, the

[45] Such as the Fisheries Act, the Biological Resources and Traditional Knowledge Act and the Environmental Planning and Protection Act.

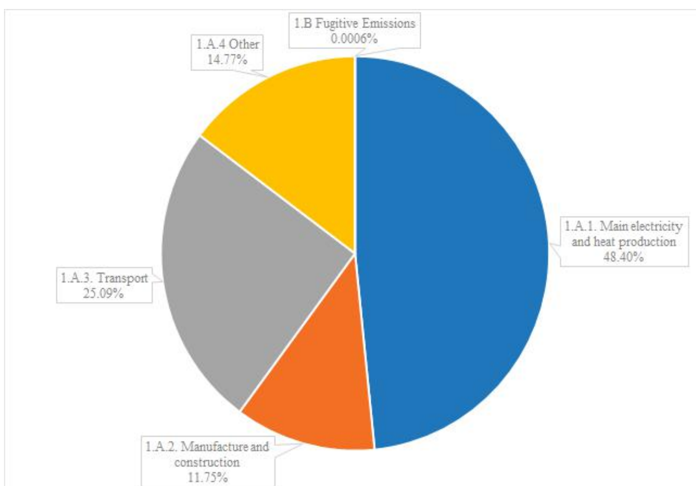
sectoral adaptive capacity of the sector to climate change-related threats is considered to be **MEDIUM.**

3.7.3. Energy

The Energy sector in The Bahamas is heavily dependent on imported fossil fuels with most of the sectors GHG emissions stemming from fuel combustion. The sector is one of the highest emitters in the country and according to the last National Inventory Report, emissions in the sector have increased by 11.7% from 2001 to 2018. This is both related to a GDP increase of 60% and a population increase of almost 30%. In addition, the increase in tourism during this period has probably led to an increase in demand for fuel and transportation. The main power and heat generation is the largest GHG emission source in the energy sector with 48.4% of total emissions, followed by transport with 25.1% (Figure 54).

Figure 54. Contribution of categories to total GHG emissions in the energy sector in 2018.

Source: National Inventory Report 2001-2018.



Power generation in The Bahamas is in the hand of two power supply companies: The state-owned Bahamas Power and Light Company Ltd. (BPL) and The Grand Bahamas Power Company. The latter services Grand Bahama only, whereas BPL services the remaining major islands, (with the exception of Spanish Wells and Eleuthera). Both companies generate electricity using fuel oil and diesel. There are also authorized public electricity suppliers in The Bahamas, including St. George's Cay Power Company and Baker's Bay power company (IDB, 2021). Both companies generate electricity using fuel oil and diesel. In 2018, there were 767 MW of installed electricity generation capacity in

The Bahamas, all of which corresponded to thermal power plants running on diesel and residual fuel oil (BUR, 2022).

As a response to rising temperatures and the growth and development of the country (rising population), the energy demand is increasing, which increases sectoral sensitivity. In particular, the most densely populated islands with the largest and most developed infrastructures (such as New Providence and Grand Bahama) are expected to have the highest energy demand in the future (The Commonwealth of The Bahamas, 2005).

Price volatility in the global energy market, increased by extreme events which cause loss and damage to energy infrastructures, causes price fluctuations and increases and poses a risk to the energy security and thus competitiveness of the Bahamian economy (IDB, 2021).

Given these characteristics, **both sensitivity and exposure** elements can be considered **MEDIUM.**

Based on average global generation costs and the country’s resource potential, renewable technologies such as solar, ocean thermal energy conversion (OTEC) wind offer an opportunity for renewable energy to diversify the energy matrix and reduce rate volatility and the potential for supply disruptions in the country, resulting in more self-sufficiency and stable energy costs over the long term (National Renewable Energy Laboratory (NREL), 2015; The Government of The Bahamas, 2014).

To date, each island has had its own generation plant, except from the Paradise Island where energy needs to be supplied by submarine power cable. The deployment of renewable energy on the islands would be done in a similar way, with one large array or micro grids.The construction of above-ground power lines has advantages in terms of cost, but they are nevertheless more vulnerable to being destroyed by adverse weather events. Strategies such as locating power generation systems in a planned and efficient manner and constructing subway rather than overground transmission cables at key grid nodes are essential to improve the resilience of the country's power system. Nevertheless, the construction cost involved, and the maintenance required to prevent salt corrosion of the cables is high and must be taken into account.

The adaptive capacity of the Bahamian energy sector to climate change-related hazards is perceived as **LOW**.

3.7.4. Human Health

Based on the latest United Nations projections, on July 2, 2022, The Bahamas population was estimated at 409,9846 inhabitants. Data from the World Bank shows that in 2021 the

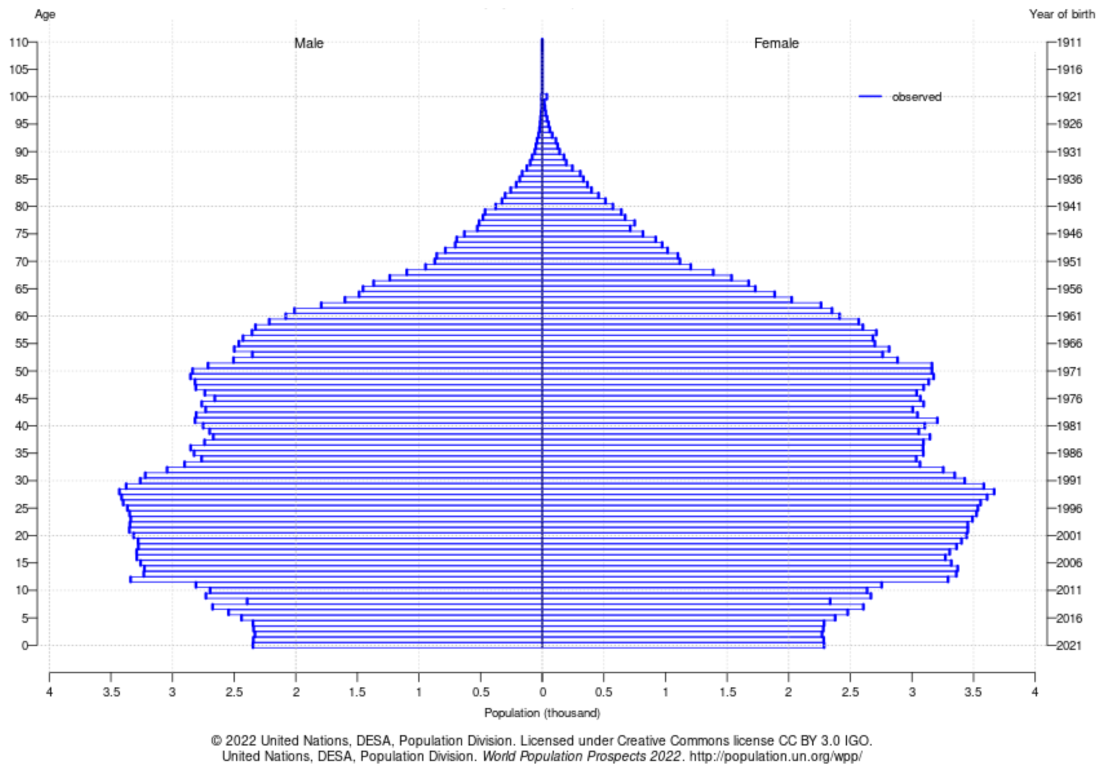
Bahamian female population was slightly higher (51,4%) than male (49%) more women than men. The median age of the population is 32 years, 30.9 for males and 33.2 for females (World Population Review, 2022).

The Bahamas currently has a fertility rate of 2 children born per woman, which is slightly lower than the replacement rate and the country's population is currently growing at less than 1% a year (World Population Review, 2022). With declining birth rates and an increase in life expectancy, the Bahamian population is ageing with a mean life expectancy of 74 years in 2020 (The World Bank, 2022), growing at an average annual rate of 0.25% (United Nations, 2020).

About 9% of The Bahamas population is 60 years of age or older (Figure 55). However, this portion of the population is expected to increase to 18% by 2030, and the portion of the population with 65 years is also expected to double from 6% (in 2010) to 12% in 2030 (Ministry of Health, 2010).

Figure 55. Bahamas population by age and sex (2022).

Source: United Nations World Population Prospects 2022.



Although in 2015, 92% percent of the population used improved sanitation facilities both in rural and urban areas, youth and Haitian immigrants are the most vulnerable populations to suffer climate change health impacts, with poor housing and sanitation conditions (WHO; UNFCCC; PAHO, 2021). As daily temperatures are rising and reaching the upper limits of human physiological adaptation, heat stress is an increasing problem, as well as climate-sensitive water-borne and vector-borne diseases are on the rise which represent a health and an economic threat to The Bahamas (The Government of The Bahamas, 2014). Furthermore, The Bahamas experiences climate-related water and food insecurity which interplays with the nation's high prevalence of noncommunicable diseases (Philippe et al., 2021).

According to the World Health Organization Country Cooperation Strategy for The Bahamas (2017) in 2014, the country ranked 55 both on the Gender Inequality Index[46] and the Human Development Index[47] Rank.

[46] Gender Inequality Index is a composite metric of gender inequality using three dimensions: reproductive health, empowerment, and the labor market. A low GII value indicates low inequality between women and men, and vice-versa. (United Nations Development Program) https://hdr.undp.org/data-center/thematic-composite-indices/gender-inequality-index#/indicies/GII

[47] The Human Development Index (HDI) is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living. The HDI is the geometric mean of normalized

As the whole population and health infrastructure are considered as exposed and sensitive elements, both the **sectoral exposure and sensitivity** to climate change-related hazards are considered to be **HIGH**.

In terms of public health care infrastructure, The Bahamas has 83 clinics providing ambulatory health care services across the 17 main inhabited islands (Table 91) and 3 hospitals (Princess Margaret Hospital and Sandilands Rehabilitation Centre in New Providence and Rand Memorial Hospital in Freeport) that cover the entire country (IDB, 2020a). Sixty-nine (69) public clinics throughout the Family Islands provide limited health care to residents, but major medical needs are accommodated at the hospitals. The country capital, Nassau, hosts one private hospital facility, Doctor's Hospital and there are also several private clinics across the country, mostly in New Providence and Grand Bahama (IDB, 2020a). In addition, there are 75 pharmacies spread across the country (Table 91). In 2019, most of the health facilities on Grand Bahama and Abaco were damaged during Hurricane Dorian with severe damage to Rand Memorial Hospital (RMH) and four clinics located on the eastern part of Grand Bahama (IDB, 2021).

Health is currently financed through a mixture of government allocated budget, direct out of pocket expenditure and private health insurance payments. In 2014 the total expenditure on health as a percentage of gross domestic product was 7.74% and the private expenditure on health as a percentage of total expenditure on health in the same year was 54.14%. The general government expenditure on health as a percentage of total government expenditure in 2014 was 14,78% (WHO, 2017).

In terms of medical emergency, air ambulances between islands provide secure transport to the nearest major hospitals.

Table 91. Public clinics and pharmacies per island.

Source (Omar Bello, Robert Williams, et al., 2017), Assessment of the Effects and Impacts of Hurricane Matthew in The Bahamas (IDB 2020) and Google Maps.

Island	Public clinics	Pharmacies
Acklins	5	-
Berry Islands	1	2
Bimini	2	-
Exuma and Black Point	6	1
Cat Island	3	-
Abaco Island	8	2
Andros Island	8	1
Eleuthera Island	14	3
New Providence	14	57

indices for each of the three dimensions. (United Nations Development Program) https://hdr.undp.org/data-center/human-development-index#/indicies/HDI

Island	Public clinics	Pharmacies
Crooked Island	2	-
Grand Bahama	10	8
Long Island	5	1
Mayaguana	1	-
Moore's Island	-	-
Ragged Island	1	-
Inagua	1	-
Run Cay	1	-
San Salvador	1	-

Islands like New Providence, Grand Bahama or Eleuthera have a greater availability of medical services than other less populated islands with less developed public infrastructure and facilities, which makes them (and their populations) much more vulnerable to humanitarian disasters, extreme events or the human health impacts of climate change.

From the point of view of adaptive capacity, it should be noted that there is a lack of financial resources at the systemic and institutional levels for the human health sector. There is also a lack of policies on climate change and health and a weak infrastructure to face future impacts of climate change (The Commonwealth of The Bahamas, 2005).

In addition, it is important to note that most secondary and tertiary health services (i.e., hospitals) are concentrated in New Providence and Grand Bahama, so a major storm in New Providence and Grand Bahama would significantly hamper the country's ability to provide health services.

For all these reasons, it is considered that efforts in investment and health infrastructure are not sufficient. Thus, sectoral adaptive capacity is considered to be **LOW**.

3.7.5. Human settlements and infrastructure

Thirty of the seven hundred Bahamian islands are inhabited, and 90% percent of the total population lives on New Providence, Grand Bahama and Abaco. New Providence has 69.9 % of the population, Grand Bahama and Abaco 15.5 %, and the remaining 10.3% are scattered through the remaining islands and cays (The Government of The Bahamas, n.d.).

With the largest population in the country, the central point of The Bahamas is New Providence and its capital Nassau. Accordingly, the main infrastructures and resources are also located there: hospitals, clinics, schools, airports, docks, water plants, telecommunications, etc.

Most of the Bahamian islands have populations of more than 1000 inhabitants, (e.g., Bimini, Exuma and Black Point, Cat Island, Abaco Island, Andros, Eleuthera, Grand Bahama and Long Island) with most of the human settlements and key infrastructure located in coastal zones, which makes them highly vulnerable to sea level rise and flooding events.

For example, all international airports in The Bahamas that receive scheduled flights from all over the world are in coastal areas (Table 92). In addition, the country also counts twenty-three (23) ISPS[48] docks and harbors facilities.

Table 92. Main airports in The Bahamas.

Source: The World Data (https://www.worlddata.info/america/bahamas/airports.php#MYBC).

IATA	Airport Name	City
NAS	Lynden Pindling International Airport	Nassau
GGT	Exuma International Airport	George Town
FPO	Grand Bahama International Airport	Freeport
MHH	Leonard M Thompson International Airport	Marsh Harbour
ELH	North Eleuthera Airport	North Eleuthera
GHB	Governor's Harbour Airport	Governor's Harbour
ZSA	San Salvador Airport	San Salvador
TCB	Treasure Cay Airport	Treasure Cay
BIM	South Bimini Airport	South Bimini
ATC	Arthur's Town Airport	Arthur's Town
LGI	Deadman's Cay Airport	Deadman's Cay
SML	Stella Maris Airport	Stella Maris
AXP	Spring Point Airport	Spring Point
CRI	Colonel Hill Airport	Colonel Hill
IGA	Inagua Airport	Matthew Town
MYG	Mayaguana Airport	Abrahams Bay
COX	Congo Town Airport	Andros
SAQ	San Andros Airport	Andros Island
CCZ	Chub Cay Airport	Berry Islands
TBI	New Bight Airport	Cat Island
PID	Nassau Paradise Island Airport	Nassau

Regarding sensitivity, housing and the quality of life of the population in The Bahamas, the main materials of outer walls in 52% of houses are wood stucco and 32.82% of the houses get their main source of water for bathing and cleaning from public water systems, but it’s not piped into dwelling (Bahamas Department of Stadistics, 2004). Also, in 24.69% of the houses the toilet facility type is latrine and in 32% is non-existing. Only 22% of poor households have fewer than two people per bedroom, and 50% have more than three people per bedroom. Those poor living conditions become vulnerability factors for the

[48] International Ship and Port Facility Security

Bahamian population, especially for the 12.5% that lives in poverty conditions (Bahamas Department of Stadistics, 2004; The Government of The Bahamas, 2016).

Likewise, due to the geographical configuration of the islands and their low elevation above sea level, the capacity of human settlements to adapt to some phenomena resulting from climate change-related events, such as sea level rise or extreme swell, is limited. Furthermore, there is a lack of urban planning[49] that takes into account the impacts of climate change, such as the loss of coastlines, along with an absence or disregard of spatial planning strategies, as mentioned before. There is a need to invest in upgrades and new infrastructure and the establishment of safety standards for public and private infrastructure (The Government of The Bahamas, 2015). The Bahamas is currently in the process of updating its building code from 2003, and this revised building code is expected to improve the minimum standards, provisions, and requirements for safe and stable building design and construction methods. Nevertheless, the sectoral adaptive capacity to climate change-related threats is considered **LOW.**

3.7.6. Tourism

Tourism is the main core of The Bahamas economy, as the country is a very popular destination, especially for recreational fishing, boating, diving tourism and aquatic activities.

However, destinations that are frequently hit by hurricanes or severe weather events suffer from the perception in the market that they are unsafe.

The primary destination for tourists to The Bahamas is Nassau, where the international airport serves as a hub to most other islands and its' bridges connect to Paradise Island. In 2014, the country's Second National Communication reported that the number of visitors to Family Island destinations such as Abaco, Andros, Exuma and Harbour Island was increasing.

According to data from The Bahamas Ministry of Tourism in 2019, for the 75% of visitors to The Bahamas, the main purpose of the visit was vacation, with only 5% of tourists visiting on honeymoon, another 5% visiting on business and 3% visiting friend and relatives. More than half (57.8%) of the foreign air and sea arrivals in 2019 landed on Nassau/Paradise, 34.9% on the Out Islands and 7.2% on the Grand Bahama (Bahamas Ministry of Tourism, 2022).

The most attractive factors for visitors are the beaches and climate, and 86% of the 2019 visitors would likely return to The Bahamas within the next 5 years. In fact, from the total

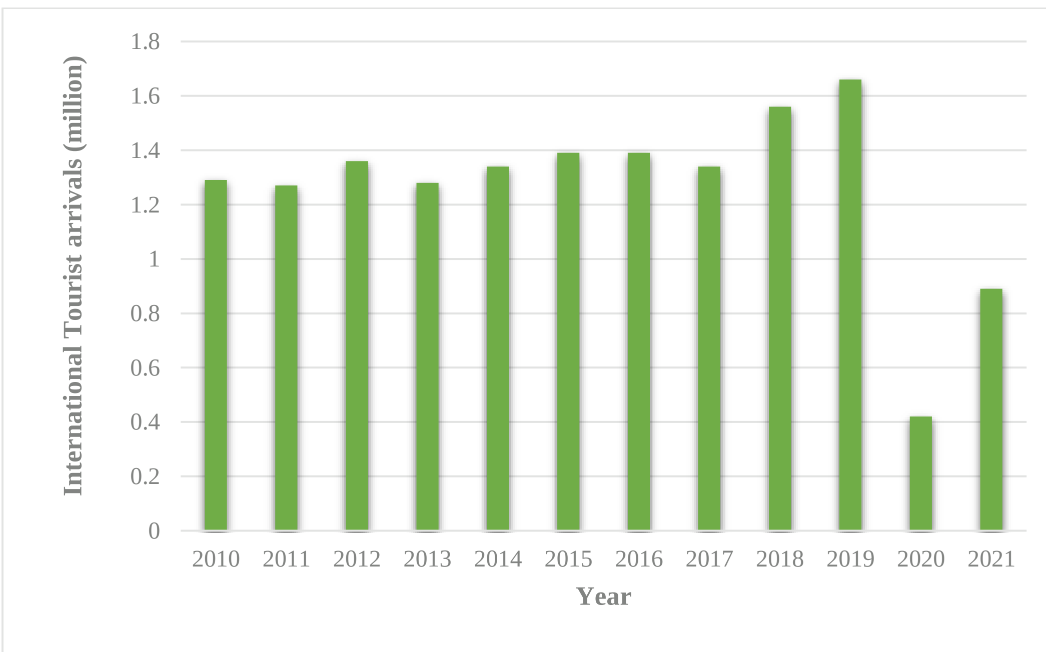
[49] IDB Assessments of the Effects and Impacts caused by the hurricanes:
Assessment of the Effects and Impacts of Hurricane Dorian in The Bahamas, IDB
Assessment of the Effects and Impacts caused by Hurricane Joaquin in The Bahamas, IDB
Assessment of the Effects and Impacts of Hurricane Matthew in The Bahamas, IDB
Assessment of the Effects and Impacts caused by Hurricane Irma in The Bahamas, IDB

2019 visitors 58% had already visited the country before. In addition, 94% of the visitors would recommend visiting the islands to friends or relatives. In that same year, approximately half of the visitors were people between the ages of 25- and 50-year-old, with only 22% of the visitors being 55 years old or older. For 94% of the visitors to the country, internet is the main source of information about the destination (Bahamas Ministry of Tourism, 2022).

However, in 2020, the COVID-19 pandemic impacted stopover arrivals from European countries that were experiencing lockdowns and flight restrictions causing a significant impact on the country's economy, which extended into 2021. Tourist arrivals to the islands started to grow during the second half of the year, with an average hotel occupancy rate of 50%, totalling nearly 2 million for the entire year, contributing to an expansion of 5.6% of GDP; however, this remained below the record inflow of the 7.2 million tourists in pre-pandemic year 2019 (Figure 56). During the first quarter of 2022, stopover visitor arrivals were well on the way to recovery (with the biggest stopover market being the United States 90%) and although the current account deficit remains high, it has narrowed to 19.3% of GDP (Bahamas Ministry of Tourism, 2022; World Bank, 2022).

Figure 56. International tourist arrivals in The Bahamas from 2010 to 2021.

Source: Own elaboration based on data from The Bahamas Ministry of Tourism.



Despite it's tremendous contribution the the country's economy, tourism and all of its asociated activities can contribute to a broad range of impacts on the environment and resources, like deforestation and destruction of landscapes and ecosystems as a consequence of the construction and installation of hotels, resorts, and other tourism facilities, which also impact marine ecosystems as well. For example, developments, such as golf courses, may pose threats to water quality and coral reefs due to leaching of fertilizers and chemical for lawns. Furthermore, due to the increase in tourism and tourist activity, there has been an increased demand for the goods and services also required for the Bahamian population such as electricity, potable water, and waste disposal.

As previously mentioned, the biggest climate change threat to The Bahamas include SLR due to global warming. As most of tourism assets, resorts, hotels and facilities are located in low lying coastal zones (especially in the narrower and smaller islands like Eleuthera, Long Island, Acklins and Exuma) if projected 1 meter sea level rise is reached by 2050, between 10-12% of the Bahamian territory will be submerged. Similarly, another important threat to the sector are extreme weather events such as hurricanes and tropical cyclones as their impacts can be davastating and lead to high socioeconomic losses (Stacey Catalina, 2021). The location of tourism infrastructure and facilities in coastal areas, together with the existing risk of extreme weather events, leads to a **HIGH exposure and sensitivity** of the sector, as the tourism sector is of great importance for the country.

Furthermore, climate change impacts and its economical consequences will not affect the whole country in the same way. The population that lives on the less populated and smaller islands, where the main economic activity is related with tourism (with its facilities and services located in coastal zones) are more vulnerable than the population living in bigger and more developed islands like Nassau or Grand Bahama, which present a more diversified and developed economic activity. Additionally, the Ministry of Tourism is increasingly promoting ecotourism on the islands as diversification is essential to the future growth and stability of the tourism industry. Dependence on the tourism sector makes The Bahamas vulnerable to changes in the global economy that affect the country overall. The designation of select islands as ecotourism destinations will enable many Bahamians to benefit from tourism revenues with minimal impact on the environment, and encourages lasting sustainable use of the resources available (The Government of The Bahamas, 2014).On the basis of the above, it is considered that the adaptive capacity of the tourism sector is **MEDIUM.**

3.7.7. Transport

The Bahamas transportation network mostly relies on 20 international airports, 23 port and harbour facilities and approximately 10,639.2 km of roads, that are mostly located on areas extremely vulnerable to seal level rise and flooding events. The transport sector has its own particular challenges based on the need to address road and marine transportation alternative in urban and rural settings (The Government of The Bahamas, 2015). In addition, the Out Islands have a less developed transport network, which increases their vulnerability and the need for investment and upgrading of the transport infrastructure. Overall, the **exposure** and **sensibility** of the transport sector in general are considered **HIGH.**

The electricity and transport sectors are the main usage sectors of fossil fuels in the country with the transport sector being characterized by the usage of larger, less fuel – efficient vehicles. Although significant gaps in data and information on energy usage, total number, and types of vehicles in The Bahamas still exist, electric vehicles sales have continued to increase annually in The Bahamas with a significant 133% increase between 2019-2020 (BUR, 2022). In addition, incentives for purchasing electric vehicles include lower import duty of 10% compared to vehicles powered by fossil fuels (The Bahamas Ministry of Finance, 2022).

The Government of The Bahamas has endeavored to invest in infrastructure development in recent years, including the rehabilitation of roads and the upgrading of port facilities and airports. However, the lack of infrastructure in the Family Islands is still an issue (Shik et al., 2018). There is a public transportation system (bus) only in a few islands of The Bahamas, mainly on New Providence and Grand Bahama. In addition, there is also the possibility to travel between the islands by ferries, which connect the islands of Abaco, Andros, Eleuthera, Exuma, Grand Bahama, Long Island, Harbour Island and New Providence (Bahamas Ferries Ldt., 2019). A better performing transport network that enables fast and smooth communication both within and between islands is important to ensure the country's resilience and resistance to climate change, especially in terms of evacuation and emergency travel capacity in the event of extreme weather events. In this respect, the Out Islands have a less developed transport network, which increases their vulnerability and the need for investment and upgrading of the transport sector. In view of the above, the adaptive capacity of the sector is considered to be **MEDIUM**.

3.7.8. Water Resources

In The Bahamas, freshwater resources are vulnerable as they are finite and limited to very fragile freshwater reservoirs in the shallow groundwater aquifers. These freshwater resources are solely precipitation dependent and occur on top of the shallow saline water, less than 5 feet from the ground surface. The availability of this resource is limited and considered scarce. The southern islands receive less precipitation and therefore have greatly reduced fresh groundwater supplies, which is also a limiting factor for economic and social development (Table 93,

Table 94).

Table 93. Renewable water resources per Bahamian island.

Source:(FAOAquastat, 2015).

Island	Renewable water resources (m^3/year)
Acklins	7.26
Berry Islands	0.28
Bimini	0.28
Exuma and Black Point	4.83
Cat Island	11.32
Abaco Island	131.70
Andros Island	349.51
Eleuthera Island	13.54
New Providence	16.03
Crooked Island	2.90
Grand Bahama	155.13
Long Island	4.80
Mayaguana	1.08
Moore’s Island	-
Ragged Island	0.02
Inagua	1.43
Run Cay	0.17
San Salvador	0.17

Table 94. Maximum water volume available daily per Bahamian island.

Source: (US Army Corps of Engineers, 2004).

Island	Maximum water volume available daily (million imperial gallons)
Acklins	4.36
Berry Islands	0.17
Bimini	0.17
Exuma and Black Point	2.9
Cat Island	6.8
Abaco Island	79.1
Andros Island	209.92
Eleuthera Island	8.13
New Providence	9.63
Crooked Island	1.74
Grand Bahama	93.17
Long Island	2.88
Mayaguana	0.65
Moore’s Island	-
Ragged Island	0.01
Inagua	0.86
Run Cay	0.1
San Salvador	0.1

Depending on the island and its particular circumstances, there are different models of access to water resources: ground water provided via the water authority on a large scale, private water wells, desalination (Reverse Osmosis - RO facilities), fresh ground water blended with brackish ground water, water trucking from one part of island to another, bottled water for drinking and cooking and ground water piped from one island to another by underwater lines. In general, water resources vary between islands and the supply-demand balance is highly dependent on population density. New Providence (the main population centre) has far less water available in freshwater lenses versus what is required for the population, and therefore relies heavily on Reverse Osmosis plants. Although there is not yet a net shortage of water on many islands, the population centres have a major deficiency (GCF, 2020). As mentioned above, New Providence island, for example, previously transported over 50% of its water supply from Andros (The Government of The Bahamas, 2014; US Army Corps of Engineers, 2004).

The primary source of drinking water is ground water treated in RO plants, which are increasing in usage, and its use is expected to continue to increase as fresh (ground) water availability continues to decline (US Army Corps of Engineers, 2004).

The Bahamas is extremely vulnerable to the negative effects and impacts of climate change and extreme weather events in terms of the availability and accessibility of water resources. As shown on

Table 94, the southern islands have less water available by daily volume, compared to the islands located further north. Drier regions, such as those in the southeast Bahamas will become drier. However, it must be noted that all the islands of The Bahamas are low-lying limestone platforms and any decreases in rainfall will result in less recharge of the groundwater (The Government of The Bahamas, 2014).

Under the development of the Green Climate Fund project "*Climate resilience of the water sector in The Bahamas*" ,the following islands have been identified as being particularly vulnerable and requiring built climate resilience in the water system and services: Abaco; Bimini; North Andros; South Andros; New Providence; Eleuthera; Long Island; Cat Island; Exuma; Ragged Island; and Acklins (GCF, 2020).

Other factors that favour the country's water resources vulnerability, in addition to those already mentioned above (inclusive of overexploitation of the water lens) are the development of canals and waterways for boat access, and seawater inundation in low - lying limestone islands and pollution of water resources. Of all the threats to water resources identified and outlined above, the most significant is sea level/water table rise, which generally occur in the flatter low-lying areas (The Government of The Bahamas, 2014). With the intensification of hurricanes and storms that cause storm surges, 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, 2009).

The primary urban centre of New Providence is one of the lowest areas within the archipelago, and as it becomes wetter, the main freshwater lenses are impacted, and important facilities will be affected. Generally, all the major freshwater lenses in the country are in the flatter low-lying areas, so they are all threatened by rising water tables.

In addition, sea level rise, pose an additional threat to The Bahamas groundwater resources as it increases the risk of seawater intrusions into the freshwater lens, directly affecting the quantity and quality of water available to the population.

Therefore, from this analysis, it can be assessed that the sector's **exposure and sensitivity** to climate change-related hazards are considered **HIGH.**

Ground water resources are important for the development of the economy in The Bahamas and both water and sewerage are two critical concerns to achieve a sustained economic growth. The Bahamas is presently investigating alternative technologies for the provision of drinking water to the nation, thru Ocean Thermal Energy Conversion (OTEC) to co-generate clean energy in addition to producing drinking water. A water-energy nexus for The Bahamas may effectively involve the use of the deep groundwater resources and pairing OTEC technologies with desalination for the provision of freshwater and the production of energy (Bowleg, 2022).

The limitation of water reserves in The Bahamas leads to inconsistences in the distribution of freshwater reserves and therefore, the development of populations and activities on the islands. Despite the emphasis on the water sector within national climate change and development policies, the management of water resources in the country is allocated between several governmental agencies and corporations, that are challenged to coordinate and properly regulate the sector (GCF, 2020). Furthermore, there is currently a lack of a coordinated water policy or plan that reflects the needs of other sectors and stakeholders, and the legal framework requires an update to reflect the climate variable and other challenges the sector faces. In this context, the sector adaptive capacity is **MEDIUM.**

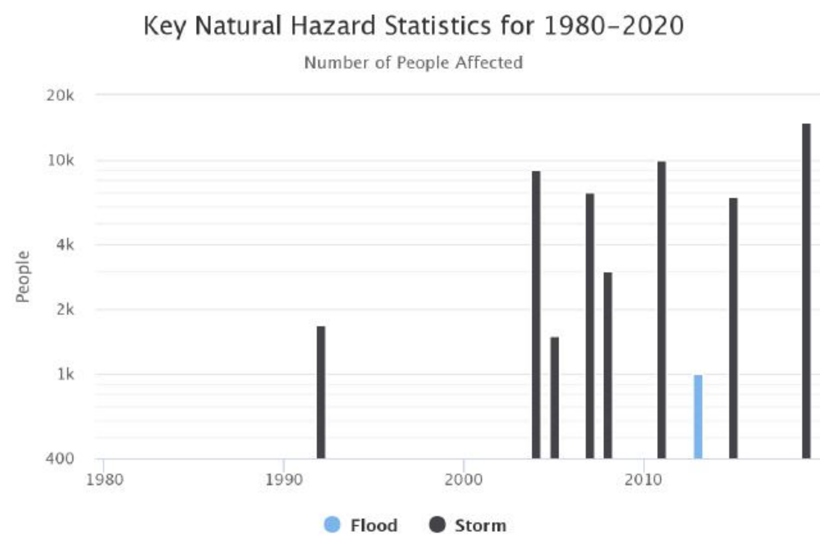
3.7.9. Disaster management

Storm surges can result in flooding, to which The Bahamas are extremely prone. Coastal flooding may also be a consequence of SLR, to which the dense tourism development along the coast is highly vulnerable. The dry nature of the soils in The Bahamas means that they are particularly sensitive to temperature increases and decreased rainfall. The risk of drought increases along a southeastern gradient since the more southern islands already experience only half of the rainfall that falls in the more northern islands (The World Bank Group, 2021). Figure 57 shows the number of people affected during flood and storm events respectively and across the country from 1980 to around 2020. The incidence of storms is much higher than the one associated with floods, and with increasing intensity and affecting a greater number of people.

The concentration of socioeconomic activities, critical infrastructure in narrow coastal zones, depend on tourism and limited human and institutional capacity are all factors that make The Bahamas vulnerable to climate change and therefore to meteorological disasters too (The Government of The Bahamas, 2015).

Figure 57. Key Natural Hazard Statistics for 1980-2020 overall Bahamas Country.

Source:(The World Bank Group, 2021)



The Atlantic Hurricane Season (June 1 to November 30) produces several hurricanes each year that often hit the country making the use of warning and alerts in The Bahamas a necessity. In general, the islands of Abaco and Grand Bahama are the most affected by hurricanes and given the high number of hurricanes that have hit Abaco, including Dorian that devastated the island along with Grand Bahama in 2019, Abaco is considered "Hurricane Capital of the Caribbean" (The Government of The Bahamas, 2014). According to the World Bank (The World Bank Group, 2022) storms occur at an annual frequency of 90% in The Bahamas on a country-wide scale.

In terms of vulnerability, the islands that are more densely populated and where most of the country's economic and productive activity takes place have a greater number of infrastructures such as hospitals, police stations, fire stations, etc. to cope with these natural disasters. These islands are mainly New Providence, Grand Bahama, and Abaco (Figure 58). However, in the majority of the islands most of the infrastructure and settlements are located along or near to the coast where they are particularly vulnerable to flooding and sea level rise which will also have serious economic and social implications for residents and for the tourism sector (Inter-American Development Bank, 2020).

Figure 58. View of the 3 most populated islands with the highest number of infrastructures (in order: New Providence, Grand Bahama, and Abaco).

Source: Google Earth.

The highly populated islands are more vulnerable to natural disasters or extreme phenomena due to its population density and because a large part of its most important infrastructures such as airports, harbours, hospitals, police stations and shelters are located in coastal areas or could be affected by flooding and a strong rise in sea level. On the other hand, other less populated islands with less infrastructure and a lower degree of development, such as Long Island, are equally vulnerable due to their narrow shape and the fact that a large part of their surface is coastal.

Table 95.Number of Approved Emergency Shelters per island.

Source: Cabinet and Disaster Management. Government of The Bahamas.

Island	Number of Shelters
Acklins	1
Berry Islands	1
Bimini	-
Exuma and Black Point	6
Cat Island	8
Abaco Island	15
Andros Island	20
Eleuthera Island	19
New Providence	24
Crooked Island	6
Grand Bahama	9
Long Island	9
Mayaguna	2
Moore's Island	-
Ragged Island	1
Inagua	2
Rum Cay	1
San Salvador	2

In addition, the major number of shelters are located in the main islands like Grand Bahama, contrary to most of the Out Islands, where the number of shelters per island is considerably lower, increasing the vulnerability of these territories to extreme weather hazards such as hurricanes - the most frequent and dangerous for islands (

Table 95).

Recent data (Inter-American Development Bank, 2020) shows that the frequency and intensity of hurricanes seems to be increasing, so there is an urgent need to develop and implement effective alert systems to warn people, tourists, and residents about the next expected extreme phenome, in order to reduce losses (human but also economical). This is especially urgent in Northern islands and in those that have the most vulnerable population (or population with higher poverty rate). In addition, it is essential to incorporate climate change predictions and considerations into existing and future national disaster planning, to better understand and assess country´s vulnerability.

Considering the analysis carried out and the data presented on this sector, it can be concluded that its exposure, i.e., the presence of people, services, etc. in places and settings that could be adversely affected, is **HIGH**. It is also evident that the sector's sensitivity to climate change, is **HIGH**.

In terms of adaptive capacity, certain solutions to help deal with climate change impacts in the country have been implemented such as parametric insurance or reinforcement of key infrastructure. However, a few policies and national strategies are somewhat outdated and there is currently a lack of urban planning and spatial planning strategies in the country that take into account the impacts of climate change. In this context, the adaptive capacity of the sector is perceived as **MEDIUM.**

3.8 Impacts of climate change

This section provides a description of the major factors that lead to climate- related impacts and risks in each of the sectors under analysis. To allow a better understanding on the risk that climate change poses to each sector, visual diagrams (impact chains) were prepared. The development of these impact chains was based on the identification of the main climate change-related hazards for each sector (highlighted in blue), their associated intermediate (highlighted in yellow) and final (highlighted in green) impacts. The terminology and concepts of impact chains refer to the 2014 climate risk concept of the IPCC.

3.8.1. Agriculture

There are many climate change related hazards that can drastically affect the agricultural sector and its future development in the Bahamas, such as SLR, flooding, hurricanes, droughts, high temperatures and longer periods of heat waves. Figure 59 graphically depicts the impacts and risks associated with the above hazards.

SLR can lead to an increased risk of water quality deterioration and soil salinization. When storm surges occur, they can cause intense waves that have a high erosive power on the coast, both by increasing the frequency and intensity of the waves (extreme swell). The northern islands of the Bahamas, which have more surface water resources, will be more resilient to the threat of salinization of aquifers due to seawater intrusion by SLR than islands that are narrower, or those that draw their water resources from groundwater resources, which would be particularly vulnerable to this threat. In addition, deteriorating water quality could also cause a loss of agricultural capacity and consequently increase production costs.

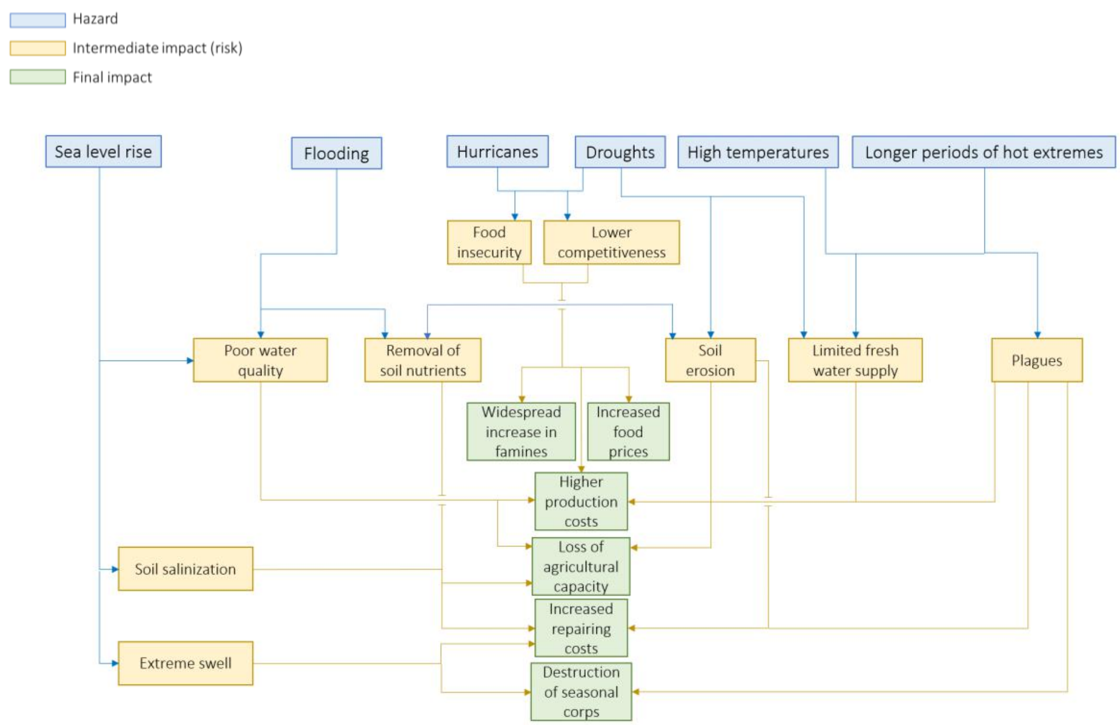
Extreme storm surges could cause destruction of seasonal bodies of water and increase repair costs. Similarly, soil salinization could also lead to crop failure (including tree crops), increased repair costs and loss of agricultural capacity. These risks will also be more detrimental on narrower islands or those with fewer coastal defense systems against such events. Deterioration of water quality also means that the availability of drinking water for livestock consumption will decrease.

Floods can also lead to a deterioration of water quality and its associated impacts and can increase the risk of nutrient removal from the soil, which could eventually also cause a loss of agricultural land and increased repair costs and thus also contribute to the loss of agricultural capacity of the land. Livestock are also adversely affected by these climatic phenomena, as they can also suffer physical damage during periods of flooding, or even die from drowning or starvation due to lack of available feed if they have also been affected by flooding. In case of deterioration of water quality an increase of water-borne diseases may occur also for livestock, which may lead to a loss of livestock production due to diseases that may occur in livestock.

The projected rise in temperatures and increased drought events may also limit the availability of freshwater, increasing both the demand for irrigation water and the costs of irrigation production. In addition, higher temperatures together with changes in precipitation and evapotranspiration patterns, increased CO2 and longer periods of extreme temperatures may increase the risk of pest spread and invasion of certain alien species as more favorable conditions for their subsistence occur, thus expanding their range. This could eventually lead to increased production and repair costs and the destruction of seasonal crops and tree crops, as well as a loss of biodiversity and native species.

As previously mentioned, these climatic variations (high temperatures, reduced water availability, seasonality of rainfall) may lead to reduced production of some crops, reducing the competitiveness of the sector, higher food prices, increased production costs and increased food insecurity.

Figure 59. Impact chain for the Agriculture sector.



3.8.2. Natural Resources

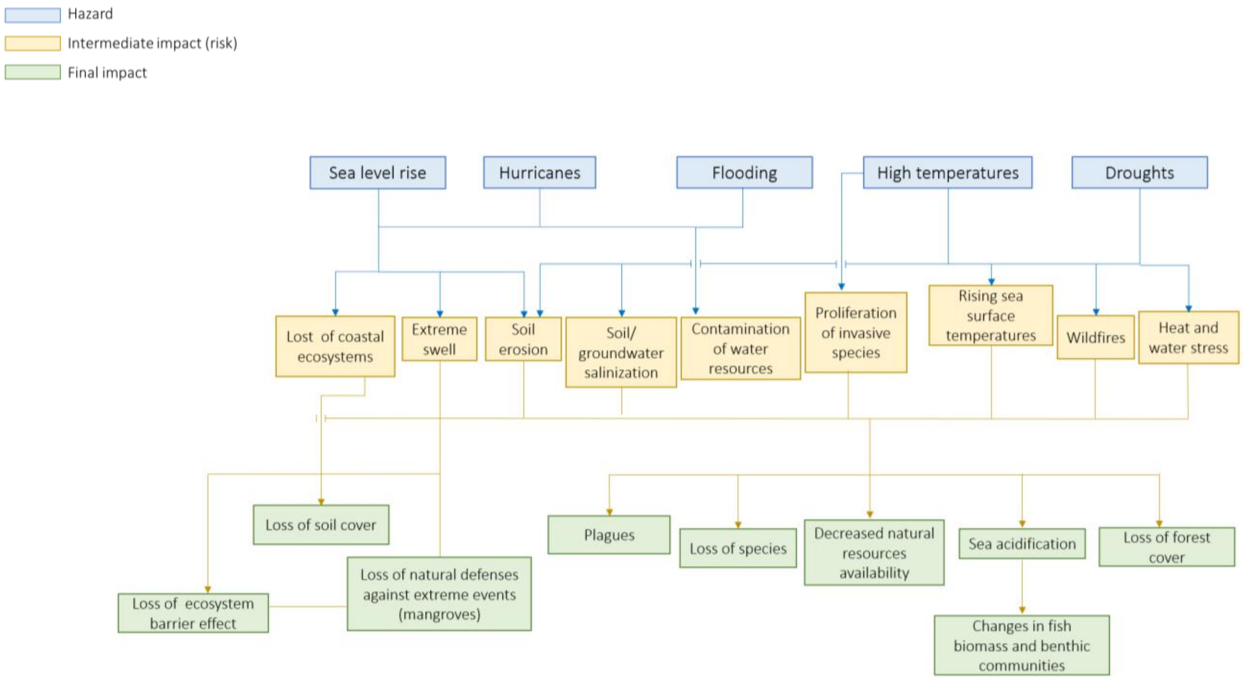
The main climate change hazards that could affect the natural resources of The Bahamas are SLR, flooding, hurricanes or extreme weather events, droughts and rising temperatures. Figure 60 graphically depicts the impacts and risks associated with the above hazards. Of all the identified threats that may affect the biodiversity and natural resources of The Bahamas, climate change is considered to have the greatest effect, as 80% of The Bahamas' land mass is within 1.5 metres (5 feet) of sea level and 90% of The Bahamas' freshwater lenses are within 1.5 metres (5 feet) of the land surface, meaning that groundwater resources are fragile and highly vulnerable to contamination. Climate change will also magnify all other identified natural hazards, such as coral bleaching, loss of forest cover and protected areas, loss of biodiversity and an increase in invasive alien species.

Additionally, tropical hurricanes coupled with a lack of appreciation and understanding of the value and fragility of the Bahamian environment and biodiversity to the population is also a major threat (Ministry of Environment, 2011). Extreme weather events such as hurricanes pose a risk to natural resources due to their destructive nature, which can impact, in the form of strong winds and rain, on the country's natural resources (especially in the case of tree vegetation, among others), causing costly physical damage.

Considering the number and variability of coastal ecosystems present throughout the country, SLR and flooding can increase the risk of extreme swell and coastal erosion and, due to that, the loss of soil cover and coastal ecosystems too. This also means the loss of natural coastal defences against extreme events, like mangroves ecosystems does, that is a loss of ecosystem barrier effect. Also, these hazards (and hurricanes too) may increase soil/groundwater salinization and contamination of water resources which may become a negative impact on the health of various natural ecosystems. Sea level rise can exacerbate the risk of reef sedimentation, shoreline retreat and consequent loss of beaches, increased vulnerability to future storms.

Similarly, high temperatures and droughts could also increase the risks of soil erosion and desertification, loss of natural protection, loss of the nursery function of the forest, and heat and water stress. Moreover, rising temperatures means that also the temperature of the seas become higher which, together with the rise of CO2 emissions, leads to sea acidification and, due to that, to changes in sea biomass and benthic communities. In addition, rising temperatures may increase the risk of hurricanes and the proliferation of invasive species and even the proliferation of plagues. Droughts and high temperatures may eventually lead to wildfires. All hazards and risks affecting the sector can lead to the following common final impacts: pests, loss of species, decreased availability of natural resources, reduced economic benefits, loss of forest cover, loss of biodiversity, loss of ecosystem services, and impacts on coastal ecosystems that also function as a barrier to climate change impacts.

Figure 60. Impact chain for the natural resources sector.

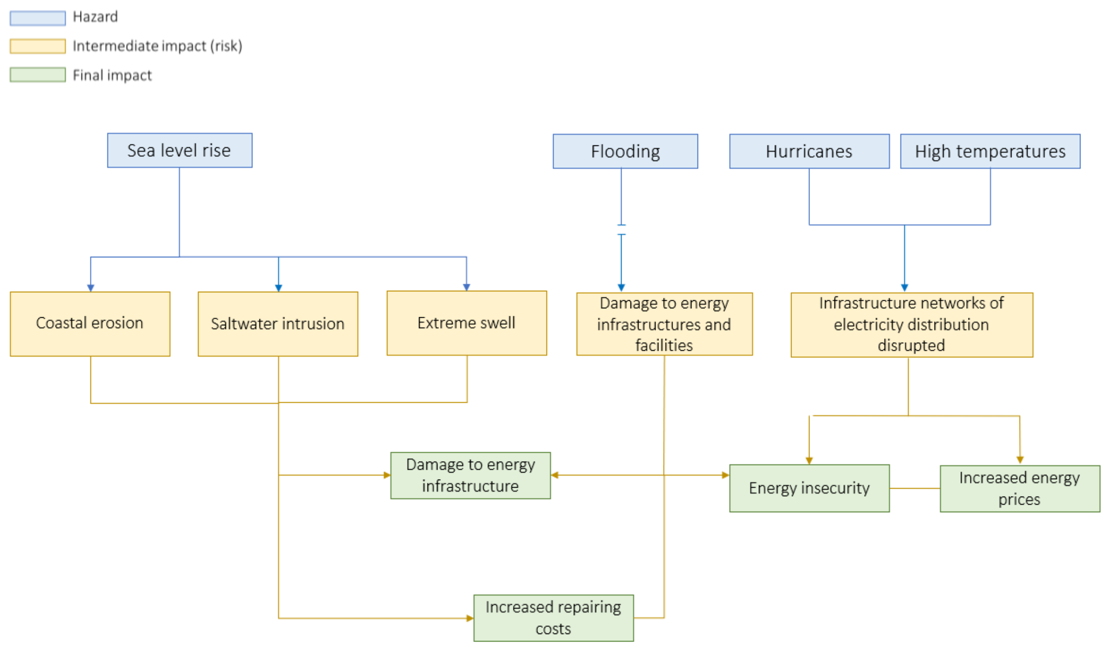


3.8.3. Energy

The main climate change hazards that could affect the energy sector of The Bahamas are SLR, flooding, hurricanes and high temperatures. Figure 61 graphically represents the impacts and risks associated with the above-mentioned hazards. SLR could increase the risk of coastal erosion, saltwater intrusion and extreme swell causing potential damages to the energy infrastructure located on those areas in the islands, thereby increasing repair costs. Flooding associated with an increase in extreme weather events, increases the risk of damage of energy facilities and transmission assets located in flood prone areas throughout the islands that would lead to similar impacts and a potential disruption of the infrastructure networks of electricity distribution. The same applies when extreme events such as hurricanes occur, which increase the risk of damaging the country's power generation and distribution infrastructure and causing power outages, which finally leads to energy insecurity and increased energy prices.

Increases in temperatures could lead to decreases in energy production efficiency (as they can cause damages to transmission and distribution systems due to overheating) and also an increased need for food refrigeration as higher environmental temperatures accelerate food degradation (Potter & Joseph H. Hotchkiss, 1995). These impacts could be aggravated by a peak demand on the energy grid for air conditioning, which could rise the electric tariffs (Greig et al., 2020).

Figure 61. Impact chain for the Energy sector.



3.8.4. Human Health

The Bahamian Human Health sector is particularly vulnerable to climate change hazards such as SLR, drought, flooding, hurricanes and high temperatures. Figure 62 graphically represents the impacts and risks associated with the above-mentioned hazards. By 2050 scientific predictions warns of a 2.0 ºC rise in temperature for all highly populated islands of The Bahamas, which leads to human health population will be compromised. Rising temperatures and prolonged periods of excessive heat can pose a particular threat to human health, as they increase the incidence of heat related illness like heat shocks, heat stroke, heat rash, heat cramps and heat exhaustion (WHO, 2021) and can also cause and increase in respiratory and cardiovascular diseases. There are some groups of people that are particularly vulnerable, mainly: elderly people, children and individuals with pre-existing health conditions or illnesses (PAHO, 2021).

Moreover, some of the world most virulent infections are also highly sensitive to climate. This means a contribution of an increase in vector-borne diseases (e.g., dengue, malaria, chikungunya, and zika). Water-borne and communicable diseases and, also an increase of the costs associated with treating these diseases.

Heat waves and high temperatures can also have serious impacts and pose a risk to food and nutrition security both directly, through its effects on agriculture and fisheries, and indirectly, by contributing to underlying risk factors (World Health Organization, 2021). Rising temperatures also affect the water retention capacity of soils and the suitability of the cropland environment (ecological conditions and requirements of crops) and, therefore, their productivity and potential to be cultivated. This leads to situations of food insecurity due to reduced crop yields, which causes difficulties in access to food, its nutritional quality and price stability.

Droughts can lead to a decline in water quality and availability, as the available water resources are affected by this alteration in rainfall patterns. In addition, reduced precipitation and increased evaporation of surface water directly affect the replenishment rate of groundwater supplies and can increase the concentration of pollutants as well as viruses and bacteria in water.

These impacts lead to a decline in water quality and availability for the entire population (U.S Department of Health & Human Resources, 2020b) which also affects soil quality and productive capacity.

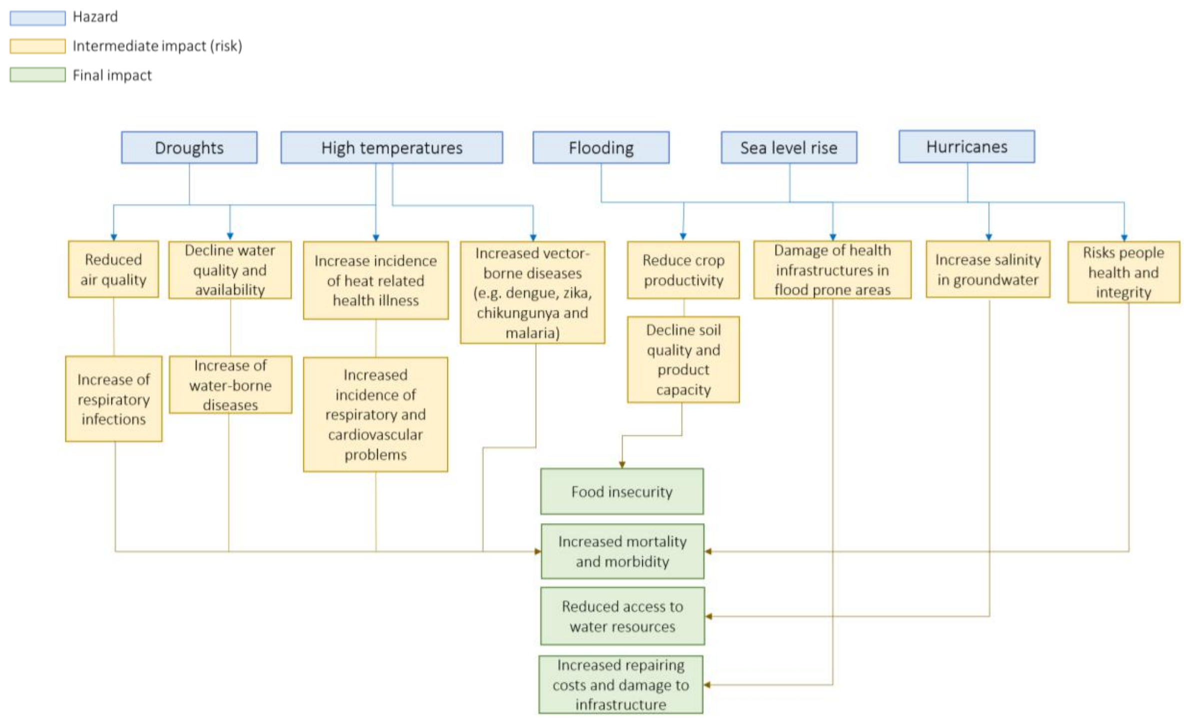
Furthermore, dry conditions and wildfires that usually accompany droughts can harm people’s health, by increasing concentration of air particulates that can, among others, worsen chronic respiratory diseases like asthma and increase the risk of acute respiratory infections.

Floodings associated with hurricanes also pose a particular risk to people's health and physical integrity during these phenomena, since when they occur, they are accompanied by other secondary effects such as strong winds and waves that may increase the risk of accidents and disasters. The impact of floodings on water quality is also of great importance as water resources can be contaminated amplifying the public health threat of waterborne diseases and leading to a reduced safe drinking water availability. The presence of human health infrastructures or facilities in flood prone areas could increase their vulnerability against floodings.

As sea-level rise, saltwater intrusion into freshwater resources increases salinity of groundwater basins and well water causing a decline in surface and ground-water quality due to salinization and contamination of aquifers and available water resources. This can lead to reduced access to these resources, availability of safe drinking water, and also crop yields posing a risk to food security.

Hurricanes are a natural catastrophe that are often associated with high winds, heavy rainfall, rip currents and storm waves and surges, that can cause severe adverse effects on human health by posing a huge risk to the safety and physical and psychological integrity as result from direct exposure to these hazards (GCF, 2020).

Figure 62. Impact chain for the Human Health sector.



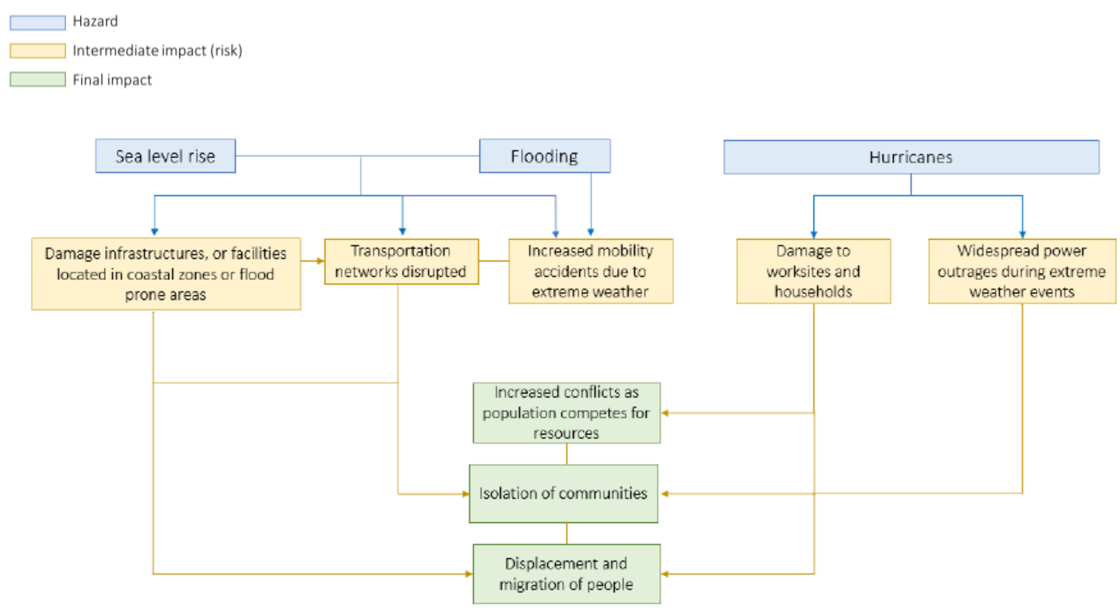
3.8.5. Human settlements and infrastructure

Regarding future climate change scenarios, there will be a negative impact on human settlements and infrastructures, particularly in those situated in low-lying coastal areas, as will be the case on the most coastal roads and transport routes. The main climate change hazards that could affect the human settlements sector of The Bahamas are SLR, flooding, and extreme weather events (hurricanes).

Figure 63 graphically represents the impacts and risks associated with the above-mentioned hazards. SLR and flooding can increase the risk of loss or damage infrastructures, or facilities located in coastal zones or flood prone areas. Flooding events can increase the mobility accidents due to extreme weather. and the isolation of communities, as well as an increase in health stress.

Extreme weather events such as hurricanes could increase the risk of disruption of transportation networks, widespread power outages, and the displacement and migration of people. These natural catastrophes are often associated with high winds, heavy rainfall, rip currents and storm waves and surges, that can cause severe adverse effects on human settlement and infrastructures, as well as causing serious losses in housing, livelihoods, worksites and cultural sites and schools. All of these potential losses can result in increased conflict among the population as they compete for the same resources in post-disaster situations.The ferocity and strength of extreme climate phenomena, such as Hurricane Dorian was, poses a serious threat to the country and its economic resilience, as such devastating events pose severe economic damage and losses (which often also have a negative impact on the tourism sector) that weaken the economy and financial sector, as well as the country's resilience.

Figure 63. Impact chain for the Human Settlements sector.



3.8.6. Tourism

Due to its interaction and correlation with other sectors, the Tourism sector in The Bahamas is very complex with a wide variety of risk components interacting among each other.

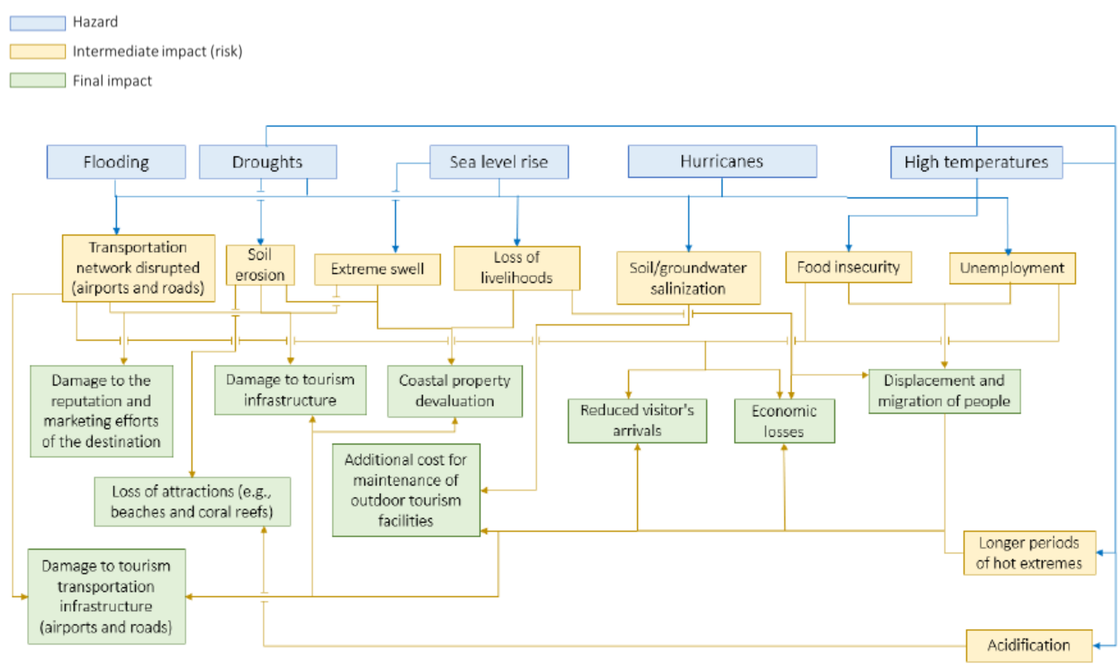
Figure 64 graphically represents the impacts and risks associated with the above-mentioned hazards. The main climate change hazards that could affect the tourism sector of The Bahamas are SLR, flooding, extreme weather events /hurricanes droughts and high temperature. The previous mentioned hazards all pose a threat to the tourism sector, as they can lead to loss of livelihoods and coastal property devaluation, soil/groundwater salinization – which can result in additional costs for maintenance of outdoors tourism facilities and activities, in addition to food insecurity and unemployment that can lead to the displacement and migration of people, economic losses and reduced visitor's arrival.

Hurricane events can lead to a displacement and migration of people, reducing the availability of tourism-related services, and hence, the number of visitors to the country.

In addition, hurricanes can also cause significant damage to tourism-related transportation infrastructure such as airports and roads that can lead to a reduction of visitor's arrivals. Higher temperatures also contribute to ocean acidification because the rate at which water absorbs carbon dioxide (CO_2) decreases as water temperature rises. This poses a significant threat to coral reefs, which are an important touristic attraction.

In addition, a rise in temperature and an increase of drought events, could increase the length of hot extremes periods implying an additional maintenance cost for outdoor tourism facilities. Droughts can also increase the risk of soil erosion that similarly to extreme swell events associated with a rise in sea level can cause damages to tourism-related infrastructure, a devaluation of coastal properties and a loss of touristic attractions such as beaches.

Figure 64. Impact chain for the Tourism sector.



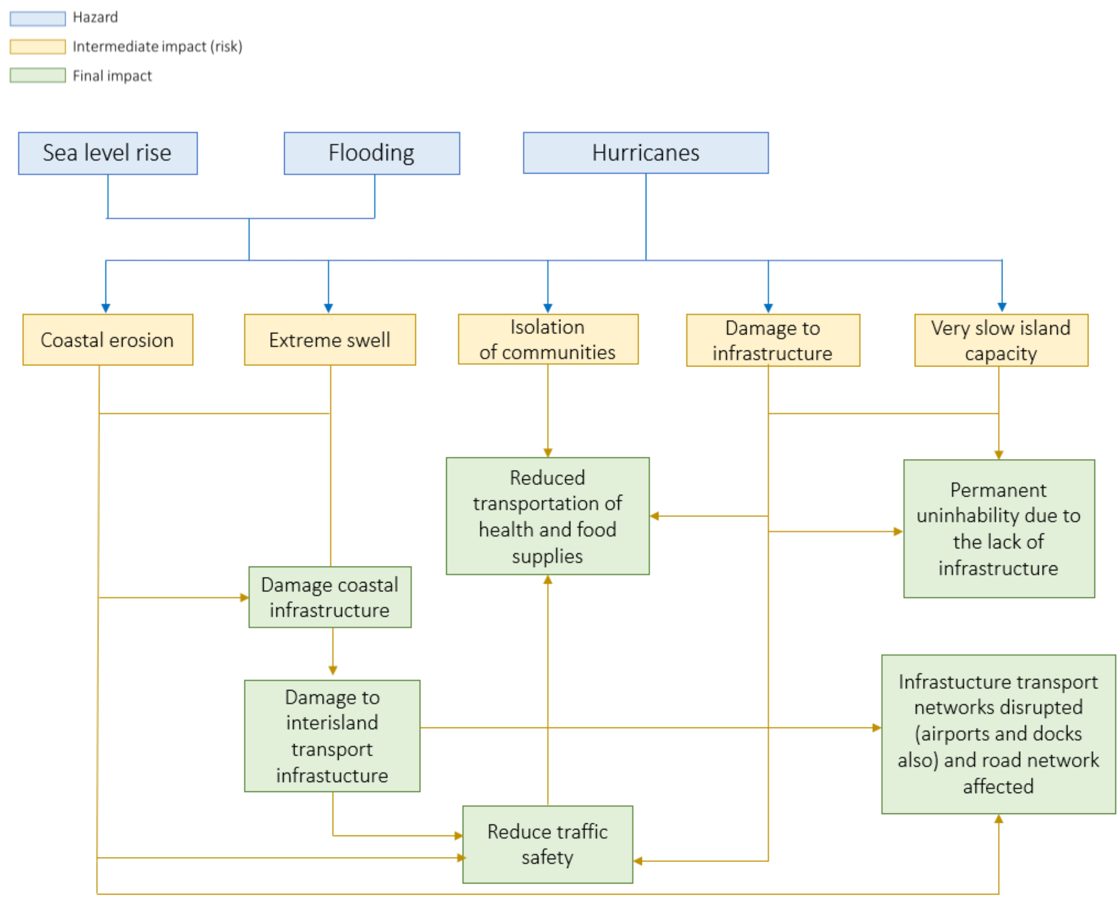
3.8.7. Transport

The main climate change hazards that could affect the transport sector of The Bahamas are mainly SLR, floodings and hurricanes. Figure 65 graphically represents the impacts and risks associated with the following mentioned hazards.

Both SLR and flooding could increase the risk of coastal erosion which, together with extreme swell can lead to serious problems, such as damaging coastal infrastructures. It poses a serious threat to all transport infrastructures located in coastal areas, mainly ports and roads running close to the coastline, which at the same time may mean an increased risk of damage to the inter-island transport infrastructure.

Regarding extreme weather events like hurricanes, they pose a very serious hazards as they damage mostly all types of infrastructures and facilities, even the transport ones, which also lead to a very slow island capacity and also the isolation of communities. Due to the threats described above, there is an increased risk of a permanent incapacity due to the lack of infrastructure and that infrastructure transport networks be disrupted (airports and docks also) and road network affected, which also could lead to a reduction in traffic safety and in the transportation of health and food supplies.

Figure 65. Impact chain for the Transport sector.



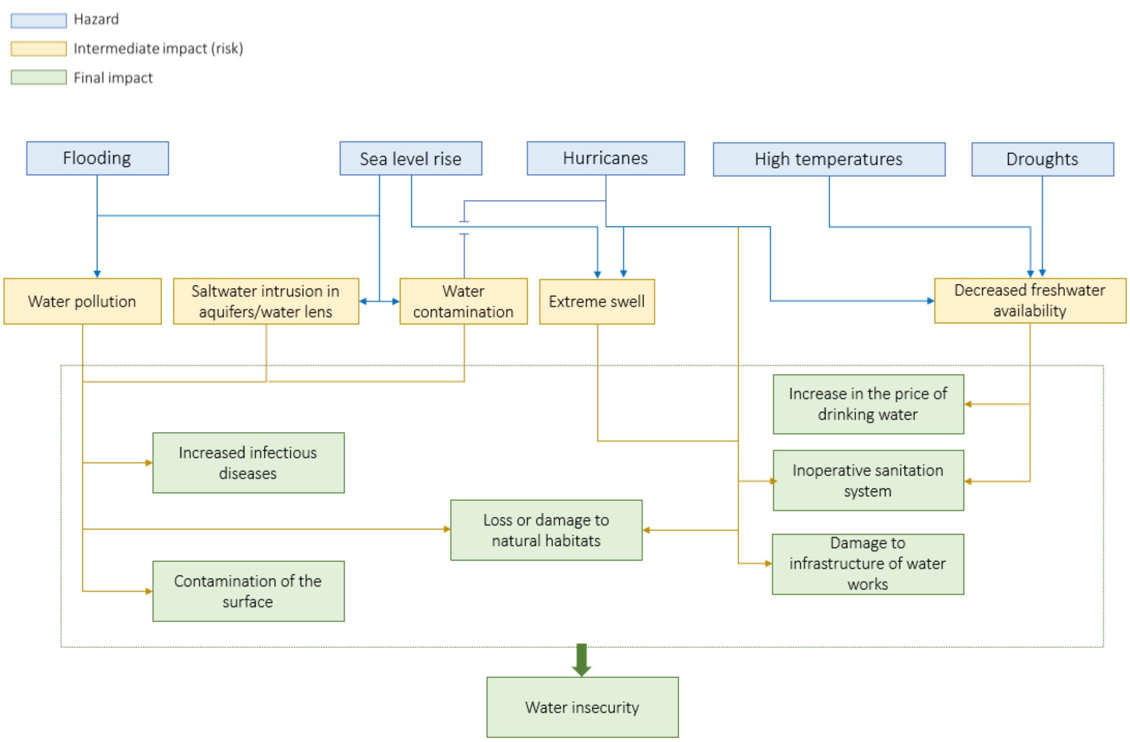
3.8.8. Water Resources

Flooding, SLR, hurricanes, high temperatures and drought are the main climate hazards that can affect the water resources sector of The Bahamas. Figure 66 graphically represents the impacts and risks associated with the following mentioned hazards. In The Bahamas, freshwater resources are vulnerable as they are finite and limited to very fragile freshwater reservoirs in the shallow aquifers. This freshwater resources mainly come from precipitation, so they lie on top of the shallow saline water, less than 5 feet from the ground surface. The availability of this resource is limited and considered scarce. The southern islands have greatly reduced freshwater supplies, being that a limiting factor for economic and social development (The Government of The Bahamas, 2014).

As shown in Figure 66, SLR impacts are similar to flooding impacts and include an increased risk of saltwater intrusion in aquifers and water lens which lead towater pollution and contamination, contributing to an increase in the propagation of infectious diseases, contamination of the surface and loss or damage to natural habitats. Extreme weather events like hurricanes also increase the risk of water contamination and also extreme swell events, which can also increase the risk of loss of habitat and biodiversity and damage to ecosystem services linked to the water cycle, and also damage to infrastructure of water works.

High temperatures and drought can affect freshwater availability that could lead to the malfunctioning of the sanitation system and an increase in the drinking water prices. All impacts mentioned for this sector could eventually translate into water availability shortages and/or losses for the country.

Figure 66. Impact chain for the Water Resources sector.

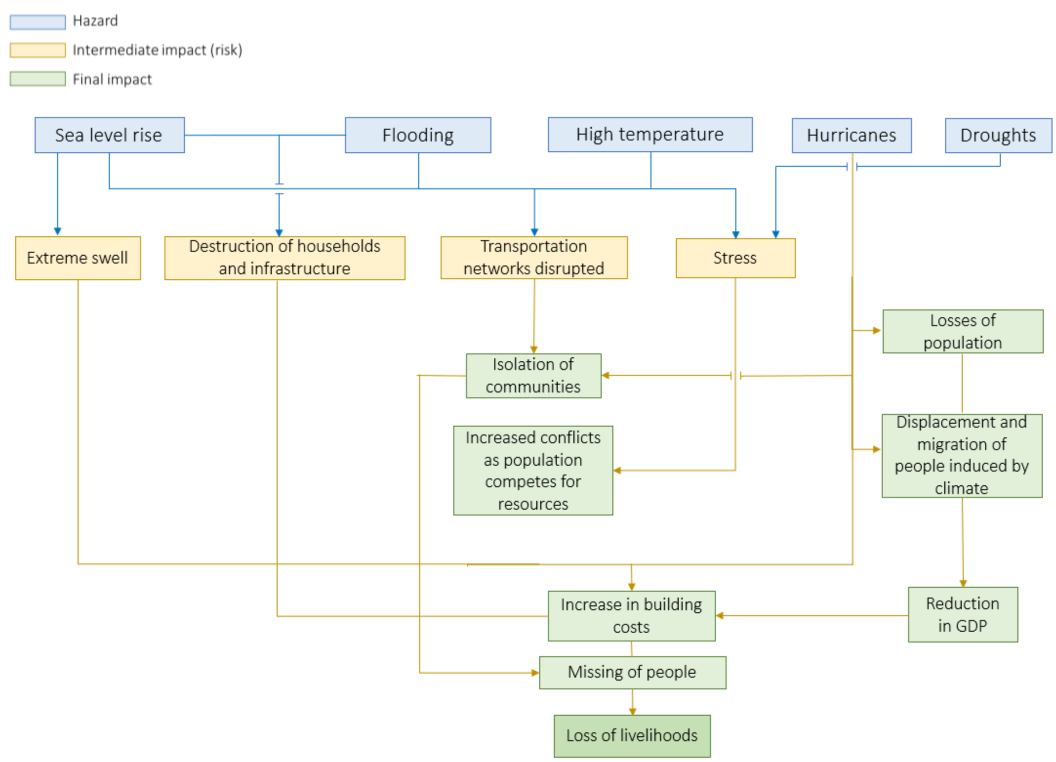


3.8.9. Disaster Management

The main climate change hazards that could affect the disaster management sector of The Bahamas are SLR, flooding, hurricanes, high temperatures and droughts. Figure 67 graphically represents the impacts and risks associated with the following mentioned hazards. Climate Change increases the risks of extreme weather events like hurricanes, which could cause isolation of communities, losses of population and the displacement and migration of people.

SLR can increase extreme swell events, which, together with hurricanes, could eventually cause the missing of people and destruction of households and infrastructure, increasing building costs. In addition, SLR and flooding could increase the risks of an increased competition for resources in the population. The occurrence of droughts could increase the stress risks in the population, which could also increase the population conflicts. Finally, high temperatures, hurricanes, flooding and SLR could also increase the risk of disruption of transportation networks, causing the isolation of communities, and stress among the population, which could eventually also lead to an increased competition for resources. The effects of these climate change hazards can result in a loss of livelihoods and also substantial income and productivity losses over time, that can lead to a reduction in GDP.

Figure 67. Impact chain for the Disaster Management sector.



3.9 Adaptation recommendations

3.9.1. Sectoral adaptation options

Recognizing the hazards posed by the adverse effects of climate change on The Bahamas, requires the development of appropriate adaptation strategies to reduce the country's vulnerability.

As mentioned above, The Bahamas is a small country which is highly vulnerable to the risks of climate change and faces a range of acute to long-term risks, including extreme weather events like droughts, cyclones, floods, hurricanes, rising sea levels, and rising temperatures, that represent significant threats and can lead to human forced displacement from SLR, saltwater intrusion of groundwater aquifers; loss of livelihoods; spread of vector-borne diseases, and death and injury from extreme weather events among other issues (WHO; UNFCC; PAHO, 2021).

Adaptation to climate change therefore requires flexible and comprehensive planning, taking into account all the actors involved and the broad time horizons, as well as the uncertainty associated with its impacts.

To improve the resilience of the key sectors described above to climate change impacts, a set of recommendations for adaptation actions were identified. The proposed measures and actions aim at building the capacity of social, economic and environmental systems to cope with and adapt to the possible impacts of climate change so that they are able to maintain or recover their functions and characteristics, and even for the most positive scenarios, to take advantage of their benefits. These measures are classified in the following ten (10) different categories:

- **Capacity building**: developing human resources, institutions, and communities, equipping them with the capability to adapt to climate change (e.g., training/ workshops for knowledge/skills development, public outreach and education, dissemination of info to decision makers/stakeholders. Identification of best practices, training materials).
- **Management and planning:** incorporating understanding of climate science, impacts, vulnerability and risk into government and institutional planning and management (e.g., developing an adaptation plan, drought planning, changing natural resource management).
- **Practice and behaviour:** Revisions or expansion of practices and on the ground behaviour that are directly related to building resilience (e.g., soil/land management practices, post-harvest storage, expanding integrated pest management).
- **Policy**: The creation of new policies or revisions of policies or regulations to allow flexibility to adapt to changing climate (e.g., mainstreaming adaptation into

development policies, improvement of water resource governance, revised design parameters).

- **Information**: Systems for communicating climate information to help build resilience towards climate impacts, other than communication for early warning systems (e.g., decision support tools, communication tools, data acquisition efforts, digital databases, remote communication technologies).
- **Physical infrastructure:** Any new or improved hard physical infrastructure aimed at providing direct or indirect protection from climate hazards (e.g., climate-resilient buildings, reservoirs for water storage, irrigation systems, canal infrastructure, sea walls).
- **Warning or observing system**: Implementation of new or enhanced tools and technologies for communicating weather and climate risks, and for monitoring changes in the climate system (e.g., developing, testing and deploying monitoring systems, upgrade weather services).
- **"Green infrastructure":** Any new or improved soft, natural infrastructure aimed at providing direct or indirect protection from climate hazards (e.g., revegetation, afforestation, woodland management, increased landscape cover).
- **Financing:** New financing or insurance strategies to prepare for future climate disturbances (e.g., insurance schemes, microfinance, contingency funds for disasters).
- **Technology:** Develop or expand climate-resilient technologies (e.g., technologies to improve water use or water access, solar energy capacity, biogas, water purification, solar salt production).

The overall list of recommended adaptation measures is summarized on Table 96 (further details are provided on sections 3.9.1.1-3.9.1.10). This table illustrates the category/type within which the proposed measure or action can be classified considering the classification explained above, the sectors targeted by the action, and the expected timeframe/horizon (short, medium, or long-term):

- **Short term (ST)**: refers to actions/measures that should be undertaken within 5 to 10 years.
- **Medium term (MT)**: refers to actions/measures that should be undertaken within 10 to 15 years.
- **Long term (LT)**: refers to actions/measures that should be undertaken from 15 years and over.

Table 96. Recommended adaptation measures.

Type	Recommendation	Sector(s)	Horizon		
			ST	MT	LT
Capacity building	Improve intersectoral linkages between sectors to avoid efforts duplication and take advantage of common challenges and opportunities.	Cross -Sector			
	Implement knowledge and techniques that promote energy efficiency and use criteria in buildings (including housing).	Energy			
	National Education Strategy or Communication Plan to increase public education and awareness of the importance of coral reefs and mangrove forests for sustainable development, forestry development and conservation and the role of each of these habitats in protection of the coastline from storm surges.	Natural Resources			
	Assessment of renewable energy potential across all occupied islands.	Energy			
	Strengthening of plans or programmes that inform the population about the importance of improving their eating habits and the consumption of healthy food.	Human Health			
	Conduct a national study on sectoral vulnerability.	Cross-Sector			
	Conduct a study on economics of climate change in The Bahamas.	Cross-Sector			
	Raise population awareness on water conservation.	Water Resources			
	Encourage participation or carry out actions with local stakeholders and tourists where they participate in ecosystem management and biodiversity enhancement activities.	Tourism Natural Resources			
	Development and improvement of sustainable ecotourism activities, including carrying capacity studies and training in responsible resource use for businesses in the tourism sector.	Tourism Natural Resources			
	Promote public awareness of the possible effects of climate change and disseminate good adaptation practices.	Cross -Sector			
	Improve livelihoods from forest management and conservation.	Natural Resources			
	Educating the construction sector on impacts they can have on natural systems and providing them with guidance on alternative methods for land clearing.	Natural Resources			
	Increase in human capacity for all environmental management agencies with representation on all islands	Natural Resources			
	Building capacity (permanent staff and other resources) within public agencies responsible for ecosystem (carbon sink area) management for the medium- to long-term.	Natural Resources			
	Institute training of all healthcare and education providers in climate change and health risk assessment.	Human Health			

Type	Recommendation	Sector(s)	Horizon		
			ST	MT	LT
	Establishment of climate-smart community shelter management protocols and procedures to ensure consistent attention of the residents, as well as the establishment of specific care guidelines for certain populations and minorities.	Disaster Management			
	Develop energy adaptation and rehabilitation plans for buildings providing essential public services or in population settlements particularly vulnerable to the impacts of climate change.	Energy			
	Promote water management and conservation practices to ensure universal access to water for different uses	Water Resources Human Health Agriculture			
	Improve and upgrade public transport systems in the most populated islands with a focus on renewables.	Transportation			
	Promote the conservation of native species or species of special interest that are in danger of extinction or are more vulnerable to the adverse effects of climate change.	Natural Resources			
	Achieve quality water and sanitation services in major urban and rural areas, considering present and future climatic conditions.	Human Health			
	Develop contingency planning for essential systems to ensure that they will not be cut off during extreme weather events.	Disaster Management Human Settlements and Infrastructure			
	Assessment of touristic areas at risk due to SLR, hurricanes or flooding across islands.	Tourism			
	Revise planning of energy facilities and infrastructure located in high-risk areas considering future climate projections and scenarios.	Energy			
	Strengthen ecosystem resilience while providing livelihoods options.	Natural Resources			
	Improve food and nutritional security through the adoption of a climate resilient agricultural development strategy.	Agriculture			
	Develop a strategic linkage with agricultural and health sectors to ensure sectoral goals are realistic and achievable	Agriculture Human Health			
	Establish a link between agriculture and forestry to have farmers or nurseries grow, acclimate, or multiply plants need for forest restoration or enhancement efforts.	Agriculture Natural Resources			
	Develop sustainable land use plans for each island, factoring in recommendations of the draft National Development Plan	Natural Resources			
	Mainstream climate change across health and health-related sectors.	Human Health			
	Improve protection for pine forest habitat from illegal clearing.	Water Resources Natural Resources			

Type	Recommendation	Sector(s)	Horizon		
			ST	MT	LT
	Develop an emergency healthcare management protocol for tracking evacuees and determining health and psycho-social outcomes for the evacuees.	Disaster Management			
	Establish a framework for handling climate-influenced or caused migration or human mobility	Disaster Management			
	Enhance land use planning policies and regulations.	Cross-Sector			
Practice and behaviour	Promote soil restoration and conservation activities.	Agriculture			
	Promote the crop of salt tolerant vegetation, including vegetables and fruits (such as coconut trees, fig trees, key lime trees, beets, tomatoes, etc.)	Agriculture			
	Enhance the protection and rehabilitation of degraded coastal and marine habitats and ecosystems.	Natural Resources			
	Promote sustainable forest management measures, including the implementation of agroforestry practices.	Natural Resources			
	Develop sustainable ecotourism plans partnering and engaging local entrepreneurs.	Tourism			
	Promote water reuse and water efficiency measures across all sectors.	Water Resources			
	Promote the conservation of native species or species of special interest that are - most vulnerable and most resilient - to the adverse effects of climate change.	Agriculture Natural Resources			
	Promote protection and management of activities surrounding blue holes.	Water Resources			
Policy	Update and implement the National Adaptation Strategy for Agriculture inclusive of costing, human resource needs assessment and implementation plan for achieving strategic objectives	Agriculture			
	Enhance land use planning regulations and policies to ensure climate change-related risks are appropriately addressed, including providing guidance on the location of coastal development.	Cross-Sector			
	Implement the updated Building Code.	Human Settlements and Infrastructure			
	Mainstream adaptation into development policies to ensure universal access and energy distribution to the entire population.	Energy			
	Develop and implement a National Adaptation Plan covering priority sectors.	Cross-Sector			
	Review and update the National Policy for Adaptation to Climate Change.	Cross-Sector			
	Development of a tourism strategic plan that will incorporate climate change considerations and measures.	Tourism			
	Enhance forestry law and regulations to assure conservation of protected areas and forest reserves, especially those that have a protective and regulating effect on soil and water resources.	Natural Resources			

Type	Recommendation	Sector(s)	Horizon		
			ST	MT	LT
	Promote universal health care ensuring that climate variability and change implications are considered and included in health-related policies and programs.	Human Health			
	Development of a National Investment Policy reflective of climate change adaptation.	Cross-sector			
Information	Implement a system for monitoring and tracking the effects of climate change in coastal areas.	Disaster Management			
	Improve accuracy of climate data, predictions, and work with regional/international platforms for knowledge exchange.	Cross-Sector			
	Development of a more robust disaster communication plan to ensure cross-sectoral communication, real-time communication and specific contact information for each relevant agency in a disaster scenario.	Disaster Management			
	More frequent press briefings with respect to food, water, clothing depots, insurance, and more information on processes for accessing the same.	Disaster Management			
	Establish a national climate research agenda across all sectors coupled with policy, human resources and funding for research.	Cross-Sector			
Physical infrastructure	Adapt critical infrastructure and buildings in flood-prone areas or in areas particularly vulnerable to the risk of hurricanes.	Human Settlements and Infrastructure			
	Improve health care infrastructure and capacity of health personnel to cope with surges of climate sensitive diseases.	Human Health			
	Promote relocation of energy-related infrastructure to lower risk areas.	Energy			
	Plan, build and design smarter and more dispersed touristic facilities.	Tourism			
	Ensure most efficient air conditioning and air-cooling systems in the main buildings that provide basic public services.	Human Settlements and Infrastructure			
	Improve and modernise transportation system and its capacity to ensure interconnection between all the islands.	Transportation			
	Plan and implement solutions to protect and defend the main transport networks and infrastructure from climate change threats.	Transportation			
	Reduce the contamination risk of freshwater resources by improving water and sanitation infrastructure across islands.	Water Resources			
	Improve healthcare facilities to ensure health coverage for the entire population.	Human Health Disaster Management			
	Ensure that islands with the least available health infrastructure have a fast, safe and accessible inter-island emergency transport system.	Human Health Transportation			

Type	Recommendation	Sector(s)	Horizon		
			ST	MT	LT
Warning or observing system	Implement local and regional early warning systems to address the increased spread and transmission of vector-borne diseases and other climate related illnesses.	Human Health			
	Strengthen the monitoring and preventive maintenance of road networks.	Transportation			
	Monitor methods and indicators to determine the impacts of climate change on human health.	Human Health			
“Green infrastructure”	Mangrove reforestation in selected coastal areas.	Natural Resources			
	Promote inclusion of EbA/NbS in coastal development and building construction sector and development of community-based climate change adaptation plans.	Natural Resources			
Financing	Adjust public investment procedures to incorporate disaster risk reduction approaches in any new public development.	Disaster Management			
	Secure investments for the development of "clean/green" energy.	Energy			
	Establishment of payments for ecosystem services and other sustainable financing mechanisms to ensure effective management and restoration of protected areas and carbon sinks.	Natural Resources			
	Secure and channel adaptation investments across all economic sectors.	Cross-Sector			
	Create investment opportunities for increasing climate resilience	Cross-Sector			
Technology	Implement agricultural practices adapted to the new climatic conditions.	Agriculture			
	Enhance low carbon tourism economy.	Tourism			
	Increase the number of desalination plants.	Water Resources			
	Explore new technological solutions to ensure water availability for different uses.	Water Resources			
	Decarbonise transportation, promoting electric vehicles as opposed to fossil-fuelled ones.	Transport			
	Explore salt-tolerant crop varieties that can aid in improving food security	Agriculture			
	Create innovation opportunities for increasing climate resilience	Cross-Sector			

3.9.1.1. Agriculture

Achieving sustainable and equitable food systems is crucial for the socio-economic development of a country. The Bahamian food system and agricultural sector, face various extremes of challenges due to climate change such as: limited arable land and freshwater resources; harsh climate change impacts, difficulty in accessing high quality hybrid seeds (due to high costs) and other resources for crop and livestock population, post-harvest losses and unsustainable agricultural practices (Federal Office for Agriculture FOAG, 2021).

Under this scenario, there is an urgent need to implement a sustainable agricultural development strategy that improves the country's food and nutritional security, is coherent with other related policies, and clearly identifies and supports national production priorities under a climate change context. To do so, there is the need to strengthen the regulatory framework which could include the development of a national adaptation strategy for the sector and promote of water management and conservation practices to ensure universal access to water. Other key actions that will increase the sector's capacity to cope with the challenges arising from climate change include:

- Promote the conservation of native species or species of special interest that are most vulnerable and most resilient to the adverse effects of climate change.
- Implementing agricultural practices adapted to the new climatic conditions (e.g., drought-adapted cultivation technologies);
- Explore salt tolerant crop varieties that can aid in improving food security.
- Establish a link between agriculture and forestry to have farmers or nurseries grow, acclimate or multiply plants need for forest restoration or enhancement efforts.
- Improving soil restoration and conservation activities (e.g., crop rotation, direct seeding, and the use of natural fertilisers and natural cover).

These should be coupled with dissemination activities towards the population about the importance of improving their eating habits and the consumption of healthy food.

3.9.1.2. Natural Resources

An overall adaptation target for this sector is to promote the conservation protection and enhance ecosystems that ensure resilience against climate-related threats while taking the opportunity to provide livelihoods options for the population. In this context, adaptation measures in the sector should focus on promoting inclusion of EbA[50]/NbS[51] in coastal development and building construction sector and development of community-based climate change adaptation plans. that not only are cost-effective, but also provide environmental and socio-economic benefits and help building resilience through ecosystem conservation actions and the efficient use of its resources and services.

Adaptation measures should also focus on capacity-building needs for protected area management, rehabilitation/restoration and research & monitoring for agencies tasked with this role; through tertiary education programs; through livelihoods opportunities. A National Education Strategy or Communication Plan to increase education and awareness of the importance of coral reefs and mangrove forest for sustainable development, forestry development and conservation and the role of each of these habitats in protection of the coastline from storm surges.

When it comes to coastal ecosystems, it is particularly noteworthy the importance coral reefs, seagrass and mangrove forests play for the country in terms of sustainable development and coastal protection, besides being an important habitat for fisheries and wildlife. The maintenance and conservation of these natural coastal barriers is therefore essential to prevent coastal erosion and the loss of coastline, increasing coastal resilience to climate change effects. In this context, adaptation actions and strategies in The Bahamas should aim at enhancing coastal protection and rehabilitating degraded coastal and marine habitats and ecosystems such as mangroves, seagrass beds and coral reefs. In addition, priority areas for mangrove reforestation must be identified. Awareness and information and dissemination activities to the public about the role that these ecosystems play the protection of the coastline from storm surges and as an important habitat for fisheries and wildlife, should also be promoted. In addition, sustainable ecotourism activities can be developed and improved coupled with carrying capacity studies and training in responsible resource use for businesses in the tourism sector, to avoid potential degradation of ecosystems and natural resources that may arise from these activities. It should be enhanced and encourage participation or carry out actions with local stakeholders and tourists where they participate in ecosystem management and biodiversity enhancement activities and improve marketing on eco-tourism alternatives.

It is also considered of particular relevance educating the construction sector on impacts they can have on natural systems and providing them with guidance on alternative methods for land clearing. Education can be tied to business license issuance with applicants having to confirm participation in required courses

[50] Nature-based solution that harnesses biodiversity and ecosystem services to reduce vulnerability and build resilience of human communities to climate change. EbA is defined as the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change (Secretariat of the Convention on Biological Diversity, 2009).

[51] Actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits (United Nations Environment Assembly, 2022)

before they can receive a license for heavy equipment operation. Also incorporating land clearing as a phase in the building permitting system so this activity can be monitored to ensure compliance with DEPP, Forestry and Physical Planning permits; any non-compliant clearing should be issued a stop-work order as well as fines.

In addition, the country should focus on improving the conservation and protection of its terrestrial forests and enhance its forestry law and regulations to assure conservation of protected areas and forest reserves, especially those that have a protective and regulating effect on soil and water resources. Sustainable forest management measures aimed at increasing the resistance and resilience of forests to droughts and high temperatures, and other climate change related impacts, should be promoted, including the implementation of agroforestry practices.

Furthermore, having a good understanding of the value and importance of forest ecosystems is another key aspect to protect them and ensure their conservation. In this context, it is essential for The Bahamas to improve and enhance public education and awareness in sustainable forestry management and conservation, in valuing the ecosystem services that forest systems provide, and how these activities can enhance job creation and improve livelihoods.

Focus on development and capitalization of sustainable financing mechanisms already in existence (e.g., Bahamas Protected Areas Fund) and other funds mentioned in more recent environmental/fisheries legislation is also critical.

None of all the purposed measures can be done without adequate skilled human resource capacity and money.

3.9.1.3. Energy

As a response to rising temperatures and the growth and development of the country, the energy demand in The Bahamas islands is increasing. Guaranteeing universal access and energy distribution to the entire population is a priority hence the Government must ensure that adaptation practices are mainstreamed into development policies. Climate change has shown us that power lines that are mostly along coastal roads need to be changed quickly.

As close to 100% of all the electricity generated in the country comes from fossil fuels, some of the most urgent objectives for the Bahamian Energy sector in terms of adapting to future climate change scenarios and predictions include adopting measures that will promote the diversification of the energy matrix and the adoption of energy efficiency measures. In this context, it is essential to understand the potential that each island has for the introduction of renewable energy options and to secure investments for the development of “clean/green” energy that can guarantee the country’s energy supply in a more sustainable way.

For example, The Bahamas is presently investigating alternative technologies for the provision of drinking water to the nation, thru Ocean Thermal Energy Conversion (OTEC) to co-generate clean energy in addition to producing drinking water. A water-energy nexus for The Bahamas may effectively involve the use of the deep groundwater resources and pairing OTEC technologies with desalination for the provision of freshwater and the production of energy (Bowleg, 2022).

Secondly, the country should implement and encourage knowledge and techniques that promote energy efficiency (efficient use of energy, reduce dependency on imported fossil fuels, develop the use of renewable energy sources, new technologies or alternatives sources of power) and develop energy adaptation and rehabilitation plans for buildings providing essential public services or in population settlements particularly vulnerable to the impacts of climate change. In this context and given the high importance of the Tourism sector for the country's economy, actions that enhance a low carbon tourism economy should also be implemented.

Finally, climate change hazards are also affecting energy-related infrastructure such as power plants and power lines posing an additional threat to The Bahamas energy security. These are mostly located in coastal zones, which are areas extremely vulnerable to climate change-related impacts such as SLR. In this context, options to reduce this vulnerability include the revision of coastal facilities and infrastructures located in high-risk areas considering future climate projections and scenarios, to assess the need of revising their planning (including revision and repair activities), limiting or reducing their use and, or even of relocating these infrastructures to lower risk areas. In addition, the implementation of solar energy on family islands will help reduce power lines along coastal roads, as it will not be necessary to have all settlements tied into a single power source.

3.9.1.4. Human Health

When it comes to human health, it should be emphasised that it is important that adaptation efforts must focus on the most vulnerable population, particularly migrant people, population living below the poverty line, children, elderly, population with chronical diseases, and women.

Promoting universal health care should be a part of the country's strategy to improve the adaptive capacity of the health care system and the Bahamian population, and climate variability and change implications should be considered for all the islands and included in health policies, plans and programmes. New policy approaches should reflect health protection from climate change associated risks. The integration of climate change into all health and health-related sectors should be promoted.

In this context, health facilities must be improved, and healthcare personnel's capacity must be developed to ensure coverage for the entire population and the country should ensure that the islands that have limited available health infrastructure have a fast, safe and accessible inter-island emergency transport system available to the entire population. The Institute's training of all health care providers and education on climate change and health risk assessment should be developed. In addition, to reduce the impacts on the population by hurricanes and other extreme weather events that frequently hit the country, coupled with the development of a disaster management and evacuation plan to respond and recover from these events, shelter management protocols and procedures should be established to ensure consistent attention of the residents, as well as the establishment of specific care guidelines for certain populations and minorities. Furthermore, The Bahamas could also pursue international cooperation agreements with neighbouring countries to ensure a safe temporary migration of people when these extreme climate related events occur in the country.

Due to the cross-cutting nature of the health sector, carrying out actions such as investing in new technical solutions for potable water and sanitary sewage to ensure population access to drinking and consumption water, adopting sustainable agricultural techniques and reducing the dependence on food imports, can help improve water and food availability and quality for the population. And while ensuring food and water security is a priority for the country, plans and programmes should also be developed to inform the population about the importance about the consumption of healthy food and of water conservation.

Climate change is also affecting vector-borne disease transmission and spread, and its impacts are likely to worsen. In this context the implementation of local and regional early warning systems in The Bahamas to address the increased spread and transmission of vector-borne diseases will allow not only the monitoring and follow up of vectors or other tropical disease transmission but also the establishment of predictive models for their behaviour. A further complementary measure to the above is the implementation of monitoring methods and indicators to determine the overall impacts of climate change on human health. The information that can be obtained from the implementation and execution of these measures makes it possible to assess and analyse the impacts of climate change on people's health. Therefore, it is possible to propose concrete actions to prevent or mitigate these adverse effects, thus increasing the adaptive capacity of the human health sector in The Bahamas.

3.9.1.5. Human Settlements and Infrastructure

Improving the resiliency of human settlements in The Bahamas is critical to minimize climate-related risks and ensure the safety of the Bahamian population and particular attention should be paid to critical infrastructure located in coastal areas or in flood prone areas, which are extremely vulnerable to SLR and storm surges form hurricanes. In addition to the process that the country is currently undertaking to update its building code - so the climate variability is considered when constructing and reconstructing infrastructure, terminating or prohibiting licensing for certain buildings utilization should also be considered, particularly when this poses a risk to the safety and physical integrity of the population.

Other actions that contribute to reducing vulnerability and increasing the sector's capacity to respond to climate change with multiple benefits across other sectors as well include:

a) contingency planning for household and social infrastructure essential systems (e.g., electricity, heating, cooling, ventilation, water supply, sanitation services, waste management and communications) to ensure that they will not be cutting off during extreme weather events, and;
b) guarantee that at least the main buildings that provide basic public services (e.g., hospitals, schools, old people's homes, public buildings) count with efficient air conditioning and air-cooling systems to face future scenarios of rising temperatures and heat waves.

3.9.1.6. Tourism

As one of the most important economic sectors in the country, particular attention should be paid to the Tourism sector where the implementation of adaptation measures should be considered a priority.

In this context, there is the need for The Bahamas to develop a strategic planning for the sector that considers climate variability but although tourism policy development is definitely needed, more importantly right now, (especially given the need to update other sectoral policies) is institutional, private sector and community capacity building to sensitize stakeholders to the direct and indirect impacts of climate on their environments and businesses, and communication of adaptative strategies based on sectoral policies is prioritized.

Ecotourism development is important for stabilizing the industry to capitalize on trends; however, this would apply only to certain pockets of tourism activity on some islands and select island destinations that could be categorized as ecotourism destinations, to avoid greenwashing. Because of the reliance on the environment for so much of our tourism activity and livelihoods**, environmental policy implementation would be considered a priority for the tourism sector.** Also planning, building and designing smarter and more dispersed tourism facilities should be encouraged.

Certainly, cross-sectoral policy priorities for better tourism business planning and retrofitting for climate adaptation would also be a higher priority than tourism policy development.

Finally, reducing the sector's dependence on fossil fuels and the enhancement of a low-carbon tourism economy should be desirable in the longer term.

3.9.1.7. Transportation

The Bahamas' transportation system is essential for the population to move within and across islands and for the development of economic or tourist activities. The Bahamas is prone to the adverse effect of SLR, flooding and extreme weather events such as hurricanes, that may damage or even destroy road, port, and airport infrastructure and disrupt the vital connections that provide the population's access to economic opportunities, education, and healthcare. Populations living in more isolated areas or where with poor availability of alternative routes or other transport options are the most vulnerable.

The Transport sector plays a central role both in building resilience and in disaster response and is essential to ensure that the transportation system remains functional particularly during and after these events.

In this context, it is critical to strengthen the monitoring and preventive maintenance of the Bahamian road networks and ensure that during these events there is a fast, safe and accessible inter-island emergency transport system that is available to the entire population. In addition, for all new transportation infrastructure, resiliency should also be incorporated from the planning stage onwards. This will reduce future damage from climate change events while safeguarding, for example, the transportation of food and goods between the islands.

In addition, the country should plan and implement solutions (e.g., building man-made structures/barriers or adopting green solutions such as mangroves in coastal areas) to help protect the main transport networks and infrastructure from climate change-related threats.

In terms of vehicles, the Bahamian public transportation system relies for the most part on imported fossil fuels. In this context, the promotion of electric vehicles as opposed to fossil-fuelled ones should be enhanced.

3.9.1.8. Water Resources

Ensuring universal access to quality water and sanitation services considering present and future conditions is a priority for The Bahamas. In this context, the country must ensure a proper management and planning of its finite and limited water resources considering future SLR and the risk of salinisation of water bodies and other climate scenarios of drought and increased heat waves.

This would encompass reducing the risk that scarce freshwater resources can be contaminated during tropical storms, floods and other extreme events by improving water and sanitation infrastructure across islands, increasing the number of desalination plants and explore new technological solutions for potable water and sanitary sewage to ensure the availability of water for different uses including consumption, and developing contingency plans for situations of water scarcity.

In this context, it is important to highlight that under the GCF project “Climate resilience of the water sector in The Bahamas” the country is already planning the development of a Decision Support System (DSS) for Water Resources Management which will strengthen the evidence base and decision support system for climate resilience in the water sector at the national level.

On the other hand, protection and management of activities surrounding blue holes (ie. not approving subdivisions or resorts around the blue holes; need for improvement of waste/sewage management to limit/prevent contamination of blue holes/water tables) are important too.

Additionally, The Bahamas is presently investigating alternative technologies for the provision of drinking water to the nation, thru Ocean Thermal Energy Conversion (OTEC) to co-generate clean energy in addition to producing drinking water. A water-energy nexus for The Bahamas may effectively involve the use of the deep groundwater resources and pairing OTEC technologies with desalination for the provision of freshwater and the production of energy (Bowleg, 2022).

Finally, given the limited water resources in the country activities to raise public awareness on the importance of water conservation and promoting water reuse and water efficiency measures across different economic sectors should be implemented.

3.9.1.9. Disaster Management

As a country that historically has been suffering from the effects of extreme weather events, The Bahamas have been developing disaster risk management strategies to help cope with those effects, such as the development and implementation of early warning systems for hurricanes. However, in The Bahamas climate change and higher mean temperatures not only are exacerbating the frequency and intensity of these events and associated storm surges but are also responsible for SLR and associated consequences.

The development of frameworks to strengthen international cooperation by pursuing climate migration/refugee agreements with neighbouring countries it might be advisable to begin to study and consider. Also establish a framework for handling climate-influenced or caused migration or human mobility will be desirable.

On the other hand, the installation of early warning systems in coastal areas will allow the monitoring and forecasting of these climate change-related hazards, that, together with the creation and implementation of action protocols, will allow a better preparedness and planning to prepare and respond to these hazards. These protocols should be defined by the National Emergency Management Agency (NEMA) and the Disaster Reconstruction Authority (DRA).

In addition, to improve the response and recovery capacity from hurricanes and other extreme weather events, efforts should also go towards the development and implementation of contingency planning for essential systems to ensure that they will not be cut off during these events, as well as disaster management and evacuation plans that establish specific care guidelines for certain populations and minorities. To avoid chaos and ensure a better response and action capacity during and/or after an event, periodic simulations of these plans should be planned and organized. In addition, there is also the need to review climate smart community sheltering infrastructure and protocols. The development of an emergency healthcare management protocol for tracking evacuees and determining health and psycho-social outcomes for the evacuees is also a recommended measure that should be prioritised.

Regarding public information and knowledge, the development of a more robust disaster communication plan to ensure cross-sectoral communication, real-time communication, and specific contact information for each relevant agency in a disaster scenario are important measures to achieve. Also, more frequent press briefings with respect to food, water, clothing depots, insurance, and more information on processes for accessing the same could be implemented. Finally, an in alignment with the Building Code currently under review, public investment procedures should also be adjusted to ensure that any new public development incorporates disaster risk reduction approaches from its feasibility or predesign studies to its completion and maintenance. Along this line, it is important to encourage the implementation of disaster resistant building techniques and materials, and the development of policy of financial incentives or aids to draw populations in at risk-areas to resettle on safer ground.

3.9.1.10. Cross-Sector

Overall, communicating climate information helps building resilience towards climate impacts and it is essential to ensure the Bahamian population is aware not only of the negative impacts of climate change and how to respond to them (good practices), but also of the opportunities it my bring to the social and economic development of the country, including their livelihoods. Awareness and dissemination activities should be implemented across sectors.

Intersectoral linkages should also be improved to avoid efforts duplication and take advantage of common challenges and opportunities. In this context, knowledge, expertise and resources can be shared among the different sectors, building positive long-term relationships.

In terms of legislation, it is important to rely on a sound and climate-informed framework based on reliable scientific data in order to improve land-use planning policies and regulations. Enforcement is essential to achieve the objectives of land-use planning. The country should ensure its regulatory framework sits on the most accurate climate data and predictions and work with other regional/international platforms for knowledge exchange with other countries in the Caribbean region. In this context, the country would benefit from developing studies on sectoral vulnerability based on geographic data and indicators and on the economics of climate change in The Bahamas providing a cost benefit analysis of adaptation actions. These results could feed into a National Adaptation Plan and could also present an opportunity to update the National Adaptation Policy to ensure it reflects the current and future needs and priorities of the country across sectors and islands.

Finally, building resilience and improving the country's capacity to be prepared and respond to climate change requires securing and channelling adaptation investments across all economic sectors, with a focus on the most vulnerable islands or populations. The creation of innovation and investment opportunities for increasing climate resilience is another proposed adaptation measure that can be prioritised.

3.9.2. Prioritization of adaptation options

A prioritization exercise to identify the adaptation actions that need to be implemented and carried out most urgently was done in consultation with stakeholders. The results for each of the analysed sectors are the following:

Table 97. Prioritization of the adaptation options.

Agriculture	• Develop a strategic linkage with agricultural and health sectors to ensure sectoral goals are realistic and achievable (within the 5 years) • Promote the conservation of native species or species of special interest that are - most vulnerable and most resilient - to the adverse effects of climate change. • Establish a link between agriculture and forestry to have farmers or nurseries grow, acclimate, or multiply plants need for forest restoration or enhancement efforts. • Explore salt tolerant crop varieties that can aid improving food security. • Update and implement the National Adaptation Strategy for Agriculture inclusive of costing, human resource needs assessment and implementation plan for achieving strategic objectives • Implement agricultural practices adapted to the new climatic conditions
Natural Resources	• Development and improvement of sustainable ecotourism activities, including carrying capacity studies and training in responsible resource use for businesses in the tourism sector.

	• Develop sustainable land use plans for each island, factoring in recommendations of the draft National Development Plan. • Promote inclusion of EbA/NbS in coastal development and building construction sector and development of community-based climate change adaptation plans. • Enhance forestry law and regulations to assure conservation of protected areas and forest reserves, especially those that have a protective and regulating effect on soil and water resources. • Educating the construction sector on impacts they can have on natural systems and providing them with guidance on alternative methods for land clearing[52]. • Incorporating land clearing as a phase in the building permitting system so this activity can be monitored to ensure compliance with DEPP, Forestry and Physical Planning permits; any non-compliant clearing should be issued a stop-work order as well as fines. • Increase in human capacity for all environmental management agencies with representation on all islands. • Building capacity (permanent staff and other resources) within public agencies responsible for ecosystem (carbon sink area) management for the medium- to long-term. • Establishment of payments for ecosystem services and other sustainable financing mechanisms to ensure effective management and restoration of protected areas and carbon sinks. • Promote Nature Based Solutions and Ecosystem Based Adaptation. • Establishment of payments for ecosystems services. • Better protection for pine forest habitat from illegal clearing
Energy	• Secure investments for the development of "clean/green" energy. • Assessment of renewable energy potential across all occupied islands. • Mainstream adaptation into development policies to ensure universal access and energy distribution to the entire population. • Implement knowledge and techniques that promote energy efficiency and use criteria in buildings (including housing).
Human Health	• Institute training of all healthcare and education providers in climate change and health risk assessment • Mainstream climate change across health and health-related sectors • Improve health care infrastructure and capacity of health personnel to cope with surges of climate sensitive diseases. • Promote universal health care ensuring that climate variability and change implications are considered and included in health-related policies and programs.

[52] Education can be tied to business license issuance with applicants having to confirm participation in required courses before they can receive a license for heavy equipment operation.

	• Implement local and regional early warning systems to address the increased spread and transmission of vector-borne diseases and other climate related illnesses.
Human Settlements and Infrastructure	• Develop contingency planning for essential systems to ensure that they will not be cut off during extreme weather events. • Implement the updated Building Code. • Adapt critical infrastructure and buildings in flood-prone areas or in areas particularly vulnerable to the risk of hurricanes.
Tourism	• Plan, build and design smarter tourism facilities. • Development of a tourism strategic plan that will incorporate climate change considerations and measures. • Enhance low carbon tourism economy. • Assessment of touristic areas at risk due to SLR, hurricanes or flooding across islands.
Transportation	• Improve and upgrade public transport systems in the most populated islands with a focus on renewables. • Improve and modernise transportation system and its capacity to ensure interconnection between all the islands. • Plan and implement solutions to protect and defend the main transport networks and infrastructure from climate change threats. • Decarbonise transportation, promoting electric vehicles as opposed to fossil-fueled ones.
Water Resources	• Protection and management of activities surrounding blue holes (ie. not approving subdivisions or resorts around the blue holes; need for improvement of waste/sewage management to limit/prevent contamination of blue holes/water tables) • Promote water reuse and water efficiency measures across all sectors. • Reduce the contamination risk of freshwater resources by improving water and sanitation infrastructure across islands.
Disaster management	• Develop an emergency healthcare management protocol for tracking evacuees and determining health and psycho-social outcomes for the evacuees. • Establish a framework for handling climate-influenced or caused migration or human mobility. • Development of a more robust disaster communication plan to ensure cross-sectoral communication, real-time communication and specific contact information for each relevant agency in a disaster scenario. • Establishment of climate-smart community shelter management protocols and procedures to ensure consistent attention of the residents, as well as the establishment of specific care guidelines for certain populations and minorities
Cross-Sector	• Enhancing land use planning policies and regulations. Enforcement of regulations is key to success in achieving land use planning objectives.

	• Establish a national climate research agenda across all sectors; this needs to be coupled with policy, human resources and funding for research. • Create innovation and investment opportunities for increasing climate resilience. • Enhance land use planning regulations and policies to ensure climate change-related risks are appropriately addressed, including providing guidance on the location of coastal development. • Improve intersectoral linkages between sectors to avoid efforts duplication and take advantage of common challenges and opportunities.

3.10 Constraints, gaps and related financial, technical and capacity needs

3.10.1. Existing capacities and opportunities

The Bahamas is one of the most vulnerable countries to the impacts of climate change and has been preparing for and taking action towards climate change resilience.

Internationally, The Bahamas is obliged to fulfil the goals of several agreements, treaties and conventions which were signed and ratified. In this basis, adaptation is addressed in all reports submitted by The Bahamas to the United Nations Framework Convention on Climate Change (UNFCCC): National Communications, Biennial Update Report (BUR) and Nationally Determined Contributions (NDC).

Adaptation to climate change is integrated into the national regulatory framework. In 2005, the National Policy on Climate Change Adaptation was defined, to provide an assessment of the degree of vulnerability of The Bahamas to the projected impacts of climate change by sectors and proposes strategies to anticipate and ameliorate or avoid the negative impacts.

The marine shore plays a very important role in the protection of the archipelago. In this sense, at the regulatory level there are a series of acts (although almost all of them were defined more than 20 years ago) focused on the protection of biodiversity and the coast. Moreover, the Forestry Act focuses on protecting mangrove ecosystems that act as a natural barrier against sea level rise and the impacts of adverse weather events such as hurricanes.

In line with marine and coastal protection, The Bahamas, in addition to acting within the framework of the UNFCCC, also acts within the framework of the Convention on Biological Diversity (CBD) and the United Nations Convention to Combat Desertification (UNCCD) and other Multilateral Environmental Agreements (MEAs). The country also committed to the Caribbean Challenge Initiative (CCI) which aimed to conserve at least 20% of the nearshore environments by 2020. The Bahamas also has extensive financial and technical support for its fight against the consequences of climate change from various multilaterals such as the World Bank, IDB, CCCCC or GCF.

In order to implement adaptation measures properly, it is important to have the democratic stability that The Bahamas enjoys, with a multi-party system, healthy elections and engaged citizens. The country also has a stable currency and an effective monetary policy; a reliable banking system and the Bahamian market is highly recognised in tourism and financial services (Government of The Bahamas, 2016).

The tourism sector of The Bahamian economy generates about 50% of total direct Gross Domestic Product (GDP) which makes a priority to increase and improve adaptation measures to climate change. Moreover, because of its geographical proximity, it retains a close relationship with the United States and most of the US companies operating in The Bahamas are involved in tourism and banking. This is conducive to the US support it receives to improve and maintain the tourism sector.

Another major problem facing The Bahamas is its vulnerability to natural disasters, particularly hurricanes, with the country still recovering from the impacts of Hurricane Dorian in 2019. However, the Bahamian government, in addition to the financial assistance it has received to cope with these impacts, has access to two financial mechanisms to help to deal with the emergency and reduce budgetary volatility:

- **Parametric insurance.** The Bahamas has been part of the Caribbean Catastrophe Risk Insurance Facility (CCRIF) parametric insurance scheme since after Hurricane Matthew in 2016. This instrument was not designed to cover all damage caused by a catastrophe, but to quickly provide governments access to short-term liquidity mechanisms to cope with the emergency and reduce budgetary volatility when a policy is triggered.
- **Contingent lines of credit.** After Hurricane Irma, the Bahamian government purchased this product from the Inter-American Development Bank (IDB). The funds obtained through these loans provide a source of liquidity right after a natural disaster strikes and feature parametric triggers based on inputs relating to disaster event location, type and magnitude to activate loan disbursements. are normally used during the emergency and early recovery phase.

Technically, the country also receives a lot of support from the IDB, which has produced reports on the impacts of hurricanes on the archipelago in recent years and possible solutions to improve its resilience and adaptation to them. Furthermore, thanks to its geographical proximity to the United States, The Bahamas can draw on data collected by the United States National Oceanic and Atmospheric Administration (NOAA) for studies and assessments of storm strength and weather patterns.

Additionally, The Bahamas can take advantage of the need to update some of its sectoral policies and plans to adjust them to the current and future needs of the country within a climate change scenario proposing more ambitious actions.

Given the increased of risk of energy insecurity due to, among other factors, climate change, one of the country's main focuses is the energy sector, for which a National Energy Policy 2013-2033 has been developed where the country commits to the diversification of energy sources and to increase the share of national and decentralized renewable energies in the Bahamian energy mix by 2033 thus decreasing the risk of energy insecurity. As the country is almost 100% reliant on imported fossil fuels that leaves the country vulnerable to global price fluctuations, The Bahamas struggles with high electricity costs, particularly industrial consumers. However, the country has reduced the import duties for solar technologies and lithium ion and lithium phosphate batteries, which are predominantly used for renewable energy, providing an opportunity for investment and to diversify the fuel portfolio and reduce rate volatility. Finally, the Ministry of Finance is developing and implementing incentives and fiscal measures to enable and support investments in modern facilities and infrastructure in the energy sector. For example, funds have been allocated to introduce commercial scale solar energy opportunities throughout the country, with particular emphasis on the Family Islands and to increase the number of electric vehicles in the Government's fleet (The Bahamas Ministry of Finance, 2022).

3.10.2. Barriers for the implementation of the adaptation actions in each sector

In order to successfully develop a climate resilient strategy to face the adverse impacts of climate change, it is important to understand what are the main barriers, gaps and needs associated with the implementation of adaptation measures in The Bahamas. These were assessed based on an extensive desk review of relevant literature for the country and validated with key national stakeholders. The following table provides a summary of the identified barriers, gaps and needs divided by category. It should be noted that some of them are cross-cutting and would apply to all of the prioritized sectors.

Table 98. Main barriers for the implementation of the adaptation actions in each sector.

Categories	Barriers	Agriculture	Natural Resources	Disaster Management	Energy	Human Health	Human settlements and infra	Tourism	Transport	Water Resources
Capacity Building	Lack of political will, efficacy, and authority of The National Climate Change Committee (NCCC)	■	■	■	■	■	■	■	■	■
	Slow legislative agenda	■	■	■	■	■	■	■	■	■
	Stakeholders with technical capacity constraints	■	■	■	■	■	■	■	■	■
	Lack of intersectoral collaboration to address climate change	■	■	■	■	■	■	■	■	■
	Lack of education in food safety	■				■				
	Lack of public dissemination regarding the role of wetlands, coral reefs and mangrove forests for the protection of the coastline		■	■						
	Low levels of awareness of energy conservation practices (energy efficiency)				■					
	Lack of public health engagement in communities around climate change					■				
	Lack of appreciation and understanding of the value of the fragile Bahamian environment and biodiversity to the population		■							
	Lack of local engagement to promote sustainable ecotourism plans							■		
	Lack of public dissemination of the importance of responsible water consumption									■

Categories	Barriers	Agriculture	Natural Resources	Disaster Management	Energy	Human Health	Human settlements and infra	Tourism	Transport	Water Resources
Management and Planning	Lack of urban planning that takes into account the impacts of climate change, such as the loss of coastlines									
	Absence or disregard of spatial planning strategies									
	Lack of emergency preparedness to heat waves and droughts									
Practice and behavior	Unwillingness to invest in upgrades and new infrastructure									
	Lack of knowledge about soil management techniques and climate-resilient crops									
	The Bahamas is heavily dependent on imported fossil fuels									
Policy	Outdated policies and strategies									
	Lack of proper regulatory framework to promote sustainable land and natural resource management									
	Limited policies/laws that encourage energy conservation and no energy efficiency standards.									
	Lack of coordinated national water policy or plan that considers the needs of other sectors and sectoral stakeholders									
	Lack of policies on climate change and health									
Information	Lack of coordination and data sharing between State entities									
	Gaps in data and knowledge needed to inform policy and decision making									
	Lack of hard data on climate change and its potential impacts on biodiversity									
	No energy balance data is available in the country									
	The inventory does not cover all the national land territory, not being considered all the unclassified areas									
	No assessment of health vulnerability and impacts of climate change has been conducted									
Physical Infrastructure	Non-established safety standards for public infrastructure									
	Scarce land availability									

Categories	Barriers	Agriculture	Natural Resources	Disaster Management	Energy	Human Health	Human settlements and infra	Tourism	Transport	Water Resources
	Weak infrastructure to face future impacts of climate change									
Warning or observing system	Lack of hard data to implement a monitoring and tacking system									
Green Infra	Lack of technical knowledge to implement green infrastructure initiatives									
	Scarce land availability									
Financing	Public fiscal constraints to generate sufficient revenue to cover its capital needs									
	The absence of studies assessing economic impacts of climate change									
	Immature value chains across most sectors									
	Lack of financial resources at the systemic and institutional levels									
	High debt burden which constrains the government's ability to respond as required									
	Limited financial (public sector) resources, to support greater provision of renewable energy and staffing/capacity needed in the area of renewables & environmental protection									
Technology	Unavailability of equipment									
	Weak early warning and disaster relief systems									
	High cost of the implementation and use of new technologies									
	Lack of meteorological information in the diseases monitoring system									

Chapter 4 – Programmes Containing Measures to Mitigate Climate Change

4.1. Introduction

The Commonwealth of The Bahamas, similar to the rest of the Caribbean islands, contributes very little to global GHG emissions (0.01%). Nevertheless, the Government of The Commonwealth of The Bahamas (GOB), conscious of the country's vulnerability as a small island developing state (SIDS) to climate change, in particular, extreme weather events, has demonstrated its commitment to combating climate change through implemented and planned actions covering the energy and forestry sectors at the national level.

This chapter presents The Bahamas' mitigation analysis and describes the mitigation actions in the five IPCC sectors of Energy, Industrial Processes and Product Use (IPPU), Agriculture, Land Use and Land Use Change and Forestry (LULUCF) and Waste. Due to the vast number of mitigation actions in the Energy sector, these have been disaggregated into Energy Demand, Electricity Generation and Transport sub-sectors.

The proposed mitigation actions for the assessment were based on desk reviews and consultations with a broad range of key stakeholders from both the public and private sectors in The Bahamas. The mitigation actions presented are in various stages of planning, preparation, and execution. The mitigation assessment provides a justified evidence base to The Bahamas for prioritising actions and registering the party's mitigation actions through the Nationally Appropriate Mitigation Action (NAMA) registry (or other climate change support mechanisms) in order to source financing for either implementation or further preparation. The chapter is organised into the following sections:

- Section 4.2: National Policies
- Section 4.3: Measures to Reduce GHG Emissions (Mitigation Actions)
- Section 4.4: GHG Emissions Projections
- Section 4.5: Barriers and Challenges to Implementation and Methods to Improve The Modelling

4.2. National Policies and Measures to Reduce GHG Emissions

4.2.1. National Policies

The Bahamas has recognised the critical role that the adverse effects of climate change play with regards to its future and highlights it as a cross-cutting challenge. As a vulnerable SIDS, the impacts of climate change are further heightened in The Bahamas by geographical location (tropical belt), topography (dispersion of islands, limited land masses), environmental conditions (high temperatures, sea-level rise, flooding, tropical cyclones) and others (Bahamas, 2015). This is despite the fact that The Bahamas contributes very little to global greenhouse gas emissions. As a result, The Bahamas' mitigation actions are enshrined within the sustainable development context. This ensures that the mitigation actions contribute to reducing emissions as well as the achievement of national economic and development goals. The Bahamas has continuously updated its many policies, plans, strategies, and initiatives to address climate change over the years. A list of the significant policies related to mitigation is highlighted in Table 99 below.

Table 99: Significant National Policies, Plans, Strategies, and Initiatives

Significant National Policies, Plans, Strategies, and Initiatives
Significant Policies and Plans
The Bahamas First and Second National Communications (2001 and 2015)
The Bahamas National Energy Policy (2013 -2033)
The Bahamas Intended National Determined Contribution (2015)
The Bahamas Building Code – 3rd edition – Ministry of Works and Utilities (2003)
The Bahamas Power and Light requirement for grid interconnection of small-scale renewable energy generation systems
Grand Bahama Power Company rules and regulations for renewable generation systems
The Civil Aviation Authority Bahamas Environmental Regulation (CAR ENV 2021)
National Policy for the Adaption to Climate Change (2005)
The Forestry Act (Amended 2014) and Forestry Regulations (2014)
Draft Vehicle Emissions Bill (2013)
Electricity Act (Renewable Energy) (Amended 2015)
Elimination of tariffs on solar panels, inverters, and LED appliances

Significant National Policies, Plans, Strategies, and Initiatives
Major Initiatives
Building the Bahamas Capacity in Transparency for climate change mitigation and adaptation (GEF) Project information
Pine Island – Forest Mangrove Innovation and Integration (Grand Bahama, New Providence, Abaco, and Andros) GEF – Project Identification document and Project Identification form
Meeting the Challenge of 2020 in the Bahamas (GEF) Project identification form
Promoting Sustainable Energy in the Bahamas – Final Draft September 2010 – Fichtner Report
The Commonwealth of The Bahamas Conditional Credit Line for Investment Projects (CCLIP) Advancing Renewable Energy in The Bahamas and Reconstruction with Resilience in the Energy Loan Proposal – IADB document
Reconstruction with Resilience in the Energy Sector in The Bahamas – Loan Contract - IADB
The Bahamas Power System Stability Study for the Implementation of a Higher Renewable Energy Penetration Level (2018)
Developing a national framework for the standardisation of stalls and procedures for a climate-smart street-side vendor throughout The Bahamas (2021)
Pilot Programme to outfit Government built homes with solar water heaters and solar panels
The Caribbean Hotel Energy Efficiency and Renewable Energy Action – Advanced Program (CHENACT-AP)
The Bahamas REEF Environment Educational Foundation
Major Strategies/Targets
30% economy-wide reduction in GHG emission when compared to BAU
30% renewables in the energy mix by 2030

4.2.1.1. Energy Policies

The Bahamas has adopted its National Energy Policy (NEP) 2013 – 2033 (Government of The Bahamas, 2013). The NEP central vision is to ensure that by 2033, The Bahamas has a modern, diversified, and efficient energy sector. This will provide Bahamians with affordable energy supplies and long-term energy security balanced with enhancing international competitiveness and sustainable prosperity.

The NEP Strategic Framework places priority on six key areas:

1. Security of energy supply through diversification of fuels;
2. Modernising the country's energy infrastructure;
3. Development of renewable energy sources such as solar, ocean energy, biofuels, waste-to-energy, and wind
4. Energy conservation and efficiency;
5. Development of a comprehensive governance/regulatory framework to support the advancement of the energy sector to be effectively able to facilitate the introduction of renewables and the diversification of fuels; and
6. Eco-efficiency in the manufacturing, agricultural and tourism sectors, and Government as leaders in energy conservation and the use of renewable energy.

The NEP is a long-term and strategic policy and contains four inter-related goals, each with specific strategies. The goals and related strategies are outlined in Table 100 below.

Table 100: Goal and Strategies from The Bahamas Energy Policy 2013-2033

Goal	Description	Strategies related to goal
Goal 1	Bahamians will become well aware of the importance of energy conservation, use energy wisely and continuously pursue opportunities for improving energy efficiencies, with key economic sectors embracing eco-efficiency	Strategies relevant to Households and Businesses related to Information, Education and Training, and Demonstration
		Strategies related to Government as a leader in energy conservation and efficiency
		Strategies related to Private Sector and Industry
		Strategies related to the Transport Sector and Buildings
		Strategies related to Legislation
Goal 2	The Bahamas will have a modern energy infrastructure that enhances energy generation capacity and ensures that energy supplies are safely, reliably, and affordably transported to homes, communities, and the productive sectors on a sustainable basis	Strategies related to Energy Generation and Distribution Infrastructure
		Strategies related to Energy Diversification
Goal 3	The Bahamas will become a world leader in the development and implementation of sustainable energy opportunities and continuously pursues	Strategies related to the economic, infrastructural, and planning conditions that will ensure the sustainable development of all of

Goal	Description	Strategies related to goal
	a diverse range of well-researched and regulated, environmentally sensitive and sustainable energy programmes, built upon our geographical, climatic, and traditional economic strengths	The Bahamas' renewable energy resources
		Strategies related to the introduction of key policy instruments (financial and fiscal) for the promotion of renewable energy
		Strategies related to the development of a dynamic legislative and regulatory environment, responsive to growth and development in the renewable energy sector
		Strategies related to enhancing technical capacity and public awareness of renewable energy through effective support for training programmes, information dissemination and ongoing communication by the Government
		Strategies related to sustained research and development (R&D) and innovation in existing and emerging RETs
Goal 4	The Bahamas will have dynamic and appropriate governance, institutional, legal, and regulatory framework advancing future developments in the energy sector underpinned by high levels of consultation, citizen participation and public-private sector partnerships	Key actions are outlined in the NEP.

In addition, The GOB has reconfirmed its commitment to energy security as a priority and ensuring reliable, affordable, sustainable energy sources, including a national target to achieve a minimum of 30% renewables in the energy mix by 2030.

4.2.1.2. Nationally Determined Contribution

The Commonwealth of The Bahamas submitted its Intended Nationally Determined Contribution (iNDC) to the UNFCCC as part of its Paris Agreement commitments in 2015 (The Government of Bahamas, 2015) and ratified the agreement on 22 August 2016, which then became its Nationally Determined Contribution (NDC), and a revised and updated NDC in November 2022. The Bahamas 2015 NDC indicated a mitigation target of an economy-wide reduction of GHG emissions of 30% when compared to its Business as Usual (BAU) scenario by 2030. In addition, the document noted that the Government defined the policy framework for a low carbon development plan through the National Energy Policy, which sets a national target to achieve a minimum of 30% renewables in the energy mix by 2030 and allow for a 10% Residential Energy Self Generation Programme within the year. The target will also be achieved through the forestry sector by reducing GHG emissions from land degradation and deforestation through the establishment of a permanent forest estate, 20% of which is designated into either one of three categories (forest reserves, protected forests and conservation forests) under the Forestry Act. These forestry sector GHG emission reductions have the potential to increase carbon sequestration of approximately 5,661.077 $GgCO_2$-eq across several pine islands in The Bahamas, according to The Bahamas submitted NDC.

The targets were conditional on access to required technologies, energy efficiency and conservation measures appropriate for The Bahamas, as well as economic growth and socio-economic progress. The costs for implementing the NDC targets were anticipated to be met through multilateral and bilateral support from various sources. However, The Bahamas is recognised as a high-income country according to the World Bank ratings and has limited access to grant and concessional financing.

4.3. Measures to Reduce GHG emissions

The measures to reduce The Bahamas' GHG emissions were assessed based on national circumstances, sustainable development goals, and national development priorities. The mitigation actions consider various aspects, including economic, social, environmental and GHG reductions capabilities. The actions are in various stages of planning, preparation and implementation. These actions were verified through multiple stakeholder engagements, including workshops, bilateral meetings, and surveys.

A review of The Bahamas’ existing climate change policies, sectoral action plans, strategies, and development priorities, as highlighted in the previous section, was undertaken to determine an initial list of mitigation actions. This list was further refined through stakeholder engagements. As a result, a total of forty-one (41) mitigation actions were identified for The Bahamas. These mitigation actions/strategies are divided into the following categories: Energy Demand, Electricity Generation, Transport, Agriculture, Land Use, Land Use Change and Forestry, Industrial Processes and Product Use and

Waste. The following section describes each action included in the mitigation strategy by sector.

4.3.1. Description of Mitigation Measures

Due to challenges with data collection and access to information, only the major islands of The Bahamas were considered in these mitigation actions. Table 101 shows the number of mitigation actions by sector. These mitigation actions have been enhanced from the Second National Communication (SNC) or are newly proposed actions. The energy sector contains over 80% of the mitigation actions identified as priority areas for the GOB.

Table 101 : Distribution of Mitigation Actions by Sector

Sector	Number of Mitigation Strategies
Energy Demand	13
Electricity Generation	14
Transport	7
Industrial Processes and Product Use (IPPU)	1
Agriculture	1
Land Use, Land Use Change and Forestry	3
Waste	2
Total	41

The description and status of each mitigation action are included in Sections 4.3.1.1 – 4.3.1.6**.**

4.3.1.1. Energy Demand

The mitigation actions identified in the Energy demand subsector are mainly based on the strategies identified in The Bahamas NEP 2013-2033. This subsector covers end-use consumption in the residential, commercial, tourism, industry and streetlighting areas. This sector does not include strategies and actions related to electricity generation and transport. Mitigation actions for energy demand primarily relate to affected changes in the end-use of electricity and fossil fuels. This includes changes in fuel and equipment used for cooling, refrigeration, cooking, appliance use, water heating, lighting and policies that would affect such changes. A total of **thirteen (13) mitigation actions** related to the **Energy Demand Subsector** were identified and are outlined in Table 102 below:

Table 102: List of Mitigation Action in the Energy Demand Subsector.

Sector	Energy Demand	
Status	**Action**	**Description**
Ongoing	Adoption and Implementation of Revised Building Code for all new buildings and renovations by 2025.	The Bahamas currently has a building code from 2003. The revised building code is expected to improve the minimum standards, provisions, and requirements for safe and stable building design and construction methods. Improving building design can reduce the energy demand and enhance resilience. The adoption and implementation of this revised building code will assist in the reduction of emissions for commercial and residential buildings. The revision of the building code is currently ongoing, with engagements of key stakeholders through workshops and webinars. The revised building code is expected to cover the entire Commonwealth of The Bahamas except for the Port area in Grand Bahama Island. In the 2013-2033 Energy Policy, the need to encourage the integration of renewable energy in building design of the physical planning process is highlighted (Ministry of the Environment and Housing, 2013). In addition, The Bahamas is also currently in the process of adopting the regional Energy Efficiency Building Code.
Ongoing	Energy Audits for All Government Occupied Buildings in New Providence by 2025.	Energy audits are instrumental in the identification of energy efficiency and renewable energy options for buildings. Initial energy efficiency measures and energy audits have been undertaken for some Government buildings in New Providence. New Providence is the most populous island, which contains the capital Nassau and over 70% of the population and the major Government buildings. This is considered an enabling action that will indirectly contribute to reducing emissions. The Bahamas Energy Policy includes strategies related to the Government becoming a leader in conservation and energy efficiency. This consists of the accelerated use of energy-efficient equipment in Government operations (Ministry of the Environment and Housing, 2013).

Sector	Energy Demand	
Status	**Action**	**Description**
Ongoing	Energy Audits for All existing Hotels and Industrial facilities by 2025 and implementation of some measures.	The tourism and industrial sectors are vital economic drivers for The Bahamas, and the hotels are critical areas for high consumption during peak tourism season. Currently, diesel is used in backup generators that provide electricity in some service sector facilities. Therefore, the identification and implementation of energy efficiency and renewable energy measures would play a crucial role in reducing energy consumption and GHG emissions. This is an enabling measure for the introduction of energy efficiency and distributed renewable energy building measures. Initial energy-efficiency measures and energy audits have been undertaken for some hotels. In addition, the Bahamas Energy Policy includes a strategy to encourage businesses to conduct independent energy audits (Ministry of the Environment and Housing, 2013).
Ongoing	Lighting Retrofits for all Government Occupied Buildings in New Providence by 2030.	The adoption of lighting retrofits is usually seen as a quick and low-cost energy efficiency measure in buildings. This energy efficiency measure will help reduce the energy demand in government buildings. This measure is expected as one of the first identified actions of the energy audits. Lighting retrofits have been conducted for some government buildings in New Providence. However, a detailed accounting of these retrofits needs to be completed, to inform further improvements in lighting retrofits as the action continues.
Ongoing	Public Awareness Campaign for Energy Efficiency and Energy Conservation by 2033.	Public education and awareness are essential mechanisms to minimise GHG emission reductions. Information on types of available energy-efficient equipment may encourage an increase in the uptake of these measures to conserve energy. A comprehensive education and awareness plan is expected to be developed for energy efficiency and energy conservation. This strategy is also highlighted as an effective strategy in The Bahamas Energy Policy.
Ongoing	Streetlighting retrofits by 2033.	Retrofits of streetlights, commonly high-pressure sodium (HPS) bulbs, to either LED or solar lights to help reduce energy consumption. There are

Sector	Energy Demand	
Status	**Action**	**Description**
		currently 46,000 streetlights managed by The Bahamas Power & Light Company (BPL), with 52% HPS, 22% mercury vapour and 2% metal halide. Approximately 35,000 streetlights are being replaced with LEDs by BPL. In December 2018, the Caribbean Development Bank reported the approval for funding to replace 30,500 existing streetlights in The Bahamas with more energy-efficient LED lights (Caribbean Development Bank (CDB), 2018). The project was approved for a loan of 14.5 million dollars and is currently being implemented with an expected reduction to the cost of electricity for street lighting by 20%.
Ongoing	Increase solar water use by 40% for the Bahamas by 2030.	In 2014 The Bahamas completed a project funded by the Global Environment Facility (GEF) called Promoting Sustainable Energy in The Bahamas (GEF, n.d.). The project provided for the installation of some solar water heaters in the residential sector. The Bahamas energy policy reiterates the need to replace electrical and LPG water heaters with solar water heaters to help reduce energy consumption and emissions.
Planned	Introduce incentives for solar water heater installation by 2025.	Incentives are expected to encourage the adoption and installation of more solar water heaters. The Bahamas Energy Policy indicates that the Ministry of Finance will be responsible for developing a programme of incentives and fiscal measures to enable and support investments in energy efficiency and conservation initiatives (Ministry of the Environment and Housing, 2013).
Planned	Energy Labelling program for all appliances by 2033.	Mandatory labelling standards to inform consumers on energy efficiency of appliances. The Bahamas, as part of CARICOM, is involved in the CARICOM Regional Energy Efficiency Labelling Scheme (CROSQ Energy, n.d.). This scheme is being piloted in four countries, but others will be able to join and benefit from the lessons learnt. In addition, The Bahamas Energy Policy includes a strategy to promote energy-efficient standards and product labelling (Ministry of the Environment and Housing, 2013).

Sector	Energy Demand	
Status	**Action**	**Description**
Planned	Establish a finance mechanism to increase access to low-interest loans for EE and RE measures by 2025.	This finance mechanism is expected to facilitate sourcing low-cost development funds for energy and energy efficiency projects for productive enterprises. This will allow businesses and residents to access low-interest loans to finance energy and energy-efficient projects by establishing a special fund. The Bahamas Energy Policy speaks to the design and introduction of an appropriate financing mechanism to facilitate the spread of energy-efficiency and renewable energy technologies (Ministry of the Environment and Housing, 2013).
Planned	Energy Efficient Standards for air conditioning systems by 2025.	Mandatory standards for air conditioning will encourage the adoption of more energy-efficient equipment. A shift to more energy-efficient air conditioning systems will reduce consumers' energy consumption and long-term costs. In addition, The Bahamas Energy Policy includes a strategy to promote energy-efficient standards and product labelling (Ministry of the Environment and Housing, 2013). In addition, seawater district cooling is practised in some hotels in the Bahamas, a technology that can significantly reduce emissions from the cooling sector.
Ongoing	Promotion of Energy Efficiency in Water production by 2033.	Water production in the Bahamas is an energy-intensive process (reverse osmosis). Therefore, introducing energy-efficient measures will reduce energy costs and reduce emissions involved in water production in The Bahamas.
Ongoing	Five (5) carbon-neutral Marine Protected Area facilities (photovoltaic substitute for diesel generators) by 2030.	This action is part of a GEF funded project – Meeting the Challenge of 2020 in The Bahamas. Replacing diesel generators with photovoltaic systems will demonstrate the social, environmental, and economic feasibility of climate change mitigation. This is achieved by implementing innovative carbon-neutral solutions to provide electricity at the marine protected areas and reduce risks associated with the use of diesel, such as pollution/storage. The use of diesel fuel requires the storage of bulk fuels on the islands and the transfer of fuel from bulk storage to monthly storage for daily use. This storage and transfer process increases the risk of a spill into the water

Sector	Energy Demand	
Status	Action	Description
		or ground resources of the park. The proposed sites are (i) Visitors Centre for Warderick Wells (ECLSP), (ii) West Andros Fee collection booth, (iii) Bonefish Pond high visibility demo, pilot (BEST Commission, Department of Marine Resources (DMR), Bahamas National Trust (BNT), The Nature Conservancy (TNC), Department of Agriculture, 2017).

4.3.1.2. Electricity Generation

The electricity generation sector covers the electricity supply from centralised and distributed generation, policies to enhance mitigation strategies for electricity generation and plans to improve electricity supply. This sector encompasses all fuels combusted for electricity generation. These mitigation actions include renewable energy generation, renewable energy assessments and improvement in the transmission and distribution network. A shift to more renewables in the energy generation subsector will significantly reduce total national GHG emissions.

The GOB has made efforts to increase its energy security by including in its NDCs specific targets for renewable energy penetration and developing The Bahamas National Energy Policy. A major strategy in The NEP is the diversification of energy. Furthermore, with the Inter-American Development Bank's (IDB) support, approval was given for a USD 170 million Conditional Credit Line for Investment Project (CCLIP). This project is expected to advance the deployment of renewable energy in The Bahamas. In addition, several renewable energy systems have been installed on some of the smaller islands in The Bahamas, including but not limited to, Over Yonder Cay with a 1MW solar facility, 300kW wind facility and 6MW battery bank, Chub Cay with 4MW solar plant and a 2MW battery bank and Ragged Island with the installation of a 390kW solar system and 1.26MWh battery storage system.

A total of **fourteen (14) mitigation actions** related to the **Electricity Generation Subsector** were identified and are outlined in Table 103 below.

Table 103: List of Mitigation Action for the Electricity Generation Subsector

Sector	Energy Generation	
Status	Action	Description
Planned	Assessment of Renewable Energy Potential Across all	Fossil fuels currently dominate the Bahamas energy mix. However, The Bahamas has committed to 30% renewables in electricity generation by 2030. An assessment of renewable energy potential will help

Sector	Energy Generation	
Status	**Action**	**Description**
	occupied Islands by 2025	identify possible locations for renewable energy projects and interventions.
Planned	30% Renewables on each major island by 2030	The Bahamas declared this target in their 2015 NDCs, highlighted in its Energy Policy. The Ministry of the Environment and Natural Resources is currently assessing how to develop the best course of action.
Planned	3MW Solar farm in Grand Bahama by 2025	The Grand Bahama Power Company has indicated plans to construct a 3MW solar farm on 11 acres of land near the West Sunrise Plant. Although plans were close to being concluded in 2018, the company has not begun the installation of the solar farm.
Ongoing	3MW of distributed generation in Grand Bahama through the Renewable Energy Rider program by 2025	The renewable energy rider (RER) introduced by the Grand Bahama Power Company allows customers to connect up to 150kW of wind or solar PV systems through distributed generation to the grid. The system is permitted to be sized to produce 1.5 times the average monthly consumption up to a limit of 150kW.
Proposed	Additional 30MW of Solar PV Installed by 2030	A move to renewables will significantly assist in achieving emissions reduction. This action was proposed to help achieve the general target of 30% renewables. The SNC proposed that 17MW of solar be installed in The Bahamas; this original target was nearly doubled for the Third National Communication. It is expected that the 30MW would include only utility-scale solar systems.
Proposed	Installation of 20MW of wind power Installed by 2030	A move to renewables will significantly assist in achieving emissions reduction. This action was proposed to help achieve the general target of 30% renewables. The Bahamas has completed several studies on the wind energy potential around the islands. The Fitchner report of 2010 indicates that the total site potential for wind is over 200MW in The Bahamas (Fichtner, 2010).
Ongoing	Installation of 10MW of distributed generation on rest of islands by 2030	Bahamas Power and Light (BPL) has established a small-scale renewable generation (SSRG) programme. For the islands of Abaco, Eleuthera and Exuma: Residential customers, the capacity limit is 3kW + Average Customer Demand with a ceiling limit of 50kW. For commercial customers, the limit is 25kW + average customer demand with a ceiling of 50kW. The maximum allowed capacity is 500kW. For the islands of Long Island, Bimini, San Salvador, North Andros, Central Andros, South Andros, Inagua, Cat Island, Great Harbour Cay, Black Point and Stanyel Cay (Exuma): Residential customers, the capacity limit is 2kW + Average Customer Demand with a

Sector	Energy Generation	
Status	**Action**	**Description**
		ceiling limit of 30kW. For commercial customers, the limit is 15kW + average customer demand with a ceiling of 30kW. The maximum allowed capacity is 250kW. For All other family islands: For residential customers, the capacity limit is 1kW + Average Customer Demand with a ceiling limit of 10kW. For commercial customers, the limit is 5kW + average customer demand with a ceiling of 10kW. The maximum allowed capacity is 25kW
Planned	Upgrade incentives for renewable energy systems by 2025	The Bahamas has made several strides to promote renewable energy systems and encourage the shift to cleaner, more reliable energy. These include the introduction of zero tariffs on solar equipment to encourage adoption in the residential sector.
Proposed	Integrated resource and resilience plan for Grand Bahama Power Company and Bahama Power and Light by 2025	Several hurricanes have impacted the Bahamas over the years. As a result, resource and resilience planning is being discussed at various levels to be implemented. As a member of CARICOM, the Council for Trade and Economic Development (COTED) has highlighted the need for all members to undertake IRRPs.
Ongoing	10 MW of installed distributed generation through a Renewable Energy Rider for Bahamas Power and Light (BPL) customers in New Providence by 2024	Bahamas Power and Light (BPL) has established a small-scale renewable generation (SSRG) programme. For New providence: Residential customers, the capacity limit is 5kW + Average Customer Demand with a ceiling limit of 100kW. For commercial customers, the limit is 50kW + average customer demand with a ceiling of 100kW. The maximum allowed capacity is 10MW.
Ongoing	Installation of approximately 1.2MW of distributed generation on 9 Government Facilities by 2030	The Ministry of Environment and Natural Resources has undertaken a detailed design of PV systems at the various locations and estimated the capacity of the system possible at each location. Funding for the project needs to be sourced to commence implementation. 1.2 MW will consist of the following: Roof-mounted systems: 12.0 kW at the House of Assembly and Senate Buildings; 51.0 kW at C. I. Gibson Senior High School; 56.1 kW at Uriah McPhee Primary school; 83.1 kW at Doris Johnson Senior High School; 136.2 kW at T.G. Glover Primary School; 76.5 kW at Customs Headquarters; 73.2 kW at Ministry of Education Building; 167.1 kW at C.V. Bethel Senior High School; Carport Systems:

Sector	Energy Generation	
Status	**Action**	**Description**
		475.5 kW at the Office of the Prime Minister. The total cost of the installation is estimated at 3.78 million dollars (BSD).
Planned	Reduce Transmission and Distribution losses by 2% by 2030	Reducing transmission and distribution losses minimises the amount of electricity required to meet demand. Capital investments are required for the acquisition of transmission equipment and meters. The Bahamas Light and Power indicates that transmission and distribution losses for their grid operations are in the range of 10.88%. A reduction in T&D losses will improve system-wide energy efficiency in the electricity supply, reducing GHG emissions from generation.
Ongoing	Pilot Project for a 30kW Ocean Thermal Energy Conversion (OTEC) Plant by 2030	The Bahamas is currently in discussions with CARICOM, CCRREE, CCCCC and SIDS DOCK to develop a pilot OTEC plant. However, OTEC is still seen as being in its experimental stage globally. Still, The Bahamas has a reverse geothermal energy profile, and it may be possible to obtain the necessary temperature difference for OTEC from deep wells rather than cold seawater.
Planned	Installation of 15MW Waste to Energy by 2030	A proposal is currently being developed to be submitted to the Green Climate Fund for assessment and funding. The waste to energy plant will serve for energy generation and assist in waste management on the islands.

4.3.1.3. Transport

From the latest National Inventory Report of The Bahamas, the transport sector remains the second-largest GHG emitting subsector for Energy in The Bahamas. The majority of these emissions are estimated from road transport. Since 2013, The Bahamas has drafted regulations to limit vehicle emissions for road transport. These regulations highlight the maximum emissions standards for vehicles by type and model year (Environment Health (Vehicle Emissions) Regulations, 2013). In addition, the NEP identifies specific strategies for the transport sector, some of which are incorporated in the mitigation actions.

Significant gaps in data and information on energy usage, total number, and types of vehicles in The Bahamas still exist. As a result of this lack of data, the mitigation actions in the transport sector are related to changes in energy use in passenger road vehicles only because sufficient data is available for this subset of vehicles. Mitigation actions for marine, aviation and freight sectors are not included. Historical information on total fuel and the number and type of vehicles was estimated based on available local, regional, international data, and expert reviews.

The mitigation actions in the transport sector include electrification of the transport fleet, improvement in public transit and improvement in vehicle efficiency standards. A total of **seven (7) mitigation actions** related to the **Transport subsector** were identified and are outlined in Table 104 below.

Table 104: List of Mitigation for the Transport Subsector

Sector	**Transport**	
Status	**Action**	**Description**
Planned	Standards implemented for vehicle fuel efficiency by 2025	Improved fuel efficiency reduces the demand for fuel in vehicles and therefore reduce the consumption of fossil fuels. Although The Bahamas does not currently have standards for vehicle fuel efficiency, there are existing regulations limiting vehicle emissions from 2013.
Planned	Improved Incentives for electric vehicles by 2025	Improved incentives for electric vehicles will enhance the attractiveness of electric vehicles for the public and increase the purchase of electric vehicles, thereby reducing fossil fuel consumption. The Bahamas currently has incentives on electric vehicles with import duties reduced to 10% for vehicles with a landing price of $50,000 (BSD). However, these incentives need to be revised to encourage increased uptake of electric vehicles.
Planned	Assessment of Government vehicles and program for replacement of suitable vehicles to electric vehicles by 2025	A fleet assessment should be conducted to effectively transition to electric vehicles and prevent stranded assets. This fleet assessment will identify suitable electric vehicle replacement for internal combustion engine (ICE) vehicles and create a plan for replacement based on age and use of vehicles
Ongoing	Introduction of electric vehicles to Government Fleet by 2033	Based on the vehicle transition plan developed, The Government of The Bahamas will begin implementing the transition. Through the office of the Prime Minister, the Government of the Bahamas implemented a pilot project in 2016 with the leasing of 12 electric vehicles. The lease was renewed, and vehicles were replaced in 2020, but the Government has undertaken no further initiatives.

Sector	Transport	
Status	**Action**	**Description**
Ongoing	Installation of charging stations for electric vehicles by 2033	Proper infrastructure such as a charging station needs to be installed to transition to electric vehicles. This is an enabling factor to increase the penetration of electric vehicles and ease customer range anxiety. The GOBH currently has one level three (3) charger installed at the Thomas A. Robinson Sports Stadium received from the Abu Dhabi Caribbean Renewable Energy Fund. In addition, a further 12 chargers are located at various business locations, including the national art gallery, and over one hundred (100) personal charging stations have been installed in New Providence. The installation of charging stations is currently ongoing.
Ongoing	Increase sales of electric vehicles to 35% and hybrid vehicles to 15% by 2030	The adoption of electric vehicles simultaneous with the transition to renewables will help reduce fossil fuel consumption in the transport sector. The Bahamas currently has approximately 7% electric vehicles share of the new car sales locally. There is one EV company, but other local importers are on the island. In addition, the Government began a pilot project in 2016 to introduce electric vehicles in the government fleet.
Planned	Promotion of the use of Public Transport by 2033	Increased access to the public transport and increased reliability may help reduce the use of private vehicles, causing a modal shift and thereby reducing the fossil fuel consumption in the transport sector and assisting in traffic management. The public transportation system requires reform as well to encourage public use. Gender-sensitive training was recommended during the stakeholder workshop for bus drivers.

4.3.1.4. Industrial Processes and Product Use (IPPU)

The Industrial Processes and Product Use (IPPU) Sector includes anthropogenic emissions from industry productions processes that are not related to or as a result of fuel combustion. Based on stakeholder consultations and data collection efforts, there does not appear to be industrial production in The Bahamas that leads to significant industrial processes GHG emissions. The only direct GHG emissions are related to hydrofluorocarbons (HFCs) imported into The Bahamas through the stock of refrigerators and air conditioners that contain HFCs and bulk imports used to recharge refrigeration and air conditioning products. Although it is known amongst experts in the country that HFCs exist on the islands, there is a significant lack of data and information on the exact amount.

The Bahamas is actively preparing to implement the Kigali amendment to the Montreal Protocol, which will phase down the consumption of HFCs in the case of The Bahamas.

As a result, mitigation action for the IPPU sector is related to the phase-down of HFCs due to The Bahamas eventual ratification of the Kigali Amendment.

The latest GHG Inventory does not include estimates for this sector due to lack of data, and as a result, baseline emissions for this sector were unavailable. **One (1) mitigation action** related to **IPPU Sector** was identified and is outlined in Table 105 below.

Table 105: List of Mitigation Action for the Industrial Processes and Product Use (IPPU) Sector

Sector	**Industrial Processes and Product Use (IPPU)**	
Status	Action	Description
Preparation	20% Phase Out of HFC by 2030	The Government of the Bahamas is preparing the necessary instruments and planning its execution of national requirements to support the ratification of the Kigali Amendment to the Montreal Protocol. The Government is conducting activities needed to enhance its capacity within the refrigeration and air conditioning servicing sector through the management (use, storage, transportation, and disposal) of current-controlled substances and introducing alternative sources. Additionally, the strengthening of existing regulatory import/export licensing systems for substances including hydrofluorocarbons (HFCs) and hydrofluorocarbon alternatives are being assessed to maintain a registry and provide a proper management system for these products.

4.3.1.4.1. Agriculture

The Bahamas agricultural activities contribute to GHG emissions through a range of different processes. Based on the latest national inventory estimates, methane (CH_4) and nitrous oxide (N_2O) are the major contributors to GHG emissions in this sector.

Mitigation in the agriculture sector comes from improved sequestration through the sustainable practices of agroforestry. In the Pine-Island Forest/Mangrove Innovation and Integration (Grand Bahama, New Providence, Abaco and Andros) project, one component is sustainable agroforestry practices, funded by the GEF. Under the Ministry of Agriculture, more agroforestry projects are currently being developed, but planning is in the very early stages. **One (1) mitigation action** related to **Agriculture Sector** was identified and is outlined in Table 106 below.

Table 106: List of Mitigation Actions for the Agriculture Sector

Sector	Agriculture	
Status	Action	Description
Ongoing	Sustainable agroforestry practices in Andros, Grand Bahama, Acklins, Crooked Island, Planna and Samana Cays by 2025	The Pine-Island – Forest/Mangrove Innovation and Integration (Grand Bahama, New Providence, Abaco and Andros) project will target non-timber forest products with a multi-pronged approach to improving livelihoods whilst ensuring the sustainability of the resources. Two projects' areas were selected: Palm cultivation on Andros and Grand Bahama and sustainable Cascarilla cultivation on Acklins, Crooked Island, Planna and Samana Cays. Integrating natural biodiversity, species and trees with crops and livestock will increase emission sinks from native trees, decrease fertiliser use, increase habitat and build resilience against one-off diseases.

4.3.1.5. Land use, Land Use Change and Forestry (LULUCF)

Land Use, Land Use Change and Forestry (LULUCF) covers removals by sinks on managed lands and protected areas. The LULUCF sector includes estimates of emissions and removals of GHGs associated with the increase or decrease of carbon in living biomass; this occurs as land-use changes occur over time. The Bahamas lies within the tropical belt, and therefore its Forestry sector is prone to extreme weather-related events such as intense Hurricanes and other factors, including illegal harvesting. As a result, emissions in the sector fluctuate, which makes it difficult to project and estimate potential future emissions and removals. Despite these many challenges, The Bahamas Forestry Department continues the efforts to improve the data for the LULUCF sectors; efforts are on the way to establishing permanent plots to monitor growth rates and carbon sequestration rates. **Three (3) mitigation actions** related to **LULUCF Sector** were identified and are outlined in Table 107 below.

Table 107: List of mitigation actions for the LULUCF Sector

Sector	Land Use, Land Use Change and Forestry (LULUCF)	
Status	**Action**	**Description**
Ongoing	The establishment of a Forestry Estate on 283,750.18 hectares (20% of the total land cover of The Bahamas) comprised of areas to be established as: Conservation Forests (149, 396.99 hectares), Forest Reserves (96,542.61 hectares), and Protected Forests (37,810.58 hectares) on Abaco, Andros, Grand Bahamas and New Providence by 2025. (Government of The Bahamas, 2012)	The Pine Island project seeks to innovate community management plans for newly gazetted forest areas, to integrate biodiversity concerns and adopt best practices in sustainable land use, Forestry and agroforestry.
Ongoing	Reestablishment & rehabilitation of 50 ha of Davis Creek, Andros Ecosystem by 2025.	Reestablishment and rehabilitation of Davis Creek in Andros will improve sequestration potential
Proposed	Sustainable land-use practices to result in zero emissions in the LULUCF sector by 2045.	The Bahamas LULUCF sector is responsible for over 45% of total national emissions. This action is considered ambitious owing to the various challenges faced in the LULUCF sector, as mentioned above.

4.3.1.6. Waste

The waste sector includes emissions from solid waste disposal and wastewater treatment. The Bahamas recently changed ownership of the New Providence Sanitary Landfill from the Department of Environmental Health Services to the New Providence Ecology Park (NPEP) in 2019. Although the NPEP is only on one island, it is estimated that it handles close to eighty per cent (80%) of the waste in The Bahamas. The NPEP has remediated the existing dumpsite and significantly reduced subsurface fires. The plans are to implement modern waste handling practices, including environmental monitoring, upgrade to collect landfill gas, expand composting and recycling systems. Historical data for the site before 2019 is very limited and therefore hinders the selection of mitigation actions.

Currently, close to twenty per cent (20%) of the waste stream is diverted to composting at the NPEP, of which sixteen per cent (16%) is green waste, and four per cent (4%) is construction debris. The expectation is that within 3-5 years, all organic waste, which is about thirty per cent (30%) of the total waste stream, will be diverted to composting.

The NPEP also plans to introduce a recycling facility at the current location. The recycling facility will be able to sort and shred plastics, aluminium, and cardboard, to name a few. It is estimated that more than nine per cent (9%) of the total waste stream is plastics. The

Government has recently included a recycling programme to their list of initiatives. The recycling facility and programme coupled with the composting programme will significantly reduce waste directed to the landfill.

Mitigation in the waste sector comes from waste management, composting practices, and recycling programmes. **Two (2) mitigation actions** related to **Waste Sector** were identified and are outlined in Table 108 below.

Table 108: List of Mitigation Actions for the Waste Sector

Sector	**Waste**	
Status	**Action**	**Description**
Newly proposed	Development of a waste management system to include composting systems by 2030.	Composting breaks down food and green waste and can be used as a soil amendment. This reduces the amount of organic waste going into landfills. Good composting practices assist in minimising GHG emissions. This proposed action is modelled after other Caribbean islands' mitigation action for waste and plans identified by the New Providence Ecology Park (NPEP) team.
Newly proposed	Introduction of a National Recycling Programme by 2030.	Recycling is the reprocessing of materials (mainly used) into new products. This programme will help reduce the waste entering the landfills, reduce consumption of raw materials, reduce energy usage and GHG emissions. It is a key component to waste management practices.

4.3.2. International Market Mechanisms

The Bahamas is a non-Annex 1 Party to the Kyoto Protocol, and was therefore eligible to participate in the Clean Development Mechanism (CDM). However, The Bahamas currently has no projects registered with the CDM or other international markets.

Following the conclusion of negotiations on Article 6 of the Paris Agreement, specifically the Glasgow Climate Pact and Sharm-el-Sheikh Implementation Plan, highlighted the need to encourage small and micro business in the mechanism, particularly in the least developed countries and small island developing states.

The Government of The Bahamas has indicated a strong interest in pursuing suitable, beneficial projects in the International Markets, and has put in place legislation and is advancing institutional arrangement to participate in Article 6 Cooperative Approaches and Voluntary Carbon Markets.

4.4. GHG Emissions Projection

4.4.1. Overview of methodology

The analysis of the GHG mitigation potential in The Bahamas was developed using the Low Emissions Analysis Platform[53] (LEAP), a software tool developed by the Stockholm Environment Institute (SEI) and widely used for energy policy analysis and climate change mitigation assessments. LEAP is an integrated, scenario-based modelling tool that can be used to quantify energy consumption and production and resource extraction in all sectors of the economy and under different scenarios. In addition, it allows for the consideration of both sources and sinks of GHG from the energy sector and the non-energy sector.

The model for The Bahamas developed in LEAP simulates the evolution of energy demand and supply in the country, as well as the emissions corresponding to the energy and non-energy sectors, and the mitigation potential of a series of sectoral measures. The model covers The Bahamas as a whole, with a regional resolution for the three major island groupings: New Providence, Grand Bahama, and The Family Islands. It covers the period from 2010 to 2050, with projections starting in 2019, as the inventory data was only available up to 2018. The 2000-2018 period provides historical context, reflects the most recent economic, demographic and energy statistics in The Bahamas, and has been calibrated to closely match the most recent GHG inventory (within 0.4% of total emissions).

The prospective period (2019-2050) uses GDP and population growth projections as the main drivers of energy demand, and to the extent possible, captures the estimated economic impact of COVID-19. Energy consumption has been disaggregated by sector and fuel, including residential, transportation, industrial, services, and agriculture. Projections are based on historical energy balances, trends, and expected economic and demographic growth. The transport sector has been supplemented by a more detailed stock-turnover analysis that represents the stock and sales of different types of vehicles. The model represents power generation in terms of capacity expansion and dispatch of power plants and transmission and distribution losses on the supply side. The non-energy sector encompasses these emission categories from the inventory: fugitive emissions, industrial processes, product use (IPPU), agriculture, land use and land-use change (LULUCF), non-CO_2 sources on land, and waste.

Three future scenarios were developed to assess GHG mitigation potential: a baseline and two mitigation scenarios as described further below. Emissions were projected for each of the three scenarios, and the results were compared under the various scenarios.

[53] https://leap.sei.org/

The mitigation effects reported in this chapter are based on comparing the baseline scenario to the mitigation scenarios.

The three scenarios developed for The Bahamas are:

- **Baseline:** Illustrates where emissions for The Bahamas are headed, assuming current trends in demographic and macroeconomic drivers, as well as in sectoral energy intensity. It also assumes modest energy efficiency improvements, which can be expected even in the absence of government policies.
- **Mitigation:** It uses the same macroeconomic and demographic assumptions as the baseline and explores the implementation of a set of mitigation actions and measures as highlighted in section 4.2.1.1 - 4.2.1.2**,** which were assessed for data availability and applicability for mitigation modelling. Actions are mainly concentrated in the energy and LULUCF sectors and were modelled either as single strategies or bundled with similar strategies. On top of these actions, this scenario considers the additional buildup of solar PV to meet the 30% renewable target from the NDC by 2030. However, results indicate that this was not enough to reach the NDC's 30% GHG reduction target by 2030.
- **Ambitious Mitigation:** It includes the same assumptions and mitigation actions as above but also explores further solar PV development, higher integration of electric vehicles, zero emissions from the LULUCF sector by 2045, and other additional mitigation measures in various sectors. This scenario meets the 30% renewable and 30% GHG reduction targets from the NDC by 2030 (as seen in sections 4.3.1.1 – 4.3.1.6).

By building the model for The Bahamas' mitigation assessment analysis within LEAP, the model is readily available for future updated mitigation assessments. In addition, in-country experts were trained on using LEAP to ensure that the government institutionalises the capacity to use the model.

A stakeholder validation workshop was held to review and validate the assumptions, analysis, and conclusions of The Bahamas Mitigation Assessment with LEAP. The model was updated to reflect feedback from the stakeholder validation workshop.

4.4.2. Baseline Scenario Description

The baseline scenario corresponds to the counterfactual scenario used to compare emissions and to estimate the mitigation potential of the modelled actions. The baseline scenario explicitly does not consider the targets, goals, and projects of the mitigation strategy; rather, the scenario reflects a continuation of existing trends and modest energy efficiency improvements and shifts in technologies that are expected to happen even in the absence of new policies.

In the baseline, future emissions are estimated based on the modelling of the energy demand, supply and non-energy sectors, which in turn are driven by historical trends and by projected macroeconomic indicators, such as population, number of households, GDP, and GDP per capita. The same macroeconomic drivers are used for the baseline and the mitigation scenarios.

Based on projections from United Nations World Population Prospects (United Nations-World Population Prospects, 2021), the total population in The Bahamas will grow from 393 thousand in 2020 to 427 thousand in 2030 and 463 thousand in 2050 (Figure 68a). The total number of households will grow from 117 thousand in 2020 to 161 thousand by 2050 (Figure 68b). In terms of economic growth, near term projections from the International Monetary Fund (IMF) World Economic Outlook were used until 2025 (IMF WEO, 2021). These projections consider the impacts of COVID-19 on GDP (Figure 69), where a decrease of 16.6% in the GDP for 2020 was estimated. From 2025 to 2050, national-level GDP growth rates from the Shared Socioeconomic Scenarios database (SSP2="Middle of the Road") were used (Keywan Riahi et al, 2017). The same GDP growth rates were used for all island groups.

Figure 68: Population (a) and household (b) trends to 2050

(a) Population (b) Households

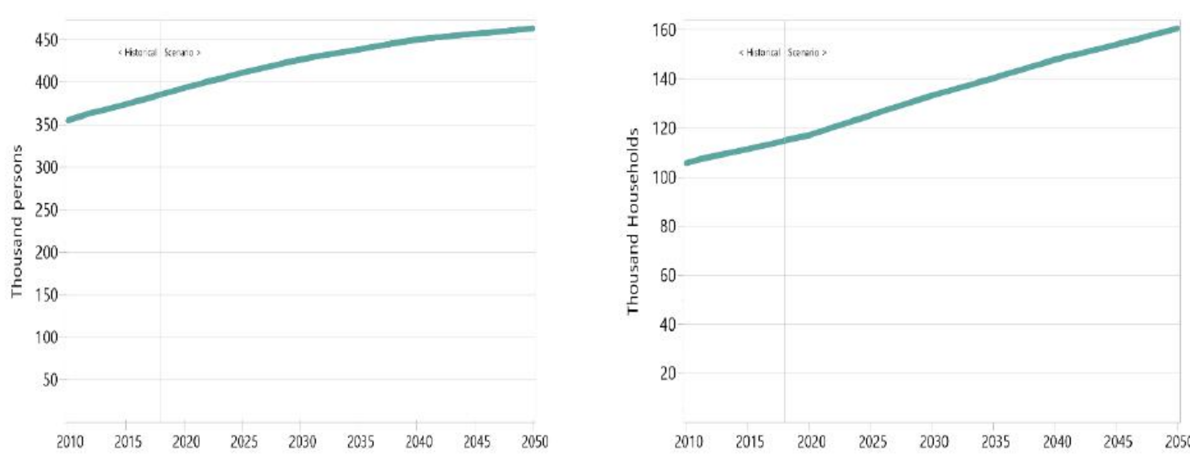
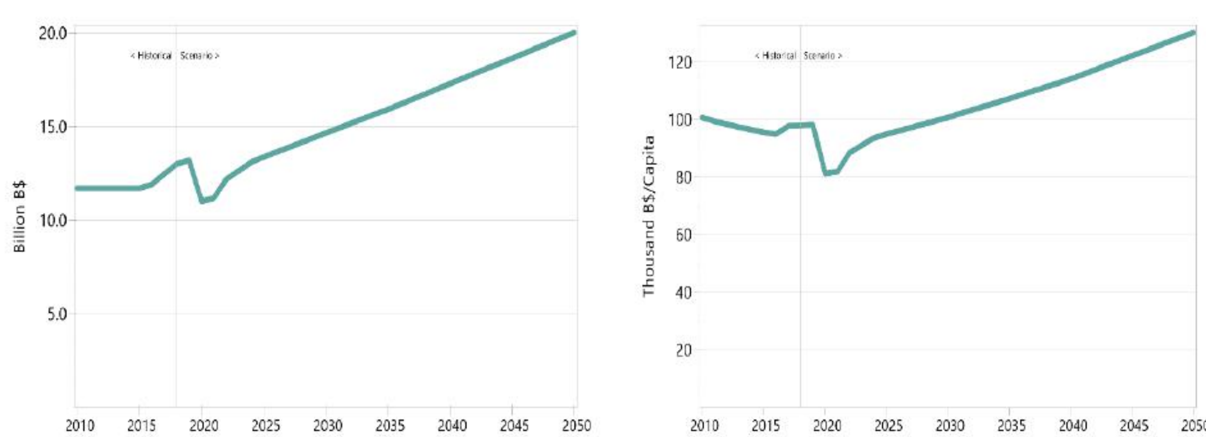


Figure 69: GDP (a) GDP per capita (b) trends to 2050

(a) GDP (b) GDP per capita



Baseline GHG emissions for all sectors, gases and regions are shown in Figure 70 to Figure 72. Total GHG emissions for 2010 and 2018 were estimated at approximately 6133.2 $GgCO_{2}$-eq and 6144.3 $GgCO_{2}$-eq, respectively. For the prospective period, the baseline presented corresponds to the best available realistic projection of future emissions based on current trends and market influences. The key driver used for the baseline GHG emissions projections in the majority of the sectors is GDP except residential demand, which is the number of households; waste, which is the population; and the LULUCF sector, which is estimated to remain constant through the projections at 2979.1 $GgCO_{2}$-eq. The final energy intensity for all sectors is expected to decline by 0.5% annually. Projected GHG emissions in the residential sector are expected to increase by 9.3% from 2018 to 2030. In the services sector and industrial sector, the projected GHG emissions are expected to increase by 6% from 2018 to 2030. The road transport and waste sector projected GHG emissions are expected to increase by 7% and 10.6%, respectively, from 2018 to 2030.

The total projected emissions reach approximately 6364.7 $GgCO_{2}$-eq in 2030 and 7173.5 $GgCO_{2}$-eq in 2050. As observed, LULUCF is an important net emitter of CO_2 and is responsible for more than 45% of the total emissions. From the energy sector, electricity generation and transportation are the most carbon-intensive sectors, contributing to 23% and 13% of the total emissions in 2030. Around 94% of the total emissions correspond to CO_2 (

Figure 71), and it is estimated that New Providence contributes to 70% of the total emissions in The Bahamas (Figure 72).

Figure 70: Projected GHG emissions in the baseline by sector

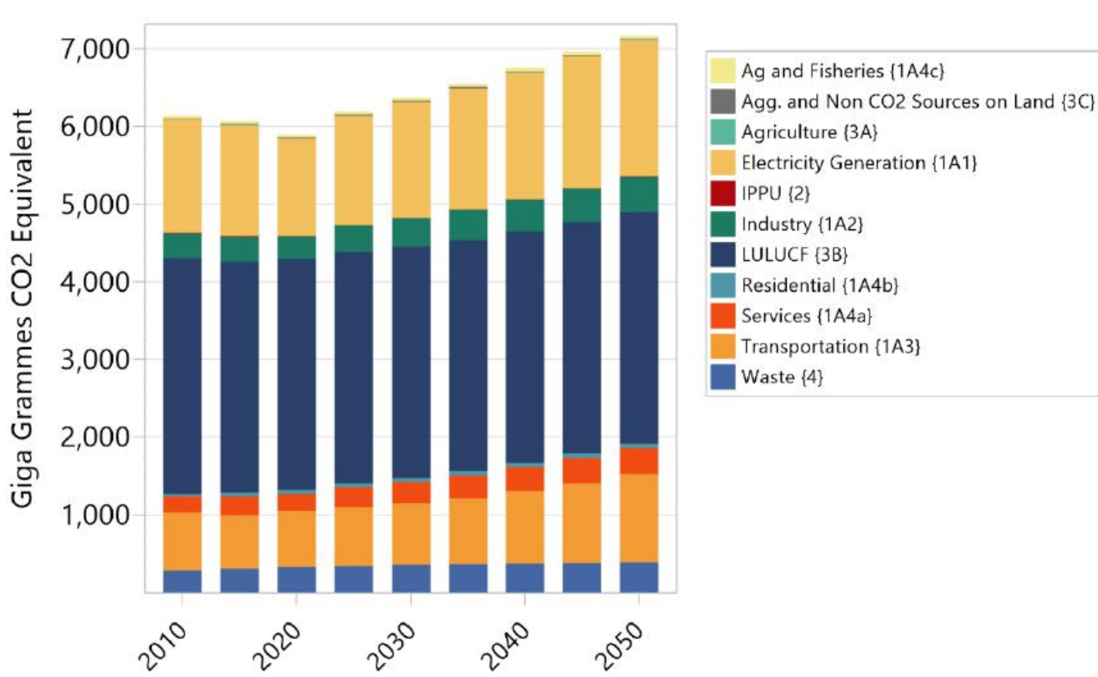


Figure 71: Projected GHG emissions in the baseline by gas

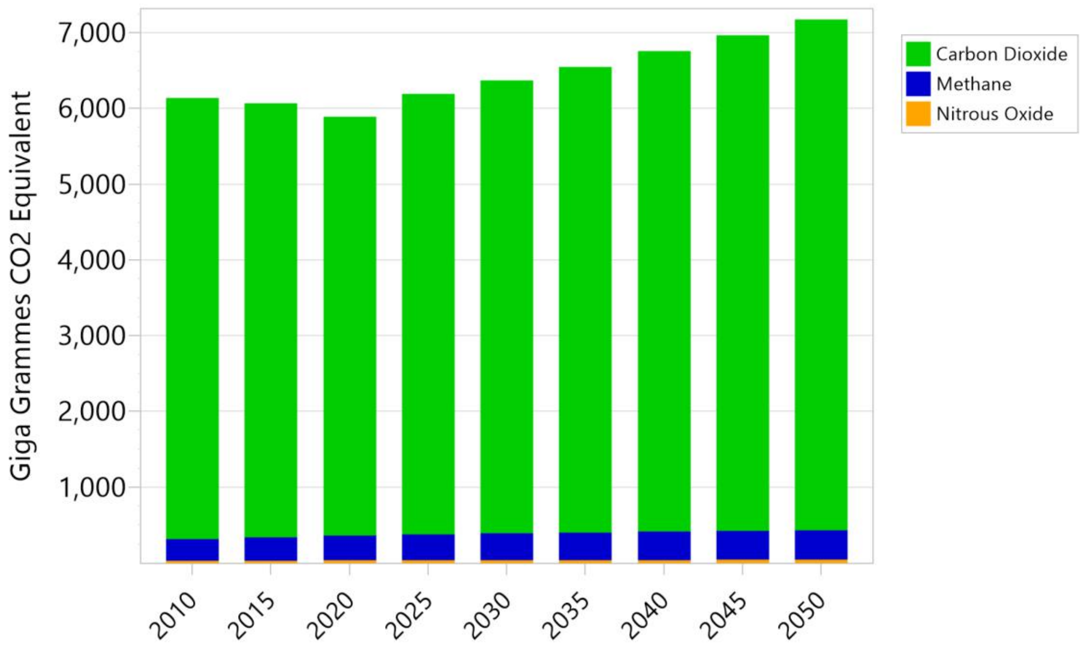
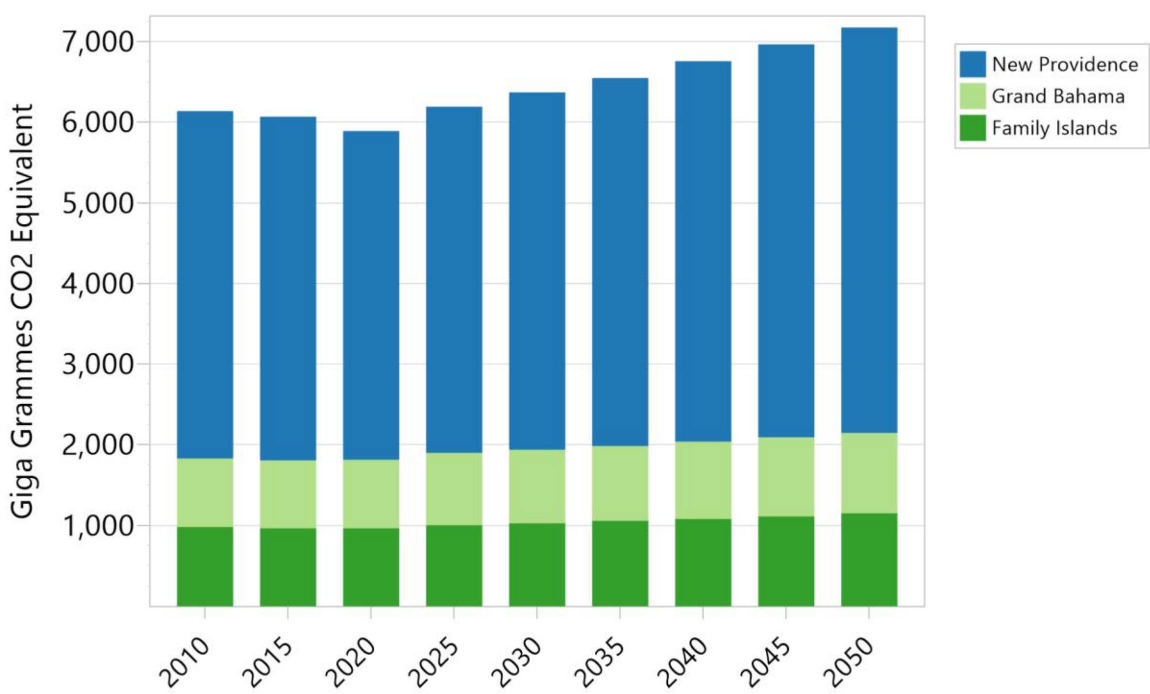


Figure 72: Projected GHG emissions in the baseline by region



4.4.3. Mitigation Scenarios(s) Description

4.4.3.1. GHG Emissions Projection Assumptions, by Sector

4.4.3.1.1. Energy Demand

The estimates of historical total energy consumption were mainly based on data obtained from The Bahamas' most recent inventory up to 2018. The data sources include 2010-2012 energy balances from the Latin American Energy Organisation (OLADE) (Latin American Energy Organisation (OLADE), 2015), The Central Bank of The Bahamas, Power Generators and Fuel Distributors - Rubis. A historical profile for fuel consumption in The Bahamas was developed using these data sets.

The historical energy consumption trends, together with key demographic and macroeconomic drivers, were used to project future energy demands by sector. The lack of more recent energy balances and the limited data available on energy end-use by sector limited the ability to conduct a bottom-up analysis of energy demand in The Bahamas. Therefore, the energy demand projections were only disaggregated by sector and fuel, and the policy measures in the residential, commercial and services sectors were represented as expected gradual energy savings, estimated outside of LEAP based on the technical characteristics, uptake rates, and other assumptions as described below in Table 109.

Table 109: Assumptions for mitigation actions in the residential, commercial and services sectors

Modelled action	Description	Main assumptions
Revised building codes	Adoption and implementation of a Revised Building Code that will impact all new construction of residential and non-government buildings between 2024 and 2030.	- The implementation of the revised code will reduce energy used for cooling and lighting by 25% in the new residential and commercial buildings. - 1132 new residential buildings per year are assumed, with average annual electricity consumption of 1835 kWh/household for lighting and 2618 kWh/household for air conditioning (AC). - 110 new commercial buildings per year are assumed, 86% of which are non-governmental. The average floor space is assumed as 1455 m^2/building, with average annual electricity consumption of 31.2 kWh/m^2 for lighting and 58.13 kWh/m^2 for AC. It is assumed that all new residential and commercial buildings will have AC.
Government building lighting retrofits	Lighting Retrofits for all government occupied buildings in New Providence.	- Approximately 14% of all buildings in New Providence are Government occupied, which represent 402 buildings. - The shift towards more efficient lighting will result in savings of 60% of the electricity used for lighting in these buildings. The retrofits are implemented starting in 2020 and reach 100% by 2030.

Modelled action	Description	Main assumptions
Street lighting retrofits	Streetlighting retrofits by 2033.	- There are approximately 46,000 streetlights in The Bahamas, including high-pressure sodium (HPS), mercury vapour, metal halide, incandescent, LED, and solar. - Streetlights are assumed to be in use for 12 hours per day. - 24% of the existing lights are LED, and less than 1% are solar. Starting in 2020 and by 2025, all other lights (estimated as 35,000 250 W lights) will be replaced by 70 W LED lights.
Solar water heaters	Increase adoption of solar water heaters by 40% for the Bahamas by 2030.	- Of the current 115,660 households, 60% use water heaters. The average annual energy consumption of water heaters is 1890 kWh/household. - There are currently 3946 commercial buildings with an average floor space of 1455 m^2/building. 10% of these buildings use water heaters with an average annual energy consumption of 2.15 kWh/m^2. - Currently, water heating is mainly electric or fueled with LPG. Only 5% of water heaters are solar. - By 2030, 40% of all water heaters will be solar
Efficient AC	Energy Efficient Standards for air conditioning systems by 2025.	- Same number of households, commercial buildings, and floor space as described above. - 60% of households have AC, with an average annual electricity consumption for AC of 2618 kWh/household. - All commercial buildings have AC, with an average annual electricity consumption for AC of 58.13 kWh/m^2. - The standards are assumed to consider a 30% increase in efficiency by 2030. In the ambitious scenario, the adoption of seawater cooling in hotels was modelled for more efficient cooling.

Modelled action	Description	Main assumptions
		- Currently, there are approximately 300 hotels in The Bahamas, with an average of 3425 m^2/building and an average annual electricity consumption for cooling of 50.4 kWh/m^2. - By 2030, 20% of all hotels will implement sea water cooling. - This technology reduces energy consumption for cooling by 80%.
Carbon neutral marine protected area facilities	Five (5) carbon-neutral Marine Protected Area facilities (photovoltaic substitute for diesel generators) by 2030.	- By 2030, 5x100 kW generators at 75% load factor and 25% efficiency will be replaced by PV systems
Distributed PV to replace diesel generators	Energy Audits for All existing Hotels and Industrial facilities by 2025. In addition, two actions were implemented 1. A fraction of the backup diesel generators in the service sector will be replaced by distributed solar PV systems. 2. Energy intensity improvements in the industrial sector.	For the ambitious scenario, in addition to the energy audits, some mitigation actions are considered. This includes the replacement of diesel generators with PV systems and a reduction in the energy intensity for the industrial sector. Currently, diesel is used in backup generators that provide distributed electricity in some of the service sector facilities. - In the ambitious mitigation scenario, by 2030, distributed solar PV systems will displace 30% of the diesel used in the service sector. - In the baseline and mitigation scenarios, energy intensity in industry decreases 0.5% per year. - In the ambitious mitigation scenario, energy intensity in the industry decreases by 2% per year.

4.4.3.1.2. Electricity Generation

The electricity generation assumptions determine the underlying GHG emissions from the supply and production of electricity. Data on electricity sales by sector was very limited and therefore constrained the ability to calibrate the energy supply from the model to observed historical data. Nevertheless, the LEAP model estimates projected electricity requirements and power generation capacity and dispatch from different types of power plants in each major island group.

In 2018, there were 767 MW of installed electricity generation capacity in The Bahamas, all of which corresponded to thermal power plants running on diesel and residual fuel oil. Based on the information provided by BPL, the transmission and distribution (T&D) losses in the BPL operated grid are estimated at 10.88%. The average T&D losses in the country are assumed to be 10% for the 2018-2030 period. In terms of generation capacity, the baseline scenario assumes that all additional capacity requirements are met by diesel generators.

The main assumptions for the renewable energy supply and T&D losses under different scenarios are described below in Table 110.

Table 110: Assumptions for mitigation actions in the power generation sector

Modelled action	Description	Main assumptions
T&D loss reduction	Reduction in the Transmission & Distribution losses in The Bahamas of 2 percentage points by 2030	The average T&D losses in the Bahamas will be reduced from 10% in 2018 to 8% by 2030.
Renewable power generation	Integration of renewable power generation in The Bahamas	- In the mitigation scenarios, the following renewable generation capacity is added to the system: • 3 MW utility-scale PV in Grand Bahama by 2025 • 3 MW distributed PV in Grand Bahama by 2025 • 30 MW of PV split among regions by 2026 • 20 MW of wind among regions by 2030 • 30 kW of OTEC by 2030 • 15 MW of Waste to Energy • 10MW distributed PV in New Providence by 2024 • 10 MW distributed PV on Family Islands by 2030

Modelled action	Description	Main assumptions
		• 1.2 MW of distributed generation on 9 Government Facilities 117 MW of additional solar PV capacity were added to the system in both the mitigation and ambitious mitigation scenarios to meet the NDC goal of 30% renewable generation by 2030.

The following Table 111 shows the expected generation capacity by type in key years under each of the modelled scenarios. Note that a fraction of the existing thermal capacity in the ambitious mitigation scenario is expected to retire after 2030, approximately 24%. However, this thermal capacity is only fractionally replaced by renewables because the reserve margin in The Bahamas will be sufficient to meet the anticipated demand.

Table 111: Expected Installed Capacity by Type in Baseline and Mitigation Scenarios

Scenario	Year	Thermal (MW)	Solar PV (MW)	OTEC (MW)	MSW (MW)	Wind (MW)	Total (MW)
Baseline	2018	767.2	-	-	-	-	767.2
	2025	845.2	-	-	-	-	845.2
	2030	845.2	-	-	-	-	845.2
	2050	845.2	-	-	-	-	845.2
Mitigation	2018	767.2	-	-	-	-	767.2
	2025	845.2	87	-	-	-	932.2
	2030	845.2	174	0.03	15	20	1054.2
	2050	845.2	174	0.03	15	20	1054.2
Ambitious mitigation	2018	767.2	-	-	-	-	767.2
	2025	845.2	87	-	-	-	932.2
	2030	845.2	174	0.03	15	20	1054.2
	2050	645.83	204	0.03	15	20	884.9

Table 112: Expected Electricity Generation by Type in Baseline and Mitigation Scenarios

Scenario	Year	Thermal (GWh)	Solar PV (GWh)	OTEC (GWh)	MSW (GWh)	Wind (GWh)	Total (GWh)
Baseline	2018	2062.6	-	-	-	-	2062.6
	2025	2100.9	-	-	-	-	2100.9
	2030	2221.2	-	-	-	-	2221.2
	2050	2629.2	-	-	-	-	2629.2

Scenario	Year	Thermal (GWh)	Solar PV (GWh)	OTEC (GWh)	MSW (GWh)	Wind (GWh)	Total (GWh)
Mitigation	2018	2062.6	-	-	-	-	2062.6
	2025	1765.6	228.6	-	-	-	1994.2
	2030	1366.8	457.3	0.2	105.1	52.6	1981.9
	2050		457.3	0.2	105.1	52.6	2441.1
Ambitious mitigation	2018	2062.6	-	-	-	-	2062.6
	2025	1767.0	228.6	-	-	-	1995.7
	2030	1377.4	457.3	0.2	105.1	52.6	1992.6
	2050	1891.4	536.1	0.2	105.1	52.6	2585.4

4.4.3.1.3. Transport

The historical energy consumption in the transportation sector was based on The Bahamas most recent inventory up to 2018 and was disaggregated by mode (road, domestic aviation, and domestic maritime navigation) and fuel. This information was supplemented by vehicle registration information to develop a stock turnover model in LEAP for road transport. The stock and sales data from the vehicle registration information was calibrated to allow the bottom-up fuel consumption projections to align with historical transport sector energy requirements. The resulting stock turnover model represents the future stocks and sales of different types of passenger and freight vehicles, including cars, motorcycles, golf carts, minibuses, buses, taxis, trucks and other miscellaneous equipment.

Based on this model, the total stock of road vehicles, including passenger and freight, grows from 136 thousand in 2018 to 150 thousand in 2030, which is equivalent to an annual growth rate of 0.82%. In 2018, hybrid and electric vehicles (EV) represented less than 1% of the total vehicle stock in The Bahamas. In the baseline, hybrid and EVs represent around 8% of car sales between 2018-2030, which results in the stock of hybrid and EVs increasing to 4% of the total stock by 2030.

The electrification of vehicles was modelled in the mitigation and ambitious mitigation scenarios, using a different set of assumptions regarding the share of hybrid and EV sales, as described in Table 113 below. The resulting share in the total stock of vehicles is also indicated.

Table 113: Assumptions for mitigation actions related to the electrification of vehicles

Scenario	Description	Baseline	Mitigation	Ambitious mitigation
Share of sales of EVs in 2030	Increase sales of electric vehicles to 35% and hybrid vehicles to 15% by 2030	3.8%	35%	50%
Share sales of hybrids in 2030		3.8%	15%	40%
Resulting share of EVs in total 2030 stock		2%	13%	16%
Resulting share of hybrids in total 2030 stock		2%	5%	11%

In addition to the higher integration of hybrid and electric vehicles, the mitigation assessment also considered the impact of increasing public transport to offset growth in car sales. The main assumptions used to model this mitigation action are described below.

Table 114: Assumptions for public transport mitigation action

Modelled action	Description	Main assumptions
Public transport offsetting growth in cars	Promotion of the use of Public Transport by 2033	- After 2025, the number of private cars will stop growing due to the increased availability of public transport. - Private cars are assumed to drive 14,484 km/vehicle per year and have an average of 1.5 passengers per car. The avoided passenger kilometres from the private cars are assumed to be absorbed by buses with an average occupancy rate of 21 passengers per vehicle and an annual mileage of 40,000 km per vehicle.

4.4.3.1.4. Land Use and Land Use Change and Forestry (LULUCF)

The LEAP model includes the historical non-energy sector emissions from the most recent emissions inventory up to 2018. From 2019 onwards, GDP is used as the key driver to project future emissions for the non-energy subsectors, with the exception of emissions from LULUCF and non-CO_2 sources on land, which are projected to remain constant and waste, which used population as the key driver. The following table describes the main assumptions for the mitigation actions modelled for this sector.

Table 115: Assumptions for mitigation actions in the LULUCF sector

Modelled action	Description and main assumptions
Sustainable management practices	The establishment of a Forestry Estate on 283,750.18 hectares (20% of the total land cover of The Bahamas) comprised of areas to be established as: Conservation Forests (149, 396.99 hectares), Forest Reserves (96,542.61 hectares), and Protected Forests (37,810.58 hectares) on Abaco, Andros, Grand Bahamas and New Providence which will avoid up to 381.151GgCO_2-eq by 2025.
Davis Creek rehabilitation	Reestablishment and rehabilitation of 50 ha of Davis Creek, Andros Ecosystem, which will increase carbon sequestration up to 14.6 GgCO_2e by 2025.
Zero LULUCF emissions by 2045	In the ambitious scenario: sustainable land-use practices will result in zero emissions from the LULUCF sector by 2045.

4.4.3.1.5. IPPU, Agriculture, Waste

There are four (4) mitigation actions for IPPU, Agriculture and Waste Sectors. Due to data constraints in the baseline, these four mitigation actions were not modelled. The Bahamas is working on improvements in their data collection methods and procedures, and it intends to model these mitigation actions for these sectors in coming years.

4.4.4. GHG Emission Projection Results

As discussed above, two mitigation scenarios were modelled, which have the same demographic and macroeconomic assumptions as the baseline, and consider a series of mitigation actions as highlighted in 4.2.1.1 - 4.2.1.2, as well as additional measures in order to reach the NDC targets of 30% renewable generation by 2030 (Mitigation scenario) and an economy-wide reduction of GHG emissions of 30% when compared to its Business as Usual (BAU) scenario by 2030 (Ambitious mitigation scenario).

Figure 73 shows the results of the total emissions in the three modelled scenarios, as well as the 2010 emissions[54], 2030 emissions in the baseline and the NDC target for 2030 as reference.

Figure 74 shows the total emissions by sector in 2010, 2030 and 2050 for the three scenarios. Figure 75 shows the current and projected shares of fossil-based and renewable power generation in the three scenarios.

[54] The Bahamas NDC is expressed both as relative to BAU and relative to 2010 baseline emissions

Figure 73: Projected total emissions in The Bahamas under three scenarios

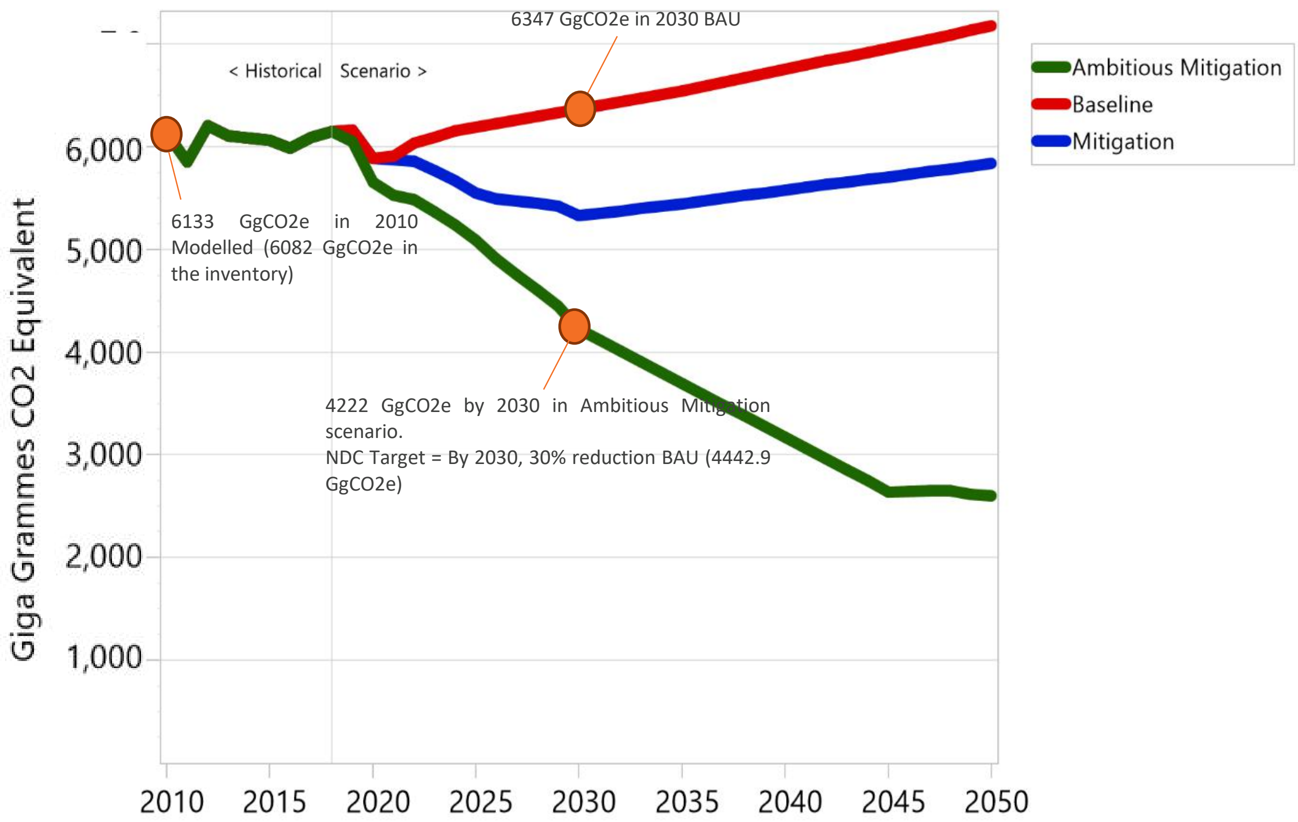


Figure 74: Projected total emissions by sector under three scenarios

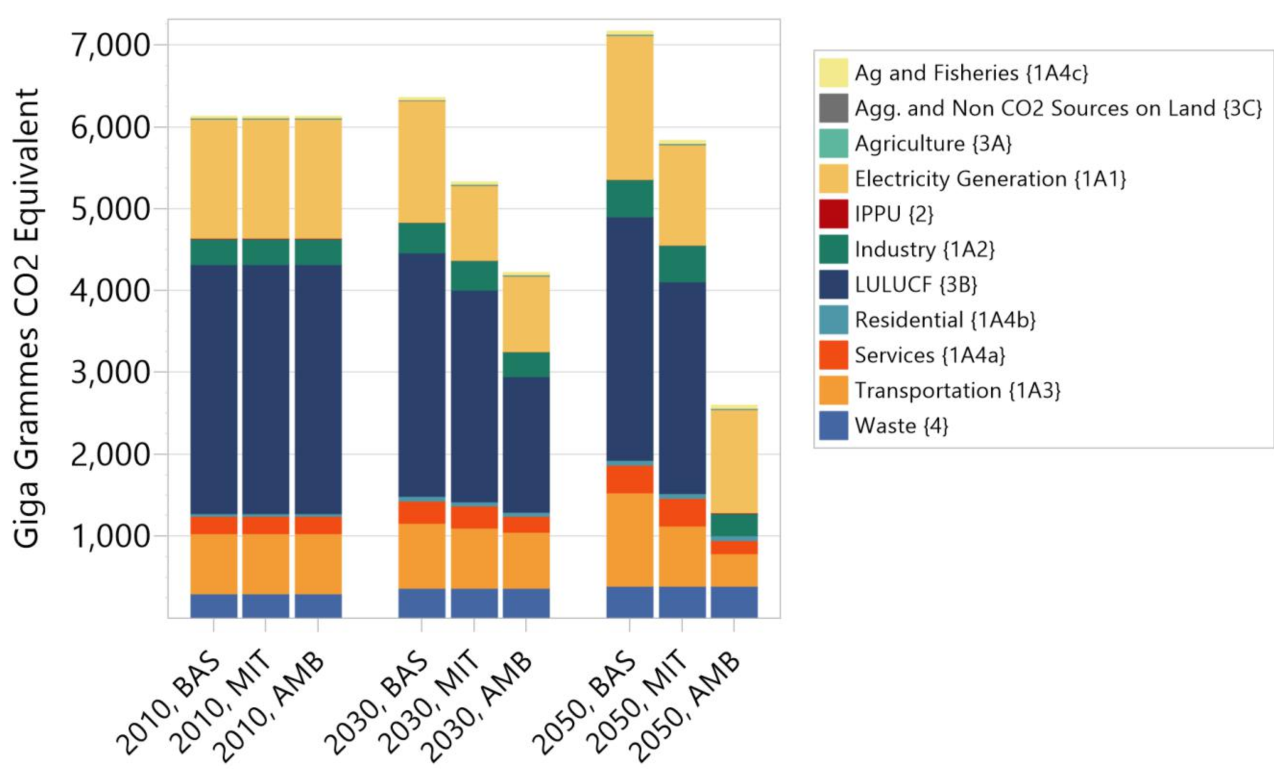
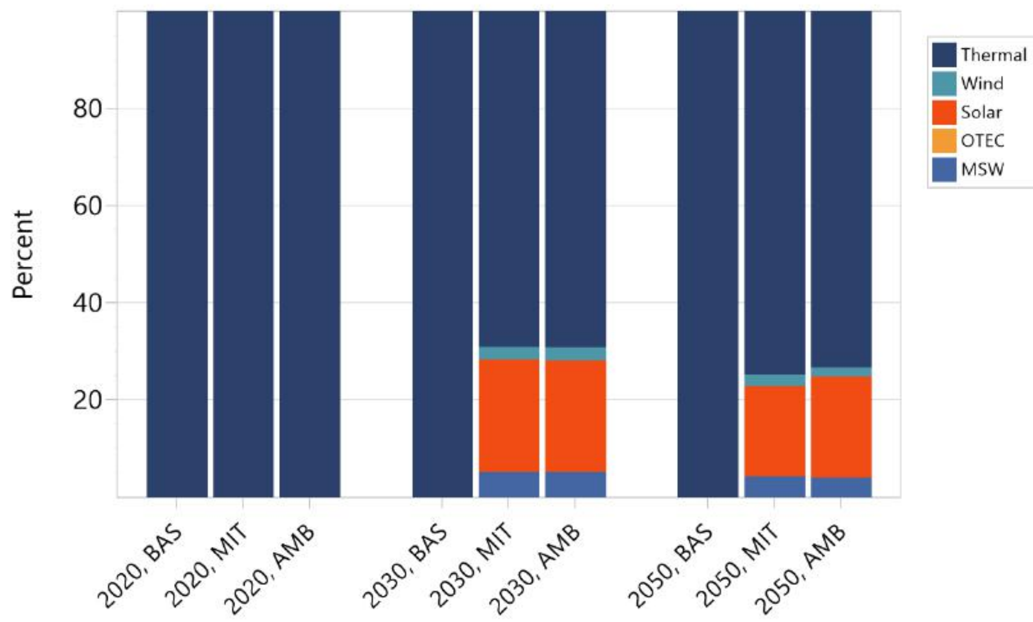


Figure 75: Current and projected share of thermal fossil-based and the renewable generation under three scenarios



In the mitigation scenario, the installed renewable capacity by 2030, which includes 174 MW of solar, results in 31% of the total generation coming from renewable sources, therefore meeting the NDC target of 30% renewable generation by 2030. However, in terms of total emissions, the mitigation scenario projects 5,328.8 $GgCO_2$-eq by 2030, which corresponds to a 16% reduction from the 2030 baseline value of 6,364.7 $GgCO_2$-eq. Therefore, the mitigation actions considered under this scenario are not sufficient to meet the overall target of a 30% reduction by 2030 from the NDC. After 2030, the total emissions in the mitigation scenario continue to increase over time.

Figure 76: Projected emission reductions by sector in the mitigation scenario compared to the baseline

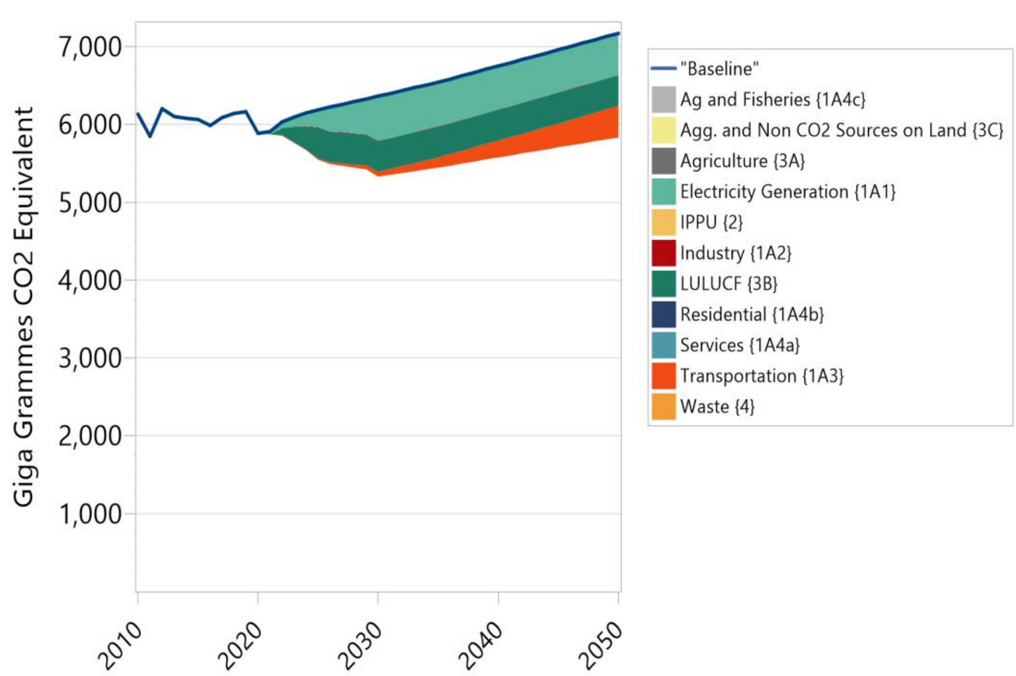
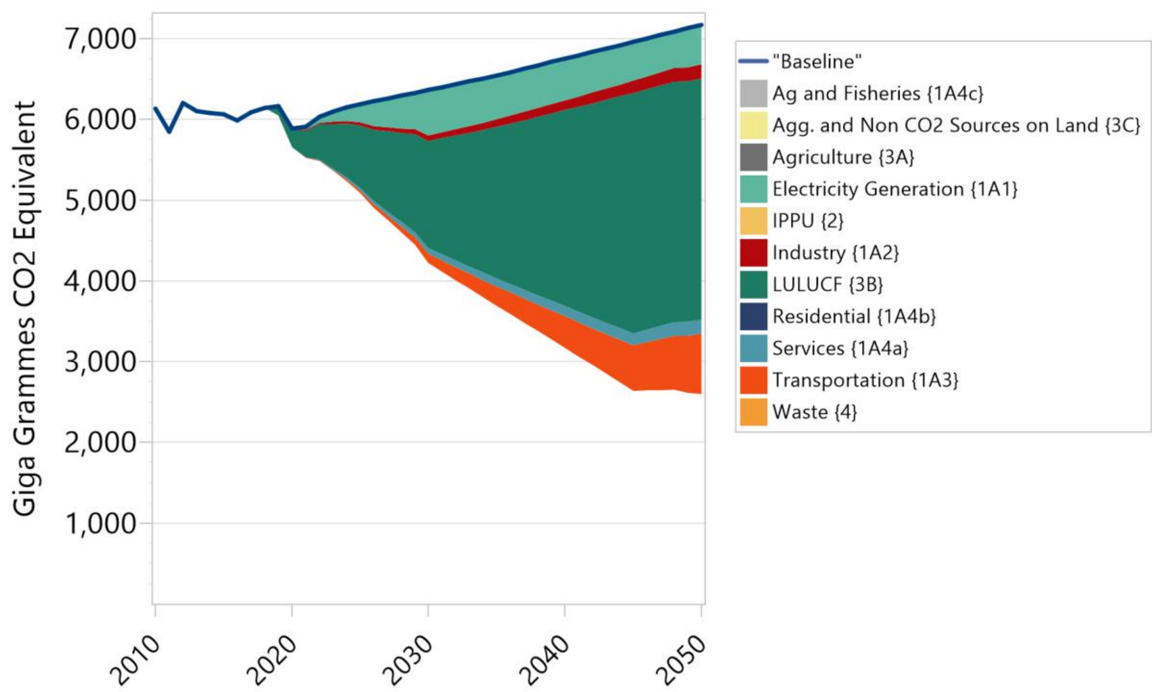


Figure 76 shows the emission reductions by sector in the mitigation scenario compared to the baseline scenario, where it can be seen that electricity generation is the largest contributor to the mitigation potential, followed by LULUCF and the transport sector.The ambitious mitigation scenario explores additional measures required to achieve both NDC targets: 30% renewable generation by 2030, and 30% reduction in total GHG emissions in 2030 compared to baseline/BAU value. As described previously, the additional measures include the replacement of diesel generators by PV in the commercial sector, seawater cooling in hotels, energy efficiency in industry, more ambitious electrification of the transport sector, and reaching net-zero emissions from LULUCF by 2045.

Under the ambitious mitigation scenario, total emissions in 2030 reach 4,222.0 $GgCO_2$-eq, corresponding to a 33% reduction compared to BAU values. After 2030, total emissions continue to decrease, reaching 2,598.0 $GgCO_2$-eq in 2050 (63% reduction compared to BAU of 2050). Additionally, 30% of the total electricity generation in 2030 comes from renewable sources. Therefore, this scenario meets the two mitigation targets from the NDC. From Figure 74 and Figure 77, it can be observed that reaching net-zero emissions in the LULUCF sector plays a major role in achieving the NDC targets.

Figure 77: Projected emission reductions by sector in the ambitious mitigation scenario compared to the baseline



4.4.4.1. Summary of GHG Reductions

For reference purposes, Figure 78 shows the difference in total direct GHG emissions that result from the individual implementation of each one of the modelled measures by 2030 compared to the baseline scenario.

Table 116 shows the total net mitigation by measure for 2030 and 2050. Although these results provide an overview of the magnitude of mitigation potential from each measure, it should be noted that interactions exist between measures, so the mitigation that results from implementing multiple measures may not necessarily be the sum of those individual measures. For example, when considered alone, the electrification of vehicles results in an increase in emissions from the power generation sector and a reduction in emissions from the transport sector due to the higher efficiency of electric vehicles compared to internal combustion engines (ICEs). Even though the net result is lower emissions than in the baseline, the overall mitigation potential is very limited if the electricity generation continues to be entirely based on fossil fuels. However, if the electrification of vehicles were to be implemented in parallel to increasing the share of renewables in the power generation sector, the mitigation potential would be significantly augmented.

Figure 78: Emission differences that result from the individual implementation of each modelled action in 2030 compared to the baseline

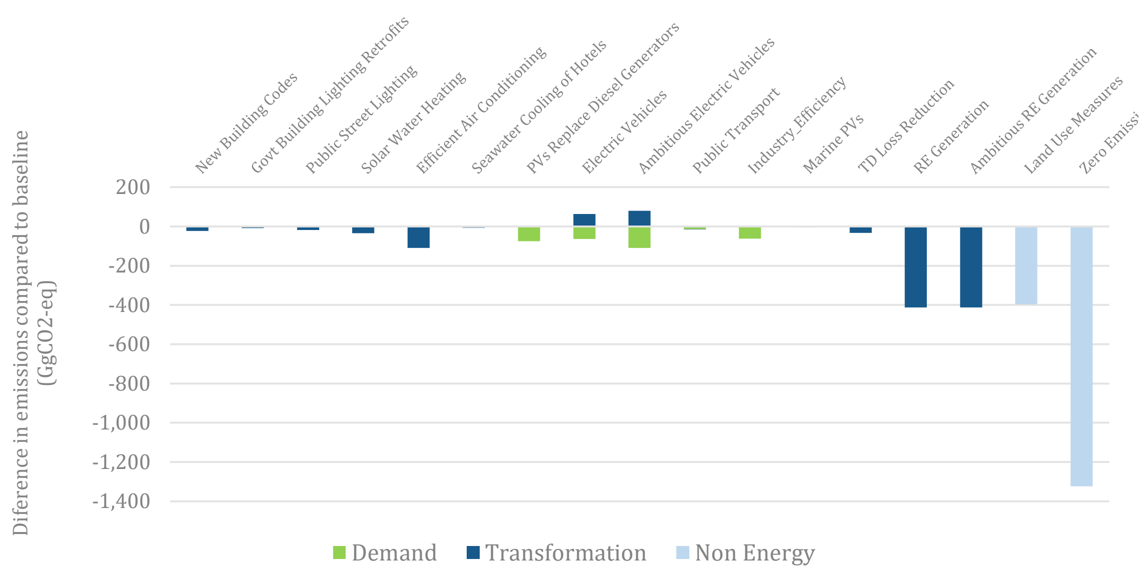


Table 116: Avoided emissions from the individual implementation of each modelled action compared to the baseline

Sector	Mitigation action	Avoided emissions compared to baseline (GgCO₂e avoided)	
		2030	2050
Energy demand in Residential, commercial and services sectors	New Building Codes	-22.6	-22.6
	Govt Building Lighting Retrofits	-8.2	-8.2
	Public Street Lighting	-18.5	-18.4
	Solar Water Heating	-34.5	-64.0
	Efficient Air Conditioning	-109.6	-145.8
	Seawater Cooling of Hotels	-6.2	-15.4
	PVs Replace Diesel Generators	-74.6	-177.6
	Energy Audits & Implementation of improve energy intensity	-61.3	-175.2

Sector	Mitigation action	Avoided emissions compared to baseline (GgCO2e avoided)	
		2030	2050
Transport	Electric Vehicles	-1.1	-195.2
	Ambitious Electric Vehicles	-29.0	-361.0
	Public Transport	-12.9	-123.6
	Marine PVs	-3.5	-3.5
Power generation	TD Loss Reduction	-32.4	-74.9
	RE Generation	-412.6	-412.6
	Ambitious RE Generation	-412.6	-429.4
LULUCF	Land Use Measures	-395.7	-395.7
	Zero Emissions from Land Use	-1,324.0	-2,979.1

4.5. Barriers and Challenges to Implementation and Methods to Improve The Modelling

A summary of the main barriers and challenges to conducting the mitigation assessment and estimate barriers to the implementation of the mitigation are highlighted below. These barriers were verified during the stakeholder workshop as part of the Mitigation Assessment:

4.5.1. Barriers and Challenges

- Lack of Adequate Data - Data quality and availability were identified as the main challenges throughout the development of the model. Insufficient data will result in limited accuracy in the modelling and also create major challenges for monitoring, verification and reporting in the future.
- Willingness to supply data to relevant authorities. This creates a lack of transparency, and it is closely aligned to the issues noted in the first bullet point.
- Political Will – Implementing mitigation actions requires broad political support and effective planning to maximise opportunities. Therefore, it is essential that sensitisation and education of high-level decision-makers to the climate change needs are sustained.
- Weak Governance – Although the mitigation actions are clearly identified under separate sectors, the Governance of some of these actions are not always clearly defined across Ministries and Departments. It is important that coordination through the National Climate Change Committee, which consist of people from various ministries are continued to minimise this challenge.
- High Capital Costs – Renewable Energy Initiatives normally require high capital costs. Although The Bahamas is considered a high-income country, the unique

challenges of SIDS need to be taken into consideration. It is essential that access to climate finance grants and low-interest loans be made available to SIDS to help reduce the costs of implementation.

- Technology Suitability/Availability – The Bahamas, in its mitigation assessment, have proposed some common technologies and others that are still in their infancy. In addition, The Bahamas archipelago is vast and therefore, it is essential that studies and testing be conducted in various regions in The Bahamas to identify the most suitable technology for each territory based on national circumstances. Furthermore, it is essential that capacity building in the suitable technologies be conducted for the sustainability of implementation.
- Natural Disasters – The Bahamas lies within the tropical belt and is the direct path of hurricanes and tropical storms, with the latest being Nicole (2022), Isaias (2020), Dorian (2019), Irma (2017), Matthew (2016). Hurricane Dorian was the strongest to hit The Bahamas, causing major destruction not only to livelihood but to the forested areas. With increasing global warming, it is expected that extreme weather events will become more frequent and intensify. This creates a major challenge for the implementation of the mitigation action of net zero emissions in the LULUCF sector by 2045. Major efforts are required by the Forestry Unit to monitor effects from natural disasters versus human-induced deforestation to distinguish between the two activities.
- Land Availability – The Bahamas has limited surface area and therefore, there is a need to balance the enhancement and protection of the LULUCF sector as well as increasing renewable energy penetration through the installation of solar PV systems. Land-use zoning and innovative use of solar PV systems will be of critical importance.

4.5.2. Key Needs for Improving Modelling

- Improvement in data collection, having more disaggregated and updated data for energy consumption and production in The Bahamas would allow for more detailed modelling of the energy sector and its GHG emissions. This would create a more transparent assessment of mitigation actions in this sector, which for the purpose of this study were mainly estimated outside of the main modelling framework.
- Assessment of data transparency issues and development of agreements to facilitate data sharing among institutions, for example, by anonymizing data (e.g. sharing semi-aggregate information by power plant type instead of by individual facilities so that interests of private companies are protected while also contributing to the public knowledge).
- Improvement in the baseline projections for the LULUCF sector. Better data collection in the LULUCF sector will allow for improvement in the assessments of the trends and the baseline emissions for the LULUCF sector.

- The LEAP model can be a useful tool for monitoring the implementation of projects. Therefore, further examination of the model needs to be conducted and adequately skilled persons identified for monitoring the implementations projects and updating the LEAP model.

Chapter 5 – Integration of Climate Change into National Development Priorities

5.1. Introduction

The Bahamas is committed to the implementation of the 2030 Agenda for Sustainable Development in national programmes and policies, making strides across all sectors. However, integrating climate into national development programmes and policies requires a holistic and integrative lens, as systems and sectors are interdependent. This chapter provides several proposals across different sectors within The Bahamas.

5.1.1. Energy

The Bahamas National Energy Policy 2013-2033 mainly focuses on lowering current dependency on imported oil and transitioning to:

- an increased share of renewable electricity production and use;
- higher energy efficiency in buildings; and
- a decarbonised transport system.

Awareness campaigns (such as workshops, television advertisements, and essay-writing competitions for school children) should focus on technological and behaviourial changes in the ways energy is consumed. In Mauritius, for example, the Energy Efficiency Management Office (EEMO) was setup in 2011 with the aim to promote awareness of energy efficiency. In Guyana, the Guyana Energy Agency promotes a number of Tip Sheets in multimedia formats for the public and industry.

Economic incentives can aid in changing behaviours with respect to energy use. In Mauritius, a grant of 40% of the total cost was awarded to low-income households to purchase solar water heaters (SWHs) during 2008-2013, where 58,900 households benefited from it. Through this initiative, the authorities have set up the groundwork for an SWH market, with awareness campaigns and the incentive schemes deployed as aids to launch the initiative.

Other programmes, like energy audits in hotels and industries or building codes should be developed. Time-of-use (TOU) tariffs allow a utility company to charge different electricity tariffs over the day to effectively shift the time for some activities from peak to off-peak time periods. This can result in significant changes for both consumers and utility companies. Comoros has installed such a system, in which the electricity tariff is higher at night.

Guyana, Mauritius, Barbados and other countries have offered some tax incentives to business in order to increase energy efficiency adoption. For example, in Guyana, the Government removed taxes on CFL lights and LED lights (Ochs et al, 2015). Some manufacturing industries has received energy audit support, however, there is no monitoring system in place.

In Mauritius, there is the Green Lending Scheme financial tool which has been funded by the Agence Française de Développement (AFD), which provides small and medium businesses with an 8% rebate on their loans from local banks upon verification of the energy savings made while running the business. In addition to this, Mauritius conducted more than 100 energy audits between 2015-2016 part of the National Energy Efficiency Program, covering 60% of their cost (MEPU, 2016).

In Barbados, the Customs and Excise Department provides tax cuts for imports of energy-efficient systems, these include (Government of Barbados, 2017):

- 5% exemption for thermal barriers, roof insulation, windows tints, and ceramic roofing coatings for households;
- 5-20% exemption for different kinds of energy-efficient lighting; and
- tax exemptions for the import of parts of SWHs and other renewable energy systems.

Implementing building and electrical codes could make sectors more energy efficient. In the Caribbean SIDS, the CARICOM Regional Organization for Standards and Quality has implemented a number of such codes (Shah, 2018).

In addition to the practices above, energy efficiency projects, energy-efficient technologies dissemination campaigns, financial incentives, legislation, and regulations should be implemented in the residential, industrial, commercial and hospitality sectors.

The cost of imported technologies and appliances will include freight, import duties, sales tax, insurance, and other fees. In many cases, cost will determine consumer decisions. Additionally, the lack of information on energy technologies and consumption could impact consumers' behaviour with respect to energy use. Information on how energy is consumed, how much can be saved, and environmental benefits – should all be visible to customers. A study on Saint Lucia has shown that customers are only willing to spend a small amount on "just a light bulb" (Shah, 2018).

Most studies (Blumstein, 2005, Jollands, 2009, Haley et al 2020) on energy efficiency governance, show there is a need for a combination of institutional arrangements, coordination mechanisms between private and public sectors, legislative frameworks, and energy efficiency policies, across all sectors where energy is consumed and produced. A pathway should be developed to achieve energy efficiency goals including the four “in’s”:

1. initiation,
2. incentivization,
3. information and
4. investment.

In sectors such as commercial and hospitality, incentives can take the form of tax rebates, exemptions or reductions; cost-sharing schemes between the public and private sectors; or voluntary agreements between these sectors. In the residential sector, subsidies for energy efficiency in housing can improve energy use. Training and capability-building must be organised for energy practitioners working in different disciplines. Informational campaigns must be implemented to encourage behavioural change of consumers and encourage them to make rational consumption choices, conservation actions and investment decisions.

In The Bahamas, the recommendation from the National Energy Policy Committee’s Second Report presented to the Government in April 2011 was that renewable energies should supply more than 20% of the national power needs, with different islands being interconnected to enable electricity to flow between them. Regarding this, the Government should focus on deploying nearshore wind power as renewable energy source; Other renewable energy sources could include solar, ocean thermal energy conversion and bioenergy.

To plan for the integration of variable renewable energy sources and achieve the target of expanding its portfolio of renewables by 30% by 2030, it is important to acquire a good understanding of the characteristics of the power system and the electricity sector in The Bahamas. Technical studies of these will help planners to understand:

- Flexibility of the existing and future power generation fleets.
- Demand and load profiles – One of the key factors for variable renewable energy integration is to understand the correlation between the system load and the expected generation profiles. This will help determine the net load that needs to be supplied by the other non-renewable generators.
- Distribution network structure – the possible ways to increase hosting capacity in the near- and long-term up to a given renewables target share.
- Operational planning with respect to the following - the short term; day to week ahead; optimal generation schedule for the upcoming operational period; and expansion.

5.1.2. Transport

Transport emissions contribute to climate change, but at the same time, transport systems are also highly vulnerable to the effects of climate change, such as extreme weather events and natural disasters. Impacts could include accelerated coastal erosion, coastal road inundation/submersion, restricted access to docks and marinas, and deterioration of the condition and structural integrity of road pavements. When mobility is compromised, freight transport and supply chains are interrupted, including for vital products like food and medicine, and populations can lose access to jobs, healthcare, and other basic services.

When disaster strikes, damage to transport systems typically makes up a large share of overall losses and is one of the main obstacles to recovery. Resilience provisions play a critical role. An example of a project where resilience transport has been introduced is the Pacific Climate-Resilient Transport Program, a series of projects spanning Samoa, Tonga, Tuvalu and Vanuatu. This programme could be tailored to meet the specific needs of a country, like The Bahamas. Interventions could be a combination of infrastructure investments and capacity-building activities to effectively manage more resilient infrastructure. This may involve building supplementary roads and improving drainage so that key corridors can remain functional when the main road is damaged. The programme allows countries to reallocate project funds to support recovery operations, which is known as a “contingent emergency response component”. Relying on a common framework across multiple countries allows countries to leverage their limited resources.

Decarbonising the transport sector in The Bahamas plays a key role in climate action. Understanding the options that are available helps businesses optimize their operating efficiency and their investments.

The cross-cutting nature of sustainable transport requires the involvement of a wide array of stakeholders in the public, private, national and international domains in support of achieving the 2030 Agenda and the Paris Agreement, such as policymakers, transport engineers, economists, social scientists, health professionals, urban and regional planners, and the private sector. An example of inter-ministerial and multi-level collaboration is of the Government of Canada who signed bilateral agreements with territories regarding several transport-related SDGs, including green infrastructure (SDG 9) and the labour market (SDG 8).

Many governments are offering incentives for decarbonization that operators of alternative transportation technologies can leverage. In Germany, for instance, companies can reduce the total cost of ownership of a battery-electric vehicle to roughly that of a diesel vehicle by taking advantage of the incentives offered by the government.

The International Maritime Organisation (IMO) has set a goal to reduce shipping emissions by 40% by 2030, compared to 2008 levels. Shipping industry leaders have committed to finding a path to zero- carbon shipping – encouraging short-term action to achieve the long-term goal. Regulation, technology, and investment are fundamental drivers of maritime decarbonisation. Ship owners should adopt alternative fuels and alternative propulsion to reduce emissions. As a flag state with shipping as an important part of its economy, The Bahamas should incorporate the IMO emissions reduction goal into its national development planning as well as its sectoral planning for shipping.

The Bahamas' transport network topology and its small scale offer an opportunity for developing public transit corridors and rapid electrification of car fleets. To assess key areas to pursue in sustainable mobility, evaluation data should be collected at the measure level inclusive of shared mobility, walking, clean vehicles in use and public transport. Exchange of information and datasets between sectors is essential to improve the decision-making process at the local level, reducing overlap of data collection efforts. Stakeholder involvement and participation in decision-making is essential in both touristic and transport sectors.

5.1.3. Water

In terms of implementation of 2030 Agenda with respect to water, the GOB has taken the following actions:

- Eliminating VAT on monthly water bills under $50 to increase water accessibility for the poor.
- A Water for All Strategy for Over-the-Hill communities on the island of New Providence. The aim of the strategy is to ensure modern indoor sanitation and access to piped water to all residents in these communities. Many of them have to use public standpipes for water and have no running water in their homes. The work will also involve refurbishment of 77 standpipes. No running water also means no indoor plumbing, so one of the objectives of the strategy is to retrofit 100 homes with indoor plumbing (OPM, 2018).

In 2015, Holding and Allen developed a hazard assessment framework for water security in small islands using The Bahamas as a case study. The framework "provides a method of incorporating the results from numerical modelling and land use/hazard surveys into an accessible map format" (Holding and Allen, 2015). Hazards identified in development of the framework that can threaten water security include water supply and pumping, septic systems, sea level rise and storm surge.

The framework can be adapted for other islands. These maps can serve as tools for water managers and decision makers as they identify high-risk areas for short-term action as well as inform long-term planning. The maps can also be used as communication and outreach tools to raise awareness about hazards that impact water security.

Climate change will increase the intensity and frequency of weather events. Sea level rise can cause an increase in coastal flooding and lead to saltwater intrusion of groundwater resources. Sea level rise can also increase vulnerability to coastal flooding and the economic cost associated with it. Uncontrolled urbanization without proper waste infrastructure can also deteriorate the quality of freshwater resources. Most of the Caribbean SIDS and the AIMS have already a moderate to high risk for groundwater pollution, because of saltwater intrusion, agricultural chemicals and other types of waste. Therefore, to fully understand water in The Bahamas, it is pertinent to assess some indicators, such as water availability, and assess their evolution periodically.

There should be development of a groundwater monitoring program that will be incorporated into the spatial decision support system (SSDS) being developed by the Department of Environmental Planning and Protection (DEPP). The program would need to include training for data collectors on each island as well as procurement of data collection equipment to be deployed in each island. Data collectors would need to be trained in use and maintenance of monitoring equipment as well as data collection, entry and reporting. Indicators to be monitored should be aligned with SDGs as well as any national indicators established by the Bahamas National Statistical Institute. Consistent monitoring will enable sustainable groundwater abstraction. Risk of contamination would be an important indicator to monitor for islands where farming is a significant economic sector; this would entail mapping of wells and their proximity to sources of contamination, such as waste (Johnson, 2020).

In the Maldives, which is highly vulnerable to salinization and other forms of pollution, part of the freshwater demand is met through desalination of water; almost every resort has their own desalination plant, and desalinated water is transported on ships to outer islands during the dry season (Maldives, 2015). Following the tsunami in 2004, the government provided every household with a rainwater tank. In 2017, the government of the Maldives formulated a national water and sewerage policy which aims to provide for equitable water supply and the sustainable management of water resources, in line with SDG 6. The Maldives National Adaptation Plan for Action sets out the priority areas for action, including water resources and tourism.

In Tuvalu, one of the principles of the sustainable and integrated water and sanitation policy 2012-2021 was linking sustainable water management to the impacts of climate change. The policy is in line with SDG 6 on managing the water supply and SDG 11 on addressing the impacts of climate change and disasters. Measures to be taken include capacity building and resilience in the different local communities and to engage them in developing new mechanisms and institutions.

The United Nations Convention on Biological Diversity requires The Bahamas to protect a minimum of 10% of its groundwater reserves. It is vital that local groundwater resources be protected in law and practice. Integration of policies and measures on climate change and disaster risk reduction should occur in The Bahamas, with water management included as one of the critical issues to be addressed.

The Bahamas must increase the resilience of its groundwater resources to climate change. The country also needs to explore and implement green alternatives to freshwater production. Examples of activities that can increase resilience include floodplain mapping to aid in water resource management and planning, isolation of trenches within wellfields, and installation of valves in each chamber to cut off the system (USACE, 2004; Bowleg and Allen, 2011). Increasing resilience may also entail investment in sustainable technologies to provide alternative sources of freshwater (e.g. solar-powered water production systems) that reduce impacts of groundwater extraction, particularly on southeastern islands (Johnson, 2020).

There should be development and implementation of a Managed Aquifer Recharge (MAR) demonstration project as a means of climate change adaptation for The Bahamas. MAR has been successfully achieved in the Marshall Islands (UNESCO-IHP, 2015).

There should also be development of a Groundwater Management Manual or Guideline for Crop Production on the islands of The Bahamas that focuses on groundwater conservation and sustainability that reduces the impact on the food chain and that presents alternative but practical ways to treat the water (e.g. chlorination by tablets or chlorinator system or ultraviolet filtration/sanitation). Development of the manual or guidelines would be accompanied by workshops/seminars to train farmers in well siting based on aquifer capacity, well construction as well as sampling and testing groundwater. Increasing laboratory capacity in-country to test for contaminants associated with agriculture (e.g. pesticides and fertilizers) that can threaten groundwater quality (Johnson, 2020).

5.1.4. Tourism

The Sustainable Tourism Policy was developed in 1994. Though it is dated, the policy provides for:

- Protection of Bahamian environmental resources and contribute to the protection of global biodiversity for future generations; and

- Protection and enhancement of the national resource base as a foundation for future tourism development.

Because the policy is rather dated, the best way forward may be for agencies involved in national planning related to climate change to work with the Sustainable Tourism Unit to develop a guidance document for hoteliers and developers looking to invest in the sector. This document can provide guidance on increasing climate resilience in the tourism sector through actions such as:

- Integration of nature-based solutions into design of hotels and resorts and ensuring ecosystem services are protected, particularly those that provide climate resilience (e.g. mangroves as storm buffers).
- Building inland rather than in high-risk coastal areas.
- Sourcing food and other resources locally for the hotel or resort.
- Designing hotels to serve as hurricane shelters.

Potential resources in developing the guidance document include the World Bank Resilient Tourism Framework (2020) and World Travel & Tourism Council Net Zero Roadmap for Travel and Tourism (2021).

5.1.5. Agriculture

The 2014 IICA-IFAD report on climate-smart agricultural production in The Bahamas is referenced in the National Circumstances chapter. This report details a number of recommendations on integrating climate change in the agricultural sector and improving climate resilience. These include:

- Development of policies to build economic resilience at the farm level (e.g. provision of insurance, securing land tenure).
- Training for farmers in sustainable soil and water management practices. This could involve local preparation of bio-fertilizers and bio-pesticides to reduce dependency on expensive, imported fertilizers and to replace hazardous agrochemicals being used in local agriculture (Sanchez Hermosillo, 2011). Intercropping or alley cropping were also recommended; inter-cropping was observed on small farms in Cat Island.

In 2019, the Climate Change Policy and Adaptation Strategy for the Agriculture and Marine Resources Sectors was developed. The overall objective of the Policy and Strategy is to increase the climate resilience of crops, livestock and marine sectors of The Bahamas. The Policy and Strategy could be strengthened with inclusion of more detailed annual workplans inclusive of climate change adaptation activities. Details would include priority locations for climate action, methodologies for action, and partnerships and means of financing for Strategy implementation.

Pursuing other methods of farming, such as container farming, can help to improve resilience of the sector as agricultural lands in The Bahamas can become inundated with saltwater during a hurricane. This results in the land being unusable for years after the storm.

Additional actions for integrating climate change into the agricultural sector include conserving ecosystems that serve as carbon sinks within agricultural lands and providing financial incentives and technical support to aid farmers in achieving climate smart agriculture.

5.1.6. Fisheries

The 2019 Climate Change Policy and Adaptation Strategy for the Agriculture and Marine Resources Sectors also applies to fisheries in The Bahamas. Actions called for with respect to fisheries include:

- Creation of adaptive marine protected areas
- Mangrove replanting
- Coral restoration
- Monitoring of ocean temperatures and seagrass depletion
- Development of mariculture and aquaculture
- Establishing insurance for fishers

The same recommendation on detailed annual workplans is also made for the fisheries sector. Additional actions for integrating climate change into the fisheries sector include conserving ecosystems that serve as carbon sinks within fishing grounds and providing financial incentives and technical support to aid fishers in increasing the resilience of their sector.

5.1.7. Construction

The Bahamas Building Code (Edition 3) is currently being amended. The amendment process includes looking at climate resilience. Amendments to the Building Code should include:

- Minimum requirements for critical infrastructure and buildings to withstand 50-year storms.
- Protection or restoration of mangrove forests and other natural ecosystems as part of site design.
- Low Impact Development (LID) methods incorporated into development projects; these methods include bioswales, rain gardens, green roofs, permeable paving systems, porous asphalt, curb bump-outs and cuts.

- Designation of no-build zones in coastal and inland areas that are at high-risk for flooding and storm damage. Designation of these zones should be combined with protection or restoration of any natural ecosystem within the zones that will increase climate resilience for neighbouring sites.

Consideration must be given for designating no build zones for areas that are repeatedly destroyed following storms. Such areas should be targeted for creation as protected areas where natural ecosystems can be maintained and serve as buffers for neighbouring areas. There are sites that are simply uninhabitable due to increasing risks posed by global climate change. Economic resources would be more wisely used to increase climate resilience rather than trying to continuously rebuild these areas.

Revision of the Building Code will have to be accompanied by capacity building for those working in the sector. There is no guarantee that professionals will have received the required training to understand climate resilience as a concept and how to implement solutions to achieve resilience. Ministry of Works and Utilities along with Climate Change and Environmental Advisory Unit, Department of Environmental Protection and Planning, Department of Physical Planning, Department of Environmental Health Services and utility corporations will have to be champions of climate action and encourage the sector to employ climate resilience methods and technologies as they review and inspect development projects, designs and construction.

5.1.8. Finance

Integrating climate change into the finance sector and national financial planning requires a move away from using traditional economic models to sustainable economic models. The Genuine Progress Indicator (GPI) is a different method of measuring national development. It factors in Gross Domestic Product, but includes benefits not included in market transactions, such as volunteer work and childcare provided by family members, and deducts harmful environmental and social costs, such as damage from climate change. Using GPI would give a more accurate picture of the national economic situation in The Bahamas, particularly in light of its high vulnerability to climate change.

Ecosystem service valuation is another important tool that can aid in national development planning. This tool can help The Bahamas to (Hargreaves-Allen, 2016):

1. Prioritize areas for adaptation action and protection of ecosystem services.
2. Raise revenue through payments for ecosystem services.
3. Increase investment in sustainable livelihoods and industries.
4. Utilize ecosystem service values in national environmental accounting – This will entail incorporating ecosystem services values into national level accounting using the United Nations System of Environmental Economic Accounting (SEEA)

ecosystem accounting approach and updating national level accounts annually as a monitoring tool for ecosystem services health and information climate action efforts.

5. Estimate costs associated with environmental threats – This will be particularly important when addressing loss and damage from climate change.
6. Use ecosystem service values to inform policy and investment decisions – This is particularly important to inform decision-making when trade-offs are being considered. In traditional economic models, ecosystem services are not factored into trade-off analysis, often resulting in loss of these services.

Being able to make the transition to utilize such models and tools will require data collection. Data is needed on supply or demand aspects of natural resource use collected to assess the sustainability of natural resource use in The Bahamas. Considerable local data needs to be collected using regular monitoring, rather than on an ad hoc basis and using appropriate sampling methodologies to ensure that data collected are representative of the true underlying trends. Examples of such data include monitoring waste generation and water and energy use by tourists, habitat clearance or modification during development, and underwater visual surveys of fish populations for species of key commercial importance (Hargreaves-Allen, 2016).

Actions to integrate climate action into the financial and insurance sectors can include:

- Providing financial incentives for individuals and organizations that increase carbon sequestration through protection of carbon sinks or have incorporated climate-resilient design as a part of their financed projects.
- Reducing insurance premiums for individuals or organizations that have carbon sinks as a part of their insured assets or have increased climate resilience of their assets.

The Government of The Bahamas has recently completed its first annual climate and disaster tagging report for 2021. It is envisioned that the climate and disaster tagging methodology will strengthen the country's capacity to allocate, manage, and monitor public resources to address climate change and disaster threats to its economy and to its very existence in the future. The tagging will also assist The Bahamas in understanding and quantifying post-disaster related expenditures and consequently will help the Government to make cost-effective and risk-based decisions

There are several financing opportunities available globally that The Bahamas can access. Through the TNC-BUR project, these have been compiled in a database of climate change financing opportunities that is now available to the Government.

5.1.9. Waste Management

Island communities have limited assets, resources, and space for waste. Climate change can be mitigated through better management of waste, and by reducing the detrimental impact to the environment. Getting revenues to support the change to move forward with collection and waste minimization is key. Shipping waste collection programmes could be implemented.

Tourism provides financial opportunities. For example, in the Eastern Caribbean, tourism is used as potential revenue source. For every tourist, 1.5 USD is charged on a ticket, specifically as an environmental levy. Such a tourism levy could be charged to assist with managing waste generated by the sector, including cruise ships. Alternatively, The Bahamas can discontinue accepting waste from the cruise industry as it is a significant burden which the country is currently dealing with at no cost.

Charging for waste management as a percentage of other utility costs has worked well in some islands. In recommending these potential revenue streams, it is also important to ensure that funds generated for waste management are allocated to waste management. The Bahamas' consolidated fund model does not work well for ensuring funds are allocated as envisioned.

While The Bahamas has implemented an environmental levy, it is paid by Bahamian citizens and residents for waste management of imported goods. Presently, the fees collected from the levy are going to the Bahamas Protected Area Fund for biodiversity and protected area conservation, another priority issue for the country. It may be earmarked specifically for waste management in the future.

5.1.10. Health

Two projects are currently underway to integrate climate change into the health sector – Developing a climate resilient health system in The Bahamas funded by the Green Climate Fund and EU/CARIFORUM climate change and health project. While these projects are likely to have detailed recommendations on climate change integration, they are not yet available.

Recommendations that can be considered include (Watts, n.d.):

1. Utilize early detection tools to identify changing disease incidence, geographic and seasonal risk mapping and climate-informed early warning systems;
2. Assess population vulnerabilities to health impacts of climate change and use the assessment to prioritize adaptation policy and actions;

3. Ensure health facilities, particularly public clinics on the Family Islands, have access to sustainable energy and water supplies, to ensure access during power outages that typically occur during and after hurricanes. These can include solar-powered equipment, such as lighting and water pumps.
4. Review and update public health programmes and activities to consider short-term influences and long-term climate change impacts on operations.
5. Update emergency response plans, evacuation procedures and emergency management coordination measures to anticipate and respond during events (e.g. flooding and hurricanes) affecting public health. Heat exposure, physical and psychological trauma, dehydration and malnutrition may be some of the public health effects following a hurricane.
6. Ensure that critical healthcare and public health infrastructure (e.g. clinics, potable water supply and waste disposal) are sufficiently robust to be safe and functional during and following extreme weather events.

5.1.11. Land and Forestry

The National Forest Plan for the National Forest Estate was drafted in 2021. This plan needs to be approved and implemented. Goal 6 of the plan specifically addresses climate change and the country's desire to manage the National Forest Estate to be more adaptive and resilient to impacts of climate change.

The plan proposed to achieve through a number of actions taken by the Forestry Unit including (Forestry Unit, 2021):

- Sustaining forest carbon stocks and carbon sequestration capacity;
- Providing sustainably produced, locally grown and manufactured wood products for building construction to contribute towards the reduction of transportation-related carbon emissions;
- Restoring areas impacted by severe weather events, including hurricanes and storm surges, using native mangrove species to offset impacts by climate change; and
- Including climate-resilient tree species in restoration, reforestation, and regeneration activities on the National Forest Estate.

The plan also seeks to integrate national, regional and international standards and guidelines inclusive of the Bahamas National Energy Policy, SDGs 13 and 15, regional climate models on forestry productivity, FAO Climate Change Guidelines for Forest Managers and IPCC guidelines.

5.1.12. Marine and Coastal Habitats

The 2016 draft National Integrated Coastal Zone Management (ICZM) Policy Framework details actions that can be taken to increase the climate resilience of coastal and marine habitats using an integrated approach. This policy framework needs to be approved and implemented.

Actions recommended under the policy framework include (SEV-CCS, 2016):

1. Climate change adaptation measures incorporated in all national plans and programs including update of Climate Change Adaptation Policy to incorporate loss and damage.
2. Development of island-specific land and sea use plans for all islands of The Bahamas with ICZM as a core of each plan.
3. Develop discrete legislation for the establishment of a Coastal Zone Unit responsible for a defined geographic area, i.e. the coastal zone as defined in the policy framework.
4. Implement regular monitoring of coastal resources, including beaches and coral reefs – This would include monitoring of carbonate chemistry should also occur as a means of establishing an early warning system for ocean acidification. Regular monitoring provides information on coastal ecosystems which can be shared with Bahamians to highlight the benefits of healthy and functioning ecosystems.
5. Encourage the use of ecosystem-based adaptation to climate change as an engineering solution.
6. Ensure critical social support services and infrastructure (e.g. hospitals) are located in low-risk zones and designed to adapt to climate change.
7. Ensure new subdivisions are not cited in high-risk coastal areas to protect homes and lives.
8. Restore damaged ecosystems that play a critical role in human well-being and climate change adaptation.
9. Support Hazard/Sensitivity Mapping and Disaster Risk Management Support Information System (DRMSIS) pilot project, which will increase availability and access to GIS data that can be used to create higher resolution models of flood vulnerability maps and other tools for robust-decision making in town and emergency planning.
10. Create community adaptation plans tailored to specific needs of each community in order to demonstrate effectiveness of climate change adaptation directives that can be scaled up to national level.

5.1.13. Biodiversity

The Bahamas National Biodiversity Strategy and Action Plan (NBSAP) 2021 – 2030 calls for a number of actions to integrate biodiversity considerations within climate change response activities. These are:

1. Develop and implement methodologies to assess climate change impacts on and risks to biodiversity – This entails containing impacts on and risks to biodiversity in hurricane assessment reports;
2. Enhance knowledge on the resilience and resistance of ecosystems and species to climate change through research and training – This includes sourcing funding for research on resilience and resistance of ecosystems and species to climate change and developing an online training module to enhance knowledge in this area; and
3. Actively participate in knowledge platforms and exchange programmes for sharing knowledge at the national, regional and international level on integration of biodiversity into climate change response activities – This involves utilizing the Bahamas Biodiversity Clearing House Mechanism as a platform for sharing knowledge on the integration of biodiversity into climate change responses.

5.1.14. Other Cross-sectoral Actions

5.1.14.1. Learning on adaptation and mult-stakeholder engagement

Climate adaptation policies are needed more than ever, as they can help to decrease climate risk via the three risk factors: hazards, vulnerability, and exposure. Establishment of an Annual Learning Forum on Adaptation is recommended. This would require convening a multi-stakeholder engagement in order to facilitate knowledge-sharing related to adaptation and improved coordination and further action. Stakeholders should include policymakers, economists, think tanks, universities and youth.

5.1.14.2. Ensuring availability of data and information

A challenge for The Bahamas is the lack of data and information available to climate action actors. Data on a wide variety of indicators relevant to the three post-2015 agendas (i.e. Climate Change, Sendai Framework and Sustainable Development Goals) are simply unavailable in many areas, especially data that relate to socioeconomic conditions and other facets of well-being. There needs to be an improvement in the amount and quality of information being collected across a range of indicators, particularly information about the impacts of climate change and the risks that climate change poses to different sectors.

In light of the gendered impact of climate change in The Bahamas, demographic data collected needs to be disaggregated by gender. This data should also be disaggregated by education level, socioeconomic status and age.

There also needs to be a greater understanding of trade-offs between use of resources. Some countries are developing information platforms and databases (e.g. climate model projections) with information at the local-scale level and national level. The Bahamas is moving in this direction with efforts such as the Spatial Decision Support System and the Storm Surge Atlas and Digital Platform, but more resources (i.e. financial, technical and human) need to be dedicated to data collection, analysis and sharing.

Other activities on data and information should include:

- Development of climate services – These could be simple data services in accessible formats to end users.
- Dissemination of information through multimedia applications.
- Training stakeholders on how to utilize climate information.

5.1.14.3. Developing an education programme on climate change

The Bahamas Ministry of Education has integrated climate change into their biology curriculum at the high school level. The curriculum addresses the evidence that the global climate is changing. It also investigates the public appreciation for the threats of global climate change. Students are also directed to consider when and how global climate change will impact the Bahamas in the future and the observations that might accompany this.

An education programme on climate change should be part of national development planning with education on climate change starting at the primary school level. Training for teachers on methods to engage with students of all ages should be a priority. Courses could be created by local academic institutions as well as government agencies such as C2EAU and DEPP. More detailed recommendations on education are provided in Chapter 9.

5.1.14.4. Building safe, resilient and sustainable communities

Integrating climate change into national development must involve local communities. A number of approaches can be taken on ensuring communities are built to be safe, resilient and sustainable. The “zero casualty” approach provides a framework to better respond to natural hazards and effects caused by climate change. The approach can include:

- Capacity building of the community - Children are educated on how to react in disaster situations and citizens are encouraged to participate in awareness raising activities on climate change.
- A regional real-time early warning system (including mapping and monitoring) and the establishment of efficient evacuation plans combined with legal and financial strengthening of disaster risk management.
- Involvement of local communities in every phase of development from project design to implementation to empower communities to determine what

infrastructure will best serve them. Community members can be upskilled and potentially employed to help scale projects. These actions can enable communities to develop stronger systems and break the cycle of vulnerability.

The Scottish Government's Community and Renewable Energy Scheme (CARES) is an example of a local community empowerment programme. CARES provides loans and helps support renewable energy projects that are beneficial to local communities. One requirement of the scheme is that projects are at least 20% locally owned or funded. The target of the scheme is 2 GW of community and locally owned energy by 2030. The Bahamas can seek to develop and implement these types of programmes, particularly in the Family Islands.

Chapter 6 – Development and Transfer of Environmentally Sound Technologies (EST)

The Bahamas has taken on the initiative of ensuring a sustainable future for the nation making the bold declaration that it intends to reduce its reliance on anthropogenic gases by 30%. The Bahamas has since made great efforts to ensure the obtainment of this goal. The Second national communication (2014) identified eight key sectors for the transfer of environmentally sound technologies in adaptation and mitigation. These were in the areas of agriculture, energy, health, transportation, water conservation, land use, forestry and tourism. Additionally, the SNC identified the critical need for a Technology Needs Assessment (TNA) to be developed for The Bahamas. The TNA would assess existing and developing technologies, identify technology gaps, and evaluate the cost and barriers to the technology implementation.

Environmentally sound technologies in its simplest form can be described as technologies that are designed to protect the environment. These can be technologies that are less polluting in that they recycle more of their wastes and products and/or handle residual wastes in a more acceptable manner than their predecessors. These are also technologies that use all resources in a more sustainable manner. Environmentally sound technologies are not only individual technologies but can also be whole systems which include expertise, procedures, goods and services, and equipment as well as organisational and managerial procedures. This includes the elements of human resource development and local capacity-building aspects of technology choices, taking into consideration the facet gender-relevant matters. Lastly EST's should be compatible with nationally determined socio-economic, cultural and environmental priorities.

The SNC details specific policy targets and objectives recommended to allow The Bahamas to reach its sustainability goals. These policies and suggested technologies primarily focused on energy efficiency measures and renewable energy options. They were captured in the form of short-term, medium-term and long-term targets with specific objectives that The Bahamas intends to pursue in order to lessen its dependency on fossil fuel combustion for its energy needs and also to promote sustainable energy future. The objectives were as follows:

Short Term Objectives:

- Identify the data gaps and then formulate and implement solutions for closing the gaps
- Setting realistic targets
- Investigating the potential exploitability of various renewable energy sources and technologies including:
    - Waste to energy

    - Wave
    - Tidal
    - Wind
    - Photovoltaic systems
    - Solar water heating units

Medium Term Objectives:

- Develop and implement a programme to increase the average fuel economy of vehicles.
- Improve the quality of diesel oils imported for local consumption to reduce particulate emissions in order to improve air quality in urban centres
- Develop and implement a national strategy for integrated traffic and transportation system management.

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
- 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.

The Bahamas has made significant progress in moving toward obtaining these objectives which is reflected in the environmentally sound technologies presented in this chapter. These technologies have been complied as a result of consultations with a number of governmental stakeholders as well as those from relevant research institutions and via desk review.

6.1 Environmentally Sound Technologies

6.1.1. Agriculture and Fisheries

The Department of Agriculture

The Department of Agriculture has been engaged in a number of projects to ensure sustainability in the agriculture sector. These projects are focused on increasing food security while simultaneously raising awareness on climate change and empowering Bahamians, especially youth and women, for the advancement of the agriculture sector. Therefore, the Department plans to provide tangible support for farmers to adapt and build resiliency. The activities are noted as follows:

- The revision of the Agriculture Climate Change Policy drafted in 2017 and presentation to Cabinet for adoption

- Training to building capacity on climate change and best practices to combat the effects in agriculture sector. Beneficiaries of the training are Ministry's agricultural officers, who will support farmers and fishers throughout the islands with a Masters Training of Trainers Program using the Farmer Field Schools (FFS) methodology.

  Persons will be trained in climate smart practices in:
    - Good Agricultural Practices (soils, plant health, animal health, food and nutrition, agroecology etc.)
    - Small ruminants (sheep & goats) and poultry
    - Agribusiness development
    - Agritourism development

- In a move to both decrease the practice of slash and burn on the Family Islands subsequently reducing greenhouse gas emissions produced by open burning and increase farmer productivity; the department intends to increase farmer access to mechanisation, especially on Family Islands with limited access to mechanisation. This will make farms more efficient in land preparation, thereby increasing productivity and food security. The project, which will begin in 2023, will commence with the purchase 3 tractors; 3 Rome discs; 3 ridging bodies; 3 bush hog mowers; and 3 post-hole diggers with attachments. The government has budgeted $1,039,981.20 in this effort.

- Improving farmer water management practices through increased access to drip irrigation. Starting 2023, the Department will purchase of 500,000 ft. of drip irrigation tubing as well as 20 solar pumps and 10 gasoline powered pumps, a $110,348.50 investment, to promote climate smart agriculture and water conservation at the farm level. The increased use of drip irrigation technology in crop production is expected to have positive impacts on Food Security in the Bahamas by improving the acreage in production, crop yield and reducing water usage the cost of production for crops.

- Promoting the use of renewable energy by providing farmers with solar pumps.

- Improvement of the breeding stock "*resource bank"* at the Gladstone Road Agricultural Centre (GRAC) to ensure that quality small ruminant breeds are available for sale to farmers at a subsidized price and the local market. This project also serves an element of disaster relief assistance to livestock farmers that lose their operations/livestock due to hurricanes or other disasters.

- Continued development of improved pastures with the Mulato & Cayman Grass which is both drought tolerant and fire resistant to support local livestock farming and reduce the possibility of fires. The results of the Mulato grass introduction was prolific however, the use of Cayman wasn't as successful and further research to investigate the cause would be necessary. The project was initially started in 2008 and thus far a budget of $7, 000 has been spent on seeds.

- Establishing local hatcheries to improve the availability of chicks for broiler and layer operations and also to mitigate challenges with access and high cost of shipping of imported chicks. Reducing the need for shipment would in turn result in a reduction of greenhouse gases.

- Diversifying production through agro-processing in order to add value, diversify availability and reduce farm waste.

- Implementation of climate change awareness activities as outlined in the 2017 Draft Climate Change Policy. Such activities include the creation of a comic book/animation, video, and posters (**2021**);

- Coral Restoration project: With Coral Vita (**2021**); [https://www.coralvita.co/]

- Development of a Good Agricultural Practices (GAPs) Course in collaboration with MAMR, BAHFSA, and Commonwealth of Learning based Canada (**2020**);

- IICA: Waste Management and composting Project (**2020)**;

- Projects to increase national food security under the National Emergency Plan in response to COVID- 19, (**2020**):
    - Backyard Gardening Initiative to increase food security at household level;

    - Chicken Layer Programme – to increase self-sufficiency in table egg production, thereby reducing imports of table eggs and providing chicken and eggs as a source of protein. About 30,000 layers (ranging from day old chicks to pullets) were distributed to farmers, backyard gardeners, government schools and one institution (Department of Corrections). Most of the major islands benefited from the distributed including Abaco, Grand Bahama, Eleuthera, Andros, Cat Island, Long Island, Mayaguana, Exuma, and Acklins. Beneficiaries ranged from backyard gardeners to commercial producers. Overall, the project has had a positive impact on table egg production in The Bahamas. Future plans include the establishment of a hatchery to address issues regarding the availability and high cost of importing birds and the production of breeder flocks to create a resilient local food supply. This project has received $790,000 in funding from the Government of the Bahamas.

- Implementation of Community Food Processing Kitchens
  - The construction of 3 processing facilities on Family Islands (Eleuthera, Cat Island, Andros) to meet international standards. The project will run from March/April 2022 – 2024.

- Integrated Landscape Management for Addressing Land Degradation, Food Security and Climate Resilience Challenges in the Bahamas: A GEF project (pending approval 2022).

Technologies that would further assist the agriculture industry of the Bahamas would be: Solar drying equipment for plants and seed, bio-ingestion (mitigation), an insemination programme for sheep and goats, the use and development of biogas, expansion of community kitchens, new buildings for the slaughter houses on the Family islands, tractor equipment upgrades and Tablets for the field technicians.

In order for the Agriculture department to research, develop, implement, and enforce novel and existing environmentally sound technologies; a major capacity supplementation is needed in the form of: A Director of Agriculture (1), Deputy Directors of Agriculture (2), Soil Scientists (2), Microbiologists (2), Entomologists (2), Horticulturalist/Plant Specialists (2), Extension Officer (Crop & Livestock) (10), Apiary Specialist (2), Agronomists (2), Veterinary Officers (4), Veterinary technicians (6), Animal scientists (poultry, swine, small ruminants) (3), Food technologists (2), Lab Technicians (Food Technology Lab) (4), Extension Officers (Food Technology Lab) for training, inspection, regulation of Family Island community kitchen which are food processing units (2), Statisticians (2), Economist/Marketing (1), Project Managers (2), Human Resource Specialists (2), Mechanical Engineer (1), Tractor Operators (6), and Persons trained in Climate Change & Agriculture/similar at the post grad. Degree level (2) and GIS analysts.

The use of GIS analysts would be useful to enable the Agriculture Department to specifically identify where flocks are throughout the country and critically for traceability in the event of poultry disease outbreak in country such as Avian Influenza.

The Bahamas Agriculture and Marine Science Institute (BAMSI)

By its very existence the institution has made great contributions to increasing the capacity of the agriculture sector. The institution offers courses at the associate's level: Agriculture, Environmental Science, Marine Science, Aquaculture, Agronomy and a certificate in Aquaponics and other subjects. These programmes are offered by the institution to support the continuance of the agriculture industry in the Bahamas and to create suitable and eco-friendly alternatives to traditional farming. The institution is also planning to expand its curriculum to include an Environmental Science programme at the Bachelors level.

BAMSI has several initiatives to ensure food security to local residents. It's National Roots and Tubers programme creates food security and is a restorative method as it provides farmers especially those that have lost their crop due to inundation by storm surge with supplies to replenish their stock. Additionally, in a preventative move, prior to an incoming storm, BAMSI delivers sheep and goats to be secured on the potentially targeted island. This ensures that there is a food source available on those islands in the immediate aftermath of the storm as it will take time for the island's operations to regain a degree normalcy.

6.1.2. Forestry and Biodiversity

Establishment of a Seedling Nursery and Replanting for Forest Recovery and Restoration on Grand Bahama.

The aftermath of Hurricane Dorian resulted in, the destruction of 24% of pine forests on Abaco and 77% of pine forests on Grand Bahama. . TFUs post-Dorian rapid forest impact assessment (estimates that 22.5% and 100% of the forest resources on Abaco (148,797 acres) and Grand Bahama (70,289 acres), respectively, suffered severe to catastrophic damage due to hurricane-force winds, saltwater intrusion, tornadoes, and fires. This project, which is a collaboration between the University of the Bahamas and the Forestry Unit, is the first official planting of pine seedlings. The Project seeks not only to reforest the areas on Grand Bahama and Abaco with pine trees but also complementary species that are typically found in the pine forest ensuring balance in the ecosystem. The restoration of the pine forests is expected to restore the understory vegetation reduce limestone exposure, which will in turn decrease the occurrence of run-off and erosion of the limestone during wet and rainy periods thus protecting the landscape from denaturation. The research component of the project will answer questions such as: What are the best methods to actually plant pine out or plant trees out in the pine forests? What will be the survival rate? Will invasive species come in if an area is reforested? Will the seedlings take a period of time and with normal cycles of fire commence growth? And would the forest reconvert to a broadleaf deciduous forest that is native to the nation? The nursery project is a BPAF funded project granted $99,987.28. The project was awarded in June of 2021.

National Forest Monitoring System.

This is an initiative that is currently in development in the GCF readiness process. The goal is to establish climate monitoring system in the nation in the form of a National Forest Monitoring System, which would simultaneously be used for verification. The network would include monitoring land cover, land cover change, and forest cover. The data would subsequently be used for calculations for the different carbon sequestration rates and greenhouse gas emissions or sinks.

Bahamas Pine Islands (BPI) – Forest/Mangrove Innovation and Integration (Grand Bahama, New Providence, Abaco and Andros)

In this GEF project, the Bahamas seeks to integrate biodiversity considerations and ecosystem services into forest management and land use planning in the northern islands; Grand Bahama, New Providence, Abaco and Andros. The project is contributing to institutional systemic support for the development of land use plans for Andros and

New Providence that incorporate conservation ecosystem considerations, expansion and improved management of the forestry sector through upgrade of forestry management plans, completion of condition status assessment and formal gazettement of the Forest Estate. It will provide models for sustainable land and forestry management and contribute to sustainable livelihoods through expansion of silvertop palm and cascarilla production.

Meeting the Challenge of 2020 in The Bahamas

The project which commenced in 2020 and will run to 2025, will strengthen management of marine protected areas in The Bahamas so that they are integrated into broader landscape planning to reduce pressures on ecosystem services and biodiversity from competing resource uses. The project will contribute to integration of natural resource management within management of marine protected areas and adjacent landscapes, the enhancement of protected area management within 5 MPAs; Moriah Harbour Cay National Park, Lucayan National Park, Exuma Cays Land and Sea Park, Andros West Side National Park and Bonefish Pond National Park. It will engage local communities that derive direct economic benefits, in enhanced environmental stewardship of the MPAs and surrounding areas.

Implementing Land, Water and Ecosystem Management (IWEco) in The Bahamas

The project which commenced in 2018 intends to develop a model of integrated land, water and ecosystem management for The Bahamas and other Small Island Developing States in coordination with the main GEF-IWEco Project. The project will implement innovative solutions for maintenance of ecosystem health in East Grand Bahama, strengthen environmental monitoring and evaluation systems, policy, legislative and institutional enabling environment in support of natural resource management and enhance knowledge exchange and best practices.

Mangrove Restoration Projects

Northern Bahamas Mangrove Restoration Project.

Research indicates that more than 73% (22,528 acres) of Grand Bahama’s mangrove cover and 40% (21,678 acres) of Abaco’s mangrove cover were damaged during the storm. In a collaboration between, the BNT, Bonefish & Tarpon Trust, local fishermen, community members and others, efforts have been made to restore mangrove forests that were devastated by Dorian. Scientists have collecting mangrove propagules to grow in nurseries on both Abaco and Grand Bahama that upon maturity will be planted in the wild. In an effort to encourage community involvement, groups of local volunteers are rallied together to assist in transplanting the young trees. To date multiple mangrove plantings have been implemented across Abaco and Grand Bahama and more than 17,000 red mangroves as part of the Northern Mangrove Restoration Project. BNT has a goal to plant 100,000 mangroves over the next few years.

Mangroves Harvesting and Replanting Project Dover's Sound, Grand Bahama

This particular mangrove restoration project specifically targets mangrove forests in high-risk flood zones. This is key as restoration efforts will increase island resiliency against increasingly severe weather systems. The project's capacity building component aims to train local workforce in mangrove restoration skills as well as educate the local population about the importance of mangrove forests and community requirements for protecting and maintaining critical mangrove infrastructures. This project is a BPAF project awarded in Oct 2021 to Waterkeepers Bahamas (WKB) in the amount of $100,000.00.

Post-Dorian Damage Assessments and Strategic Restoration of Mangrove shorelines of the Little Bahama Bank

This project will produce a detailed assessment of Hurricane Dorian's impact to mangrove communities, including damage to the mangroves themselves and marine life that depends on mangroves to assess disruption in ecosystem function. The assessment will be followed by the development and implementation of restoration activities aimed at facilitating ecosystem recovery in key areas. Implementation of those strategies will include capacity building for mangrove restoration in the form of planting mangroves, hydrologic restoration, and/or debris removal within local communities as well as the actual restoration of mangrove ecosystems. The 12-month project (initiated May 2021) is being managed by the Bahamas Undersea Research Foundation and was awarded 100,000.00 by BPAF.

The legal framework for the development and implementation of an Integrated Watershed Management Plan for East Grand Bahama.

The Marine biodiversity in the Bahamas is threaten by a number of variables. Land degradation in the form of economic development occurring on land and facets of the tourism industry, such as hotel and resort wastewater, damage the biodiversity resources of wildlife and fish habitats such as those provided by pine forests and coral reefs. The aim of the *Integrated Watershed Management Plan For East Grand Bahama (IWEco*) is to "place under a management regime at least 20000 hectares of ecologically important biological corridors (comprising of mangrove wetlands and pine forests) and contribute to reduces pollutant loadings, particularly of sediments and nutrients to avoid excessive eutrophication of nearshore waters and smothering of coral reef systems". The Core outputs of the Project will include a watershed management plan, a biodiversity inventory, restoration methodology and increased sustainable livelihoods to diversify the financial resource base in local communities in East Grand Bahama (‘EGB’). The project aims to address the eco-tourism sector in component 1 of the project. Component 1 will also produce a Biodiversity Inventory which enlists the use of GIS data and will be a useful resource for future researchers. Upon a successful model of integrated landscape and seascape management, the Government of The Bahamas will replicate this project on other islands and can share with other Small Island Developing States regionally and globally.

Park Management and Restoration.

Currently, supported by The Bahamas government and other partners, the Bahamas National Trust protects 32 land and sea parks covering more than two million acres, across 10 islands. Their efforts include habitat restoration, park management, collecting and using data from strategic monitoring and science-based conservation techniques, the creation of green spaces, and the removal of invasive species. Their efforts result in building resilience in habitats and wildlife populations in national parks and the protection of coral reefs and coastlines via the removal of the invasive Casuarina Tree which erodes coastlines and damages reefs when they are uprooted during storms. Funding support from the Global Environment Fund (GEF) Small Grants Programme, Global Environment Facility & United Nations Environment Programme (GEF/UNEP), the National Fish and Wildlife Fund (NFWF) and private donors has allowed the organisation to hire an Exuma Programme Coordinator and Deputy Park Warden, secure property for a park headquarters, install demarcation buoys, procure vehicles for park operations and increase community engagement.

One of the park projects under BNT’s purview is**: Restoring and Building Climate Resilience at Rand Nature Centre (RNC).** This 13-month long project was awarded a BPAF grant in August 2021 and serves to restore and strengthen terrestrial ecosystems within national park boundaries building resilience of critical habitat needed to sustain important migratory, native and endemic biodiversity. The plant nursery and arboretum therein will both serve as key resource areas for repopulating destroyed or damaged sites after storm or man-made disturbances. Another is **Rebounding from Hurricane Dorian, the Abaco National Parks Road to Recovery** a 15-month BPAF project awarded $99,997.80 in May 2021.

- **Conch Management Project**. This project was piloted in Grand Bahama and focuses on working with local fishers to ascertain the needs of their communities, teach sustainable conch fishing practices, and help develop alternative livelihoods for the benefit of the communities and the preservation of the conch species. Surveys were conducted with The Nature Conservancy (TNC), followed by consultants engaged to train Grand Bahama residents in conch ranching as a means of managing depletion;

lastly exposure to a successful fishery in Puerto Rico was arranged for project participants to learn about how to manage a conch fishery at a sustainable level and explore their newly developed conch hatchery. This was accomplished in 2018, with funding from the Japan Special Fund for Poverty Reduction through the Inter-American Development Bank and conducted by the BNT.

Coral Propagation & Restoration.

Given the horrors inflicted on the Bahamian Coral reef by both Stony Coral Tissue Loss Disease (SCTLD) and Hurricane Dorian, the work of Coral restoration has never been more critical to the nation. The Bahamas Coral Innovation Hub, a research facility based at the Cape Eleuthera Institute, The TNC, Perry Institute and other research partners research and implement the latest and most effective coral reproduction techniques notably: Mircofragmentation, facilitated sexual reproduction, and optimising on the coral's natural spawning events and collect coral eggs and sperm applying the latest techniques in facilitated sexual reproduction in order to create healthy new embryos. These efforts result in maintaining or improving the genetic diversity of the reefs and increasing the rate of survival of young corals encouraging reef rehabilitation. A pilot coral spawning expedition in 2018 resulted in the creation of 1.3 million new embryos.

- **Awareness programmes**:
  - Stony Coral Tissue Loss Disease (SCTLD). It was first documented in Florida in 2014 and its presence was confirmed in The Bahamas in 2020 in waters around Grand Bahama. Since its discovery, confirmed spreading across coral reefs all around The Bahamas have been noted. Noting the urgency of the situation, The Government of The Bahamas assembled a task force of government officials, scientists and NGOs to learn more about the disease and raise awareness of its presence in the country and develop national-level strategies to slow and halt the spread of the disease.

  - The creation of *Xuma the Explorer!* Xuma was created by BNT's s Education Team, and she is the main character of the video series *"The Adventures of Xuma,"* - *a* young Bahamian explorer who shares the wonders of the world, explores the beautiful and unique ecosystems and species of The Bahamas. The show is aimed at teaching children ages 5 to 12 about the environment.

  - BNGIS previously initiated an Education Programme in school to teach students, a project which they hope to start up again by the end of 2023.

6.1.3. Energy and Transportation

Many of the policies and suggested technologies in the Second National Communication focused primarily on energy efficiency measures and renewable energy options. The National Energy Policy recognised the importance and the urgency of transitioning to a cleaner, greener, more affordable and more efficient energy sector keeping our own commitment to generate at least 30% of our energy from renewable sources by 2030. As indicated in the SNC, The Bahamas has sought funding in order to pursue its initiatives of reducing the nation's reliance on fossil fuels. The Bahamas has received and IDB-funded loan of $80 million and a $9 million EU-CIF grant for renewable energy projects. The nation has also received funding and support from the GCF, GEF, and CCCCC. These projects are discussed further below.

<u>2009-2014</u>

The Bahamas was engaged in the project **Promoting Sustainable Energy in the Bahamas.** This project was supported by the Global Environment Facility via Inter-American Development Bank and valued at $1,000,000 USD. The project, which has been carried out in partnership with the Ministry of Environment has been successfully completed. The objectives of the project promoted and supported the development and implementation of sustainable energy sources in The Bahamas by providing alternatives to reduce dependency on imported fossil fuels. The results of this project provide foundational evidence that the installation of solar energy systems and use of net metering in public buildings and the residential and commercial sectors supports the attainment of the country's energy efficiency goals.

<u>2017-2019</u>

Energy efficient lighting improvements in select public buildings in Harbour Island, Bahamas. This project was supported by the Inter-American Development Bank and valued at $38,060 USD. The aim of this project was to implement a pilot project focused on increasing awareness of the importance of energy conservation and the use of high energy efficiency technologies that are in line with achieving the country's NDC and Goal 1 of the NEP.

This project promoted the use of energy efficiency lighting equipment in selected public buildings on Harbour Island and resulted in a strong use-case for energy and cost savings, as well as GHG emission reductions. This would be contribute towards addressing target 3 of the SNC's medium term targets to "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." The project was made possible by the technical assistance support of the Inter-American Development Bank and government representatives on Harbour Island.

January 23, 2017. **Strengthening Bahamas' NDA and Developing its Country Programme**. This project communicated the Country Programme for The Bahamas, as well as strengthened the NDA in terms of tool and guidance development for engaging with GCF. The framework that was created under the capacity building process will provide the Capacity building for Energy Auditing and Solarization Readiness in The Bahamas with an established theoretical base from which to build upon in a practical, hands-on manner. $300,000 USD in funding was given to this project supported by the Caribbean Community Climate Change Centre (5Cs) and the GCF

June 12, 2018. **The Bahamas Power System Stability Study for Implementation of a Higher Renewable Energy Penetration Level.** This project was supported by United Nations Industrial Development Organisation (UNIDO) on behalf of The Climate Technology Centre and Network (CTCN) Readiness and Preparatory Support provided by GCF. The project, which has been completed was valued at $369,715 USD. The goal of this project was to identify appropriate climate technologies for the energy sector of The Bahamas. The focus was primarily on solar energy.

January 10, 2019. **GCF Readiness and Preparatory Support in the Bahamas (Phase II)** supported by the Caribbean Community Climate Change Centre (5Cs) with readiness and preparatory support provided by GCF. The project was funded $359,950 USD. The project details the development of a national level Monitoring, Reporting and Verification System to track climate finance inflows and public expenditure in The Bahamas.

November 8, 2019. **Building Blocks for Strengthening The Bahamas Country Programme**. This project was supported by the Caribbean Community Climate Change Centre (5Cs) with the readiness and preparatory support provided by GCF with a funding of $951,903 USD and is in the process of implementation. This project builds upon The Bahamas' first readiness project with the goal of advancing the country program. This project will provide important lessons learned, updates, and recommendations, as well as bolster capacity, to move forward the execution of the original Country Programme developed. It would provide the NDA with an up-to-date roadmap and enhanced technical skills on increasing renewable energy penetration nationwide and further address energy efficiency gaps identified in the Country Programme, and enhance the NDA's capacity to access and benefit from potential climate financing.

July 22, 2020. **Building The Bahamas capacity in transparency for climate change mitigation and adaptation**. Valued at $1,354,200 USD This project was funded by the Global Environment Facility via United Nations Environment Program and is currently being implemented. The project is expected to be in operation between 2021 and 2024. The objective of this project aims to create a transparency framework through which The Bahamas is able to meet reporting requirements in accordance with Article 13 of the Paris Agreement. To accomplish this goal, UNEP is working with the Government of The Bahamas through technical support, training, and development of tools, in order to enable submission of transparent, consistent, complete, and accurate GHG inventories nationwide.

Capacity building for Energy Auditing and Solarization Readiness in The Bahamas. This project is spearheaded by Ministry of Environment and Housing (MoEH). The project is designed to build a framework for energy auditing and solar assessment which will be required to scale a national pipeline of projects necessary to achieve The Bahamas' Nationally Determined Commitment (NDC) by 2030 and transform its energy sector to mitigate the effects of climate change locally. The proposed scope of work will involve the creation and implementation of a training program to be embedded within MoEH to conduct energy audits and provide practical experience for trainees through classroom learning and on-site audits of five government facilities. The main beneficiaries of the project will be staff members of the MoEH and the Ministry of Public Works, as well as individuals from civil society organizations such as the Bahamas Society of Engineers. This Readiness Proposal complements "*Strengthening Bahamas' NDA and Developing its Country Programme*" as it references and uses as an input the Country Programme created under its implementation.

Photovoltaic systems

Ragged Island Solar Microgrid Project

In August 2022, the first island-wide solar project - *Ragged Island Solar Microgrid Project* - *was* established. The system consists of 924 individual solar panels and a 12-battery storage unit to create a 401KW solar field. The solar field has a diesel generated automation system. The project on Ragged Island hails as a forerunner being the first to convert a main island to a solar based energy distribution system. Providing energy at a rate that is financially attainable, this project has not only attained the goal of switching to a renewable energy source but also of providing power to local residents at a much lower cost addressing the issues of financial constraints amidst rising oil prices. This was a point indicated in the National Energy Policy which highlighted the relationship between the cost of living and the then 100% dependency on fossil fuel. The move has also addressed some of the gender concerns in the midst of climate mitigation as female led households in The Bahamas had a higher poverty rate 9.7% as of 2014. When Hurricane Irma passed over Ragged Island in 2017, it completely devastated the island. Leaving it without power and virtually uninhabitable. Therefore, as an adaptation measure, The Bahamas has allocated more than $35 million for the installation of solar photovoltaic systems in the Family Islands. Progress has already been made for the installation of photovoltaic systems on other Family Islands. Thus far, feasibility studies for Inagua, Mayaguana, Acklins, Crooked Island, Long Cay and North Andros have been concluded and are awaiting the next phase in development. The Government plans to invest 4.5 million in the installation of five microgrids in East End Grand Bahama and 14.2 million dollars in installing a 25 MW Battery Energy Storage System at the Baillou Hill Power Plant.

Improving sustainability and building resilience at Forest Heights Academy (FHA) - Marsh Harbour, Abaco through the installation of a solar photovoltaic system with batteries. Is a BPAF project granted $ 95,534.00 and coordinated by Friends of the Environment (FRIENDS). The results of this project are: a move to 20% renewable energy, the enabling of the Forest Heights Academy (FHA) to be able to open for full time operation by the end of 2022, savings generated from their monthly electricity bill which can be used to further improve the school's sustainability and resilience, the installation of a well with pressure pump supported by the solar PV system which will eliminate the need to send students home due to water and power outages, educational opportunities for students interested in pursuing careers in renewable energy and the capacity building of FHA staff members in the safe operation/ management of the solar PV system and community engagement.

Solarising the UB-North (Grand Bahamas), Marine and Environments Science Field Station. As a result of Hurricane Dorian, much of Grand Bahama is now considered to be part of a broader Protected Area zone. A functional research field station will directly enable long term surveillance and facilitate the execution of forest restoration, aquifer recharge and coastal regeneration efforts on Grand Bahama. The solarisation of the field station, a 6-month project which began in September 2021, will shift the dependency of the field station from fossil fuels to the use of renewable energy increasing the stations resilience to climate change and setting it up as an excellent case study for the students studying conservation and renewable energy. The solarisation increases the capacity of the station to operate normally as it promotes research and instruction in the fields of: sustainable development, sustainable energy, marine science, environmental science, atmospheric science/meteorology, conservation, climate change, hurricane science, emergency planning and disaster response and management; provides a living and learning environment for UB students, and opportunities for international collaboration and joint research. The project was awarded a BPAF grant of $100,000.00 to complete this project.

The Bahamas plans to invest more than $36 million in renewable infrastructure in Abaco and East Grand Bahama. The focus of this investment in Abaco will include $18 million for the restoration of electricity services and the rehabilitation of physical infrastructure damaged by Hurricane Dorian.

The solar rooftop programme has a budget of $1.9 Million. This project will enable clinics, public libraries and schools to take part the nation's renewable energy progress. The Ministry of Public Works is assessing eight government buildings for this programme. Further discussion and progress of these and the aforementioned solarisation projects will be detailed in the following national communication.

Energy Efficiency

Employing advanced energy efficient lighting systems in public spaces is one of the targets defined in the SNC. By the end of 2022, the Bahamas Power and Light Company Ltd. (BPL) is preparing to replace 30,000 street lights as part of the Street Light Retrofitting Project. This project is funded by the Caribbean Development Bank (CDB) and the Government of The Bahamas. As stated by BPL, the main objectives of the project are to reduce the cost and the environmental impact of street lighting by upgrading existing high-pressure sodium (HPS) and mercury vapor (MV) lights with LED (light emitting diode) luminaires. Using LED lighting would consume more than 30% less power than conventional HPS or MV lighting for the same degree of illumination. The reduction in power needs will overall demand on the network and lowering the overall cost of street lighting. This mitigation action fulfils the NEP goals of both climate change mitigation and modernizing the country's energy infrastructure.

Other Renewable Energy Technology

As of 2022, the Government of The Bahamas has eliminated import duties on lithium ion and lithium phosphate batteries, the batteries predominantly used for renewable energy. Additionally, the government has simplified the process for bringing in renewable energy parts. This move is in line with the Government's goals of public awareness and encouraging the use and adoption of environmentally sound technologies.

Fossil Fuel Alternatives:

Biofuels

Biofuels are fuels produced directly or indirectly from organic material – biomass – including plant materials and animal waste. In contrast to fossil fuels, the source biomatter of biofuels can regrow quickly. For this reason, bio-based fuels - the most common of which- ethanol, biodiesel, biomass and biogas can be classified as a form of renewable energy.

Bahamas Sustainable Fuels produces different biodiesel blends based on the company's need. This is represented in the form Bx where 'x' is the percentage of biofuel in the blend. Biofuel is produced via chemical process from vegetable oils, animal fats, or recycled restaurant greases such as the oil collected from all of the fast-food restaurants on the island of New Providience, from as well as the major hotels. Producing biofuels lessens the dependence on traditional fossil fuels and improves diversity of fuel supply.

This is in line with the country's NEP. Biofuels also burn more efficiently than petroleum diesel and are typically less flammable making it safer to transport. Additionally, the use of biofuel in The Bahamas is environmentally beneficial as it:

1. Reduces lifecycle greenhouse gases by 86%
2. Reduces hydrocarbon emissions by 67%
3. Biodiesel production reduces wastewater by 79% and hazardous waste by 96%.

Within 28 days, pure biodiesel degrades by 85 to 88 percent in water. Blending biodiesel with diesel fuel accelerated its biodegradability such that even a B10 blend ensures the biodegradability of the product.

Bahamas Waste has incorporated the use of biofuel into their company and currently 75% of the fleet use a B35 blend. That is a blend of 35% biofuel oil and 65% diesel. By the end of the year, the remaining 25% of the fleet will also be using biofuel, a B20 blend. Bringing the entire fleet to 100% users of biofuel.

Pending a successful pilot launch, the Water and Sewage Corporation is considering the consumption of 60,000 gallons of biofuel per year to be distributed for use in their fleet of trucks firstly and secondly in the water plant. The conversion of fossil use usage to biofuel eliminates the plumes of thick black smoke often associated with heavy-duty vehicles and will reduce the nations contributions of GHG emissions.

Transport

Electric Vehicles (EVs)

As of the formulation of this national communication, the Government has reduced duty on EV chargers. The Government has also made the decision to lower the duty on the electric vehicles with a value of under $70,000 to 10 percent, for vehicles over $70,000 the duty will be 25 percent, allowing for this green technology to be made affordable to local citizens. The same framework is employed for hybrid vehicles.

UHY's research (2021) showed that The Bahamas placed at the eighth largest year-over-year electric vehicle sales increase in the world in the preceding year. The Government has begun a shift to convert its fleet of vehicles to electric vehicles. Cars operated by the Water and Sewage Corporation will also begin a shift toward the use of electric vehicles.

As stated in the SNC, emissions testing is still on the agenda for The Bahamas however this project will not commence until the Ministry of Transport has completed its move into its new building. Therefore, the following National Communication will detail the progress of this policy.

6.1.4. Infrastructure and Coastal Management

June 2018: The Climate-Resilient Coastal Management and Infrastructure Program.

This project is funded by an IDB Loan (BH-L1043) and is expected to conclude in 2024. The objective of the program is to build resilience to coastal risks including those associated with climate change through sustainable coastal protection infrastructure, including natural infrastructure and integrated management of the coast. The program will finance science-based shoreline stabilisation and coastal flooding control measures in East Grand Bahama, Central Long Island and Nassau/Junkanoo Beach in New Providence; natural infrastructure for hazard resilience through restoration of coastal natural habitats (mangroves, reefs) in Andros; and institutional strengthening for coastal risk management. This program is expected to result in a reduction of the severe economic losses due to natural disasters and an increase in local economic activity through coastal resilience.

The Climate-Resilient Coastal Management and Infrastructure Program has 5 components which are as follows:

- Component 1: Sustainable Coastal Protection Infrastructure. The objective of this component is to increase resilience to coastal hazards through science-based shoreline stabilization and coastal flooding control measures coupled with sustainable rehabilitation of adjacent critical public infrastructure at three priority sites: East Grand Bahama, Central Long Island and Nassau/Junkanoo Beach in New Providence.

- Component 2: Natural infrastructure for hazard resilience in Andros. The objective of this component is to enhance communities' resilience to coastal hazards and climate-related impacts through implementation of pilot projects on Andros that demonstrate the effectiveness of natural habitat restoration for coastal protection in line with the Andros Master Plan.

- Component 3: Institutional strengthening for coastal risk management. This component aims to increase the Executing Agency's (EA) capacity to engage in coastal resilience project formulation through enhancing institutional capacity and capability, and integrated planning.

- Component 4 and 5: Administration and Contingencies Administration resources aim to facilitate the program processes and implementation as guided by the loan contract. This component will support procurement activities for the above three components to their realization.

Coastal Protection

Hurricane Dorian Small and Medium Marine Debris Removal on Man-O-War Abaco. Debris left over from hurricane Dorian contributed to additional damage to the environment and to human health. To address this issue, a clean-up effort by the Disaster Reconstruction Authority (DRA) over a 12-month period (starting August 2021) to facilitate the removal of 240 cubic yards (2 x 30 cubic yard bins per week) of small and medium sized marine debris from the marine environment caused as a result of Hurricane Dorian. This project was supported by the BPAF and awarded $100,000.00.

Activities on Human settlements

Building Code

The building code (edition no. 3) for The Bahamas has not been updated in the last 20 years. Previously, the building code allowed for winds of 130 mph. The new building code will allow for buildings to be constructed with greater resistance of winds up to 180 mph. It should be noted however, that new buildings have always been reliant upon the American civil engineers and followed their building designs which are updated every three years. Therefore, although the code itself has not been updated, officially designed buildings would have been created to sustain increasing wind speeds using the American civil engineer’s standard. Furthermore, the new building code takes into consideration evaluations made on the building codes and standards of neighbouring countries and its design will include plans for energy efficiency, accessibility, sustainability, and use of renewable energy. These changes will be in line with *Persons With Disabilities (Equal Opportunities)* Bill, 2014.

Progression of the Climate-Resilient Coastal Management and Infrastructure programme:

<u>Component 1: Sustainable Coastal Protection Infrastructure</u>.

Junkanoo Beach

- Start of Baseline Coastal Studies & Design- October 2022
- Coastal Zone Photogrammetry Study - August 2022
- Shoreline Change Study –December 2022 (anticipated completion date)
- Nearshore Wave and Current Study –November-2021
- Sediment Transport Study- February 2023 (anticipated completion date)
- Coastal Infrastructure Asset Assessment- February 2023 (anticipated completion date)
- Environment & Social Baseline Studies- January 2023 (anticipated completion date)
- Engineering Studies- July 2023 (anticipated completion date)

- Environmental Economic Valuation Baseline Study January 2023 (anticipated completion date)

East Grand Bahama

- Expression of interest baseline study and design- Nov 2021
- Financial & Final Evaluation Completed August 2022

Central Long Island

- Expression of Interest baseline study and design Strategic Coastal Protection and Flood Mitigation- November 2021
- Financial & Final Evaluation Completed-August 2022

Component 2: Natural infrastructure for hazard resilience in Andros.

- First Interim Report - April 2022
- Climate Change, Met-Ocean Coastal Analysis - July 2022
- Socioeconomic Assessment-August-2022
- Biophysical Assessment November- 2022
- Hazard Assessment Report and Maps - September-2022
- Vulnerability Assessment Report and Maps-October-2022
- Hazard Risk Assessment Report - November 2022
- Final Report-March-2023 (anticipated completion date)

Component 3: Institutional strengthening for coastal risk management.

- Upgrading the Bahamas Building Code Incorporating Coastal Infrastructure Design Guidance (End of Year-2022 anticipated *Draft* date)

Component 4 and 5: Pending further development

It should be noted that there is a severe gap in this Technology (Component 3) as it pertains to the lack of building inspectors. Although there is a new code, having the necessary number of building inspectors on each island is critical to ensure the successful enforcement of the new regulations. As it pertains to the Family islands of The Bahamas, each island needs at least four inspectors. However, this current estimate may depend on the amount of development that is currently happening on the respective island and may vary.

Road Works

Transportation is responsible for 24% of direct CO_2 emissions from fuel combustion with road vehicles accounting for nearly three quarters of these emissions. Gladstone Road serves as the primary route to the major industrial centre on the island of New Providence. As a primary route, it is subject to long delays and high volumes of traffic on a daily basis that are anticipated to worsen with new development. The Government of The Bahamas (GOB) through the Ministry of Public Works (MOPW) seeks to undertake the widening of the route from a single lane to a dual carriageway. In addition to increased vehicle capacity, the improvements will include junction improvements, installation of medians, drainage facilities, street lighting, traffic signs, and road markings. The intersections at the northern end of the road will include smart lights with cameras that use algorithms to predict and direct traffic flow. It’s important to note that hazard maps and SLOSH models indicate the southern end of Gladstone Road could be impacted by severe hurricane (Category 3+) surge approach from the south. The environmental report also indicated a risk of inland flooding from nearby lakes during storms. Therefore, the Gladstone Road may be elevated as a solution. It is also the intention of the Government to elevate the other roads of the nation 2.67 feet above the water table reducing their susceptibility to flooding as a result of heavy downpours of rain. The results of progress of these projects will be further discussed in the following national communication.

6.1.5. Water Resource Management

Abaco Sunny Waters Project

In order to restore a reliable and resilient supply of water to the residents of Abaco after Hurricane Dorian, UNICEF provided over $1 million in funding to Water Mission to work in close coordination with WSC on *The Abaco Sunny Waters* project.

The goal of the project is to produce a technology that would ensure a decrease in vulnerability in the event of future natural hazards induced disasters - a vulnerability that was exacerbated by the unstable electrical grids and the generator dependant water systems. This resulted in the solarisation of the Marsh Harbour, Abaco well fields and pumping station and the consideration of power blending between the electric grid, back-up generators and solar panels to achieve resilience and redundancy.

The solar solution will provide a portion (25-30%) of the energy requirements. The project also included a capacity building component for the Water and Sewage Corporation on solarization design, technology and operation & maintenance and the proposed improvement of sustainable management of water resources at schools by the use of rainwater harvesting, thereby improving the WASH resilience and sustainability of schools. A collaboration with WSC, the Ministry of Education, and Water Mission was needed to discuss possible ways to increase children's understanding of WASH related programs.

Preparation of a Water Supply Development Strategy for Utility and Non-Utility Service Areas in the Family Islands.

Being an archipelago with a dispersed population, poses a challenge for public services to be distributed equally and interrupted over the islands. Water networks are one of those services that do not provide full coverage. The public water utility in The Bahamas, the Water Sewerage Corporation (WSC), is the main water supply operator in the country; however, some other operators cover limited areas. WSC supplies New Providence and 24 Family Islands and Cays. The water infrastructure managed by the Water and Sewerage Corporation (WSC) in the Family Islands consists of more than 50 standalone systems and utilise two water sources: the well fields and Reverse Osmosis (RO) plants. Almost 75% of Bahamians are not connected to public sewage, with WSC currently having no wastewater treatment facilities in the Family Islands.

Despite this challenge, The Commonwealth of the Bahamas has initiated a process to ensure sustainable water supply services to 100% of the population. This is in line with Sustainable Development Goal #6 (SDG6) and the National Development Plan (NDP). The Water Sewerage Corporation (WSC), using funds from the Inter-American Development Bank (IDB), requested Hydroconseil and its local partners, ETS and Blue Engineering, to develop a Water Supply Development Strategy (WSDS) for the Family Islands and Cays (FI). This strategy includes investing in the water supply (reverse osmosis plants, leak detections, storage and pressure tanks), sanitation and sewage projects, and research and capacity building.

Ocean Thermal Energy Conversion (OTEC)

As The Bahamas continues the search for sustainable, renewable, available and affordable water resources for its citizens; Ocean Thermal Energy Conversion (OTEC) is a sustainable technology application that has and is currently being explored. As mentioned above, The Bahamas presently utilizes groundwater supply and discharge wells for SWRO.

The groundwater resources of the nation are comprised of fresh, brackish, saline and hyper saline waters found in the near and deep subsurface and in the lakes and ponds that intercept the surface.

The use of OTEC requires a temperature differential of 20°C (36°F) between the hot and cold waters. The Bahamas has a very warm surface temperature of 27°C (80.6°F) on average year-round. While, an estimated depth of 914.4 meters (3,000-feet) gives the necessary difference of 7°C (44.6°F).

To improve efficiency and for a proof of concept, a paper by John Bowleg - *Climate change, water resources, & renewable energy in the Bahamas use of the inverted geothermal conditions of the water resources, toward climate adaptation measures for both water and energy – by Ocean Thermal Energy Conversion (OTEC)(2022)* - suggests the use of solar photovoltaic cells to warm water from existing cold water supply wells to 50°C (122°F). To improve resiliency, the technologies of SWRO, Seawater district cooling and OTEC can be combined and serve as renewable energy options. Additionally, no fuel storage is associated with Seawater district cooling or OTEC.

A pilot OTEC project has been proposed as a mitigation action for The Bahamas to meet its 30% Renewable Energy Goal.

6.1.6. Health

Developing a Climate Resilient Health System in The Bahamas

Climate change affects the health service's ability to deliver healthcare and healthcare access in SIDS. Most populations and health care facilities in The Bahamas islands are at risk of damage by tropical cyclones, floods, storms, and disturbances in water supplies. Damage to infrastructure and essential supplies/amenities affect the capacity of health systems to provide services when they are most needed in emergency situations.

This project was designed to build upon and strengthen national bodies, communities and human resources with new mechanisms for the preparation, coordination and response to climate change, gender inclusiveness and health issues on The Bahamas' health system, national shelters, and general population inclusive of vulnerable individuals.

The health care system is need of development and capacity building in the areas of 1) climate change, health and a gender inclusive policy, 2) health workforce, 3) community/civil society engagement, 4) climate resilient health infrastructure, 5) data collection, information & technology, and 6) financing for climate change and health issues.

Therefore the objectives of the project include:

The development of a 'climate SMART health' in all policies systems framework with cross cutting national policies, procedures and practices and interventions to build a climate resilient, gender inclusive and health care system in The Bahamas;

The enhancement of the national public health surveillance systems of healthcare facilities such as hospitals and primary care clinics in the Ministry of Health and for community shelters; and

The strengthening of coordinated mechanisms, communication across agencies (governmental, private sector, and civil society) and human capacity to respond to climate change effects.

At the time of this document, The Bahamas had developed a Climate Change and Health Country Profile, but has not managed to complete a Health-National Adaptation Plan, or a Health and Climate Change Vulnerability and Adaptation Assessment, nor does it have any institutionalized provider/patient/community advocacy networks to address climate change and health matters from a multiple marginalized vulnerabilities perspective.

A major outcome of the project will be the development of a Health National Adaptation Plan (HNAP) for climate change, which would form a main chapter in the NAP for The Bahamas. The HNAP aims to strengthen the health system's capacity to adapt to climate change, improve prevention and preparedness efforts, and prioritize adaptation actions, particularly among vulnerable populations. The development of the HNAP has already begun with the inception workshop having taken place in the last quarter of 2021.

Progress has also been made in the form of the development of the procedural manuals for the climate SMART facilities in the country. Facilities that will be greatly welcomed as the number of viable shelters have decrease with every storm.

Digitalisation of Health System

The Ministry of Health is currently engaged in a paperless paper to electronic project for the National Health Care System. This digitisation fulfils the desire of the health care system to utilise green technology options. The flow of data increases efficiency and capacity, as it allows for a greater ease of data sharing and access. The digitisation process is still under implementation.

Disease control and Prevention

Along with changes to heat and rainfall patterns, associated with climate change, the treat of vector borne and associated climate change related illnesses or conditions remains a threat for The Bahamas.

The Department of Environmental Health Services (DEHS) is working on a programme called "Enhancing capacity for the use of sterilized insect Technique as a component of mosquito control". The objective of the programme is to provide a safe non-chemical method of mosquito control that can be used in conjunction with the use of chemicals in a mosquito control programme. The project is ongoing and thus far it has achieved the collection of the baseline data for the operation of the programme.

Medical Waste Removal

Safe disposal of medical waste is critical to not only ensuring a healthy environment, but also to ensure that the materials are not the cause of additional human health issues. As such the Ministry of Environment has instituted a “Disused radionuclide sources” programme to determine the location of all disused sources so as to ensure safe disposal. Thus far, the DEHS has achieved a partial listing of all available sources. To achieve this goal, it has partnered with the International Atomic Energy Agency with a project budget of 300,000.

6.1.7. Meteorology & Disaster Preparedness and Management

Storm Surge Mapping (Department of Meteorology)

The Government of The Bahamas has begun the process to produce a storm surge map for the entire Bahamas. As of October, 2021, The Bahamas Department of Meteorology has presented the result of the project which was the modelling and flood mapping of two islands - Grand Bahama and Eleuthera. The other islands remain to be completed as it would take $9,826,000.00 (USD) to produce LiDAR information for the entire Bahamas and additional funding is needed for the project. The storm surge mapping depends on the LiDAR data of the land and shallow water in order to produce a flood map for each island and subsequently a comprehensive storm surge atlas.

The storm surge model covers all of The Bahamas extending in the south to Cuba, in the west to Florida and around 200 miles out into the North Atlantic. It reveals the degree of which various sections of the island are likely to be flooded in the event of a storm, enabling regional authorities to understand where flooding is most likely to happen, and how severe it might be. The model uses information from every hurricane in the region since 1970, variations in paths, wind speed and size are all mathematically analysed.

This information is used to simulate thousands of ‘synthetic’ hurricanes in the storm surge model and results are displayed in maps that show the extent and depth of predicted flooding across each island. The model can predict surge and forecast flooding from incoming hurricanes up to five days before they will reach the islands and all predictions are updated every few hours.

It is an excellent tool for emergency services as they can evacuate key parts of the island prior to an impending storm and as a forecasting tool for developers and the Government. Climatologists will be able to accurately make predictions of Climate Change and forecasting with Sea Level Rise (SLR) variations. As well as present day predictions, the atlas also includes predictions for climate change scenarios up to 2100, based on guidance from the IPCC.

Radars and Automatic Weather Stations

The Bahamas Meteorology Department has purchased 16 and was gifted 4 automatic weather stations (AWS) valued between $15,000 - $ 20,000 (USD) dollars per instrument through the CCCCC – as part of a Green Climate Fund project. These instruments are in need of installation that is designed specifically to meet International Civil Aviation Organization (ICAO)/World Meteorological (WMO) standards.

Automatic Weather Stations (AWS) will be set up by a team of technicians from the Meteorology Department. The weather station must be installed according to WMO standards with the correct exposures and must meet ICAO certification. Data will be uploaded to NOAA via satellite and there is also a digital ground recording system.

Since the model is capable of withstanding hurricane winds up to Category 3, officially, and some instruments have withstood Category 5 storms, then the AWS is able to collect data in the midst of hurricanes thereby providing much needed data that would assist in the future modelling of the storms and their impact.

The accurate measurement of rainfall and temperature data across the country will:

- Aid in more accurate climate models e.g. drought predictions. This will enable better city planning and influence decisions in agriculture.
- Ensure accurate and consistent rain measurements for future climate and drought models/analysis
- Support data/forecasting for business analysis and informational products and apps: e.g. planning outdoor activities (weddings etc.), tourism related activities and infrastructure development.
- Provides critical aviation data
- Monitors airport conditions
- Provide opportunities for data mining and student/university/climate research

The Meteorology Department plans to place 6 of the AWS in the following locations: In New Providence: 1) South Beach Pool, 2) Sandilands, and 3) the National sports stadium.

On the Family Islands: 1) Andros (BAMSI), 2) Ragged Island, and 3) Mayaguana. Approximately $150,000 (USD) is needed for the installation of all AWS.

By the end of 2023, The Bahamas should have 5 operational Doppler radars at the following locations:

1. Marsh Harbour
2. New Providence
3. Long Island
4. Ragged Island
5. Mayaguana

This technology will enable the Department to accurately track hurricanes as they move through the islands and analyse the features of the eyewall. Furthermore, it will enable forecasters to give better “Now casting” reports and impact-based forecasting.

The Cape Eleuthera Institute/Island School also plans to install automatic weather stations on the islands of Eleuthera and Cat Island with the goal of reducing errors in data collection and improving weather predictions.

Digitalisation of Historical Meteorological Data

In 2021, the Department of Meteorology concluded its initative to digitise historical climate data, leading not only to information that is greener and more climate resilient, but also increasing the ease of access to climate data that many other stakeholders, both in the private and public sector have been in need of.

The need for meteorological data, particularly rainfall, air quality, tidal, and temperature has been continuously requested by stakeholders in several meetings and fora.

Regrettably, the Department of Meteorology does not have air quality or recent tidal data available, as there are severe gaps in meteorological instruments in the country. Additionally, the democratisation of meteorological data has also been a moderately contentious topic, as data collected by the Meteorology Department is government owned and stewarded by them. They generously allow educational and other government agencies access, however, private stakeholders may some barriers - as the intent of usage of the data must be determined, as well as possible fees. The fee is vital from the Department of Meteorology’s perspective, as they are a vital source of information for climate change data and a key stakeholder in early warning systems, data collection and management, forecasting and disaster management. However, the Department requires greater finances and human resources. The SNC expressed that the Department of Meteorology needed additional staff and training, to date, the Department is still requesting 16 to 20 additional staff members. A review of hiring practices, to improve speed of onboarding and pay scales in the Department of Meterology, will prove beneficial in closing this gap.

Geomatics Capacity Enhancement for Disaster Risk Management Project (GCEDRM)

The GCDRM project commenced in 2018 and is partially complete with Components 3 & 4. The training and mapping has not started yet. The project is being implemented on these five islands: Nassau, Eleuthera, Exuma, Long Island, and Cat Island. Proposals have been submitted for the other islands of the Bahamas.

The project has several components including:
1) High Resolution Aerial Photography, Ortho-Imagery rectification, Topographic Mapping and Digital Terrain Model;

2) Quality Assurance Quality Control review of deliverables produced by Component 1;

3) Flood, Storm Surge, Wind and Coastal Erosion Modelling and Mapping;

4) Disaster Risk Management Information System (DRMIS); and

5) Equipment/ICT.

The technologies derived from the project will be: topographic mapping, digital elevation models risk assessment, disaster management, and flood plain mapping.

BNGIS has expressed a need for this project's completion, as The Bahamas can benefit from improving the level and number of high-quality high-resolution data needed to make critical climate-informed decisions in the nation.

Interviews with BNGIS also indicated that at least 20 tidal gauges are required for the country to support climate/meterological related information. BNGIS has a data portal that was expected to be officially launched by the end of 2022 and for its GIS data to be made available to other government and approved agencies.

DisasterAWARE

The Government of The Bahamas has partnered with the Pacific Disaster Center to create The Bahamas Disaster Risk Profile and produce The Bahamas National Disaster Preparedness Baseline Assessment and the Bahamas Island Risk Profiles. The documents are available virtually via the Pacific Disaster Centre's website. The collaboration between the Government of The Bahamas and the Pacific Disaster Centre has produced some much-needed resources in the area of disaster management software and capacity building by the training of the staff in its use. DisaterAWARE uses data obtained from The Bahamas to provide risk assessments, disaster management strategies, and operates as a forecasting and modelling tool. From this project, information such as: multi-hazard exposure, multi-hazard risk, coping capacity, vulnerability, island capacity, logistics capacity, and resilience scores have been produced and mapped out for each island of the Bahamas.

6.1.8. Technologies From The Bahamas Provisional Technology Needs Assessment (TNA)

As indicated in the Second National Communication, the Bahamas is in need of a Technology Needs Assessment. With the support of a UNEP-DTU partnership, the government of the Bahamas selected four sectors for the TNA project. In the area of climate change adaptation: the Education and Meteorology sector. In the area of climate change mitigation: The Forestry and Waste sectors were selected.

The TNA is a stakeholder driven process engaging experts in the public and private sector to advise the process from the development of a long list of necessary technologies for each sector to short list and final selection via multicriteria analysis (MCA) and a subsequent sensitivity analysis. The MCA for the TNA was held in the 3rd quarter of 2022 and resulted in the selection of the following technologies (Table 117).

Table 117: Results of the MCA

Sector	Technology
Meteorology	Data sharing network for meteorological data
Education	MSc/BSc degree programmes: Meteorology, Oceanography, Environmental Studies, and Computational Physics etc.
Waste	Liquid Waste | Effluent Disposal Methods for Rural (Family Island) Communities
Forestry	Develop a National Forestry Strategy to Introduce Policy Directives and Regulations [Refinement | Implementation]

Further evaluation and development of the selected technologies will be done in the form of concept notes, barrier analysis and a technology action plan. The implementation and results of these technologies will be explored in the next National Communication.

6.2. Overview of Environmentally Sound Technology transfer in The Bahamas

Table 118: Overview of Environmentally Sound Technology transfer in The Bahamas

Sector	Summary of EST's	Gaps
Agriculture and Fisheries	Projects • The revision of the Agriculture Climate Change Policy • Capacity building on climate change and best practices in: Good Agricultural Practices Small ruminants (sheep & goats) and poultry, Agribusiness development, Agritourism development • Decreasing the practice of slash and burn on the Family Islands subsequently reducing greenhouse gas emissions and other farming practices • Improving farm water management • Improving Food Security in the Bahamas o Chicken Layer Programme o National Roots and Tubers programme (BAMSI)	Gaps: • Solar drying equipment for plants and seed • Bio-ingestion(mitigation) • Insemination programme for sheep and goats • The use and development of biogas, • Expansion of community kitchens, • New buildings for the slaughter houses on the Family islands, • Tractor equipment upgrades • Tablets for the field technicians.
	• Promoting the use of renewable energy by providing farmers with solar pumps. • Diversifying production through agro-processing in order to add value, diversify availability and reduce farm waste. • Implementation of climate change awareness activities • Coral Restoration • Waste Management and Composting • Implementation of community food processing kitchens • Courses at the associate's level: Environmental Science, Aquaponics and Aquaculture	Capacity gaps: • A Director of Agriculture (1) • Deputy Directors of Agriculture (2) • Soil Scientists (2) • Microbiologists (2) • Entomologists (2) • Horticulturalist/Plant Specialists (2) • Extension Officer (Crop & Livestock) (10) • Apiary Specialist (2) • Agronomists (2) • Veterinary Officers (4) • Veterinary technicians (6)

		• Animal scientists (poultry, swine, small ruminants) (3) • Food technologists (2) • Lab Technicians (Food Technology Lab) (4) • Extension Officers (Food Technology Lab) for training, inspection, regulation of Family Island community kitchen which are food processing units (2) • Statisticians (2) • Economist/Marketing (1) • Project Managers (2) • Human Resource Specialists (2) • Mechanical Engineer (1) • Tractor Operators (6) • Persons trained in Climate Change & Agriculture/similar at the post grad. Degree level (2) • GIS analysts
Forestry and Biodiversity	Reforestation and Forest Protection • Establishment of a Seedling Nursery and Replanting for Forest Recovery and Restoration on Grand Bahama. • National Forest Monitoring System (In development) • Bahamas Pine Islands (BPI) - Forest/Mangrove Innovation and Integration (Grand Bahama, New Providence, Abaco and Andros. • Meeting the Challenge of 2020 in The Bahamas: (strengthening management of marine protected areas) • Implementing Land, Water and Ecosystem Management (IWEco) in The Bahamas	Gaps: • An arial Forestry Monitoring System (Drones) • GIS analysts
	Mangrove Restoration • Northern Bahamas Mangrove Restoration • Mangroves Harvesting and Replanting Project Dover's Sound, Grand Bahama Post-Dorian Damage Assessments and Strategic Restoration of Mangrove shorelines of the Little Bahama Bank. • The legal framework for the development and implementation of an Integrated Watershed Management Plan for East Grand Bahama. (Watershed management plan, a biodiversity inventory, restoration methodology and increased sustainable livelihoods)	

	Park Management and Restoration. • Restoring and Building Climate Resilience at Rand Nature Centre (RNC). • Rebounding from Hurricane Dorian, the Abaco National Parks Road to Recovery • Removal of invasive species Other EST's • Conch Management Project • Coral Propagation & Restoration • Awareness programmes	
Energy and Transportation	Projects • Promoting Sustainable Energy in the Bahamas (2009-2014) • Energy efficient lighting improvements in select public buildings in Harbour Island, Bahamas (2017-2019) • Strengthening Bahamas' NDA and Developing its Country Programme (January 23, 2017) • The Bahamas Power System Stability Study for Implementation of a Higher Renewable Energy Penetration Level (June 12, 2018) • GCF Readiness and Preparatory Support in the Bahamas (Phase II) (January 10, 2019) • Building Blocks for Strengthening The Bahamas Country Programme (November 8, 2019) • Building The Bahamas capacity in transparency for climate change mitigation and adaptation(July 22, 2020) • Capacity building for Energy Auditing and Solarization Readiness in The Bahamas.	Gaps: Emissions Testing • Emissions testing is still on the agenda for the Bahamas however this project will not commence until the ministry of transport has completed its move into its new building. Biofuels • Public knowledge about biofuel, its presence in the nation, environmental benefits and approved distributors.

	Photovoltaic systems • Ragged Island Solar Microgrid Project • The allocation of more than $35 million for the installation of solar photovoltaic systems in the Family Islands. o Feasibility studies for Inagua, Mayaguana, Acklins, Crooked Island, Long Cay and North Andros have been concluded and are awaiting the next phase in development. • The Government plans to invest 4.5 million in the installation of five microgrids in East End Grand Bahama and 14.2 million dollars in installing a 25 MW Battery Energy Storage System at the Baillou Hill Power Plant. • Improving sustainability and building resilience at Forest Heights Academy (FHA) - Marsh Harbour, Abaco through the installation of a solar photovoltaic system with batteries. • Solarising the UB-North (Grand Bahamas), Marine and Environments Science Field Station.	
	• The Solar Rooftop programme. This project will enable clinics, public libraries and schools to take part the nation's renewable energy progress. The Ministry of Public Works is assessing eight government buildings for this programme. • $36 million planed investment in renewable infrastructure in Abaco and East Grand Bahama. o $18 million for the restoration of electricity services and the rehabilitation of physical infrastructure damaged by Hurricane Dorian in Abaco. Energy Efficiency • Employment of advanced energy efficient lighting systems by the replacement of 30,000 street lights as part of the Street Light Retrofitting Project by end of year 2022. • Elimination of import duties on lithium ion and lithium phosphate batteries. (2022) • Simplification of the process for bringing in renewable energy parts.	

	Biofuels • Bahamas Waste has incorporated the use of biofuel into their company and currently 75% of the fleet use a B35 blend. By the end of the year the remaining 25% of the fleet will also be using biofuel, a B20 blend. Bringing the entire fleet to 100% users of biofuel. • Pending a successful pilot launch, the Water and sewage corporation is considering the consumption of 60,000 gallons of biofuel per year to be distributed for use in their fleet of trucks firstly and secondly in the water plant reducing the nations contributions of GHG emissions. Transport EV cars • Reduced duty on EV chargers. • Lower the duty on the electric vehicles themselves allowing for green technology to be made affordable to local citizens. • Shift to convert government fleet of vehicles to electric vehicles. • Cars operated by the Water and Sewage Corporation will also begin a shift toward the use of electric vehicles.	
Infrastructure and Coastal Management	Coastal Protection • Hurricane Dorian Small and Medium Marine Debris Removal on Man-O-War Abaco. (2021-2022) Progression of the Climate-Resilient Coastal Management and Infrastructure programme: • Component 1: Sustainable Coastal Protection Infrastructure. Junkanoo Beach o Start of Baseline Coastal Studies & Design- October 2022 o Coastal Zone Photogrammetry Study - August 2022 o Shoreline Change Study – December 2022 (anticipated completion date) o Nearshore Wave and Current Study –November-2021 o Sediment Transport Study- February 2023 (anticipated completion date) o Coastal Infrastructure Asset Assessment- February 2023 (anticipated completion date) o Environment & Social Baseline Studies- January 2023 (anticipated completion date) o Engineering Studies- July 2023 (anticipated completion date)	Gap: • There is a severe gap in capacity as it pertains to the lack of building inspectors which can hinder the successful enforcement of the new building code regulations. • As it pertains to the Family islands of The Bahamas, it was recommended that each island obtain at least four inspectors depending on current levels of development.

	o Environmental Economic Valuation Baseline Study January 2023 (anticipated completion date)	
	East Grand Bahama o Expression of interest baseline study and design- Nov 2021 o Financial & Final Evaluation Completed August 2022 Central Long Island o Expression of Interest baseline study and design Strategic Coastal Protection and Flood Mitigation- November 2021 o Financial & Final Evaluation Completed-August 2022 • Component 2: Natural infrastructure for hazard resilience in Andros. o First Interim Report - April 2022 o Climate Change, Met-Ocean Coastal Analysis - July 2022 o Socioeconomic Assessment- August-2022 o Biophysical Assessment November- 2022 o Hazard Assessment Report and Maps - September-2022 o Vulnerability Assessment Report and Maps-October-2022 o Hazard Risk Assessment Report - November 2022 o Final Report-March-2023 (anticipated completion date)	

	• Component 3: Institutional strengthening for coastal risk management. o Upgrading the Bahamas Building Code Incorporating Coastal Infrastructure Design Guidance (End of Year-2022 anticipated Draft date) • Component 4 and 5: Pending further development Road Works • The widening of Gladstone Road from a single lane to a dual carriageway. (Commencing by end of 2022) • Elevation roads 2.67 feet above the water table reducing their susceptibility to flooding. (Pending)	
Water Resource Management	Projects • Abaco Sunny Waters Project – the restoration of a reliable and resilient supply of water to the residents of Abaco after the event of Hurricane Dorian. The solar solution will provide a portion (25-30%) of the energy requirements • Preparation of a Water Supply Development Strategy for Utility and Non-Utility Service Areas in the Family Islands • Ocean Thermal Energy Conversion (OTEC) is a sustainable technology application that is currently being explored as the Bahamas has the necessary 20°C difference needed for successful execution.	

Health	Projects • Developing a Climate Resilient Health System in The Bahamas o The development of a 'climate SMART health' in all policies systems framework with cross cutting national policies, procedures and practices and interventions to build a climate resilient, gender inclusive and health care system in The Bahamas o The enhancement of the national public health surveillance systems of healthcare facilities such as hospitals and primary care clinics in the Ministry of Health and for community shelters; o The strengthening of coordinated mechanisms, communication across agencies (governmental, private sector, and civil society) and human capacity to respond to climate change effects. o Progress has also been made in the form of the development of the procedural manuals for the climate SMART facilities in the country.	Gaps: • Air quality assessment Capacity gaps: • Epidemiologists • Communication specialists • Economists • Improved hiring process – A point that is elaborated further in the Meteorology section • Continuous training/ Upskilling opportunities
	• Health National Adaptation Plan (HNAP) for climate change, which would form a main chapter in the NAP for The Bahamas. o The development of the HNAP began with the inception workshop in the last quarter of 2021. o The HNAP aims to strengthen the health system's capacity to adapt to climate change, improve prevention and preparedness efforts, and prioritize adaptation actions, particularly among vulnerable populations.	
	• Digitalisation of NHS • Disease Control and Prevention o Enhancing capacity for the use of sterilized insect Technique as a component of mosquito control • Medical Waste Removal o Disused radionuclide sources programme	

Meteorology & Disaster Preparedness and Management	Projects • Storm Surge Mapping (Department of Meteorology) o The Bahamas department of Meteorology has presented the modelling and flood mapping of two islands - Grand Bahama and Eleuthera. • Radars and Automatic Weather Stations o The Meteorology department plans to place 6 of the AWS in the following locations: § In New Providence: South Beach Pool, Sandilands, and the National sports stadium. § On the Family Islands: Andros (BAMSI), Ragged Island, and Mayaguana.	Gaps: • Modelling and flood mapping the other islands of the Bahamas remain to be completed as it would take $9,826,000.00 (USD) to produce LiDAR information for the entire Bahamas and additional funding is needed for the project. The storm surge mapping depends on the LiDAR data of the land and shallow water in order to produce a flood map for each island and subsequently a comprehensive storm surge atlas. • Air quality data for all islands • Tidal data for the entire Bahamas • Components 3 & 4 of the GCEDRM • Inclusion of the remaining islands of the Bahamas into the GCEDRM project
	o By the end of 2023, the Bahamas will have 5 operational doppler radars at the following locations: § Marsh Harbour § New Providence § Long Island § Ragged Island (expected end of year 2022) § Mayaguana (expected end of year 2023) o The Cape Island Institute also plans to install automatic weather stations on the islands of Eleuthera and Cat Island with the goal of reducing errors in data collection and improving weather predictions. • Digitalisation of Historical Meteorological Data	Capacity Gaps: Staff and Hiring process • The SNC expressed that the Department of Meteorology needed additional staff and training, to date, the Department is still requesting 16 to 20 additional staff members. • GIS Analysts – All stakeholders engaged in Disaster management indicated a need for additional experts and training in the area of GIS. • It has also been revealed that the ability of government employees to switch departments without prior or post training leads to a deficit in capacity in either the department the employee has departed from or within the department the employee proceeds to. Therefore, the constant training of existing staff and cross sectorial and open upskilling opportunities are essential to ensure optimal performance.

	• Geomatics Capacity Enhancement For Disaster Risk Management Project (GCEDRM) o The project is being implemented on these five islands: Nassau, Eleuthera, Exuma, Long Island, and Cat Island. Components: o 1) High Resolution Aerial Photography, Ortho-Imagery rectification, Topographic Mapping and Digital Terrain Model; o 2) Quality Assurance Quality Control review of deliverables produced by Component 1; o 3) Flood, Storm Surge, Wind and Coastal Erosion Modelling and Mapping; o 4) Disaster Risk Management Information System (DRMIS)	• The payment scheme of the Department of Meteorology as well as other Bahamian government agencies are in need of revision as both the painfully slow process and extremely low pay scale are severe deterrents to locals returning from studies abroad. This is most unfortunate as it appears that the nation has unintendedly set deep barriers to a very natural source of capacity building. • The Met Department has also indicated a need for a public relations officer and a separate entity to develop and maintain a weather app. This will avoid the very common issue of the cessation of a project when key personnel transfer or retire out of the department.
	o 5) Equipment/ICT o The technologies derived from the project will be: topographic mapping, digital elevation models risk assessment, disaster management, and flood plain mapping. • BNGIS' data portal officially launched end of 2022 Collaboration Between The Bahamas Government and the Pacific Disaster Centre: • DisasterAWARE software • The Bahamas Disaster Risk Profile • The Bahamas National Disaster Preparedness Baseline Assessment and the Bahamas Island Risk Profiles • Development of the following measures for each island of the Bahamas: o Multi Hazard Exposure o Multi-Hazard Risk o Coping Capacity o Vulnerability o Island Capacity o Logistics Capacity o Resilience Scores	
Technologies From The Bahamas Technology Needs Assessment	As indicated in the Second National Communication, the Bahamas is in need of a Technology Needs Assessment. With the support of a UNEP-DTU partnership, the government of the Bahamas selected four sectors for the TNA project: Meteorology, Education, Waste and Forestry.	

	The results of the MCA conducted in the 3rd quarter of 2022 indicate the selection of the following technologies for each sector: • Meteorology - Data sharing network for meteorological data • Education - MSc/BSc degree programmes: Meteorology, Oceanography, Environmental Studies, Computational Physics etc. • Waste - Liquid Waste | Effluent Disposal Methods for Rural (Family Island) Communities	
	• Forestry - Develop a National Forestry Strategy to Introduce Policy Directives and Regulations [Refinement | Implementation]	

Chapter 7 – Research and Systematic Obeservation

As we try to address climate change, we face uncertainty. As we move from determining GHG emissions to selecting which adaptation responses will succeed, we face more uncertainty. Research and systematic observations or RSO are a means to reduce uncertainties as we take climate action.

Implementation of research under the Convention and Paris Agreement is supported through cooperation with the World Climate Research Programme (WCRP), which coordinates the coupled model intercomparison project (CMIP) and the Coordinated Regional Climate Downscaling Experiment (CORDEX), the Integrated Assessment Modelling Consortium (IAMC), the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO), IPCC experts and other partners and relevant organizations active in climate change-related research.

Implementation of systematic observation is supported through the World Meteorological Organization (WMO), Global Climate Observing System (GCOS) and Global Ocean Observing System (GOOS), the Joint Working Group on Climate (WG Climate) of the Committee on Earth Observation Satellites (CEOS) and the Coordination Group for Meteorological Satellites (CGMS), as well as other partners and relevant organizations.

This chapter details RSO occurring in The Bahamas. With respect to RSO generally, The Bahamas is active on the Intergovernmental Panel on Climate Change (IPCC) and in the World Meteorological Organization (WMO) through the Bahamas Department of Meteorology. The main objective of the Bahamas Department of Meteorology is to predict, record and report the best information possible on the atmospheric conditions over and around The Bahamas to both citizens and visitors. This information is important for persons to make well-informed decisions that would affect their safety in travel, transport and their working environment.

Their work involves various types of meteorology – climatological, aviation, broadcast, and forecast. The Department is actively involved in climate change policy, planning and projects for The Bahamas and is working to expand its scope to maritime and agricultural meteorology.

7.1. Research

Climate change research in The Bahamas includes research on:

- Climate change, tourism and sustainable development
- Non-economic loss and damage
- Management of loss and damage

- Climate change and human rights
- Climate change impacts on marine, coastal and terrestrial habitats and the organisms that utilize these habitats inclusive of AGRRA surveys of coral reef systems and assessments of pine forest systems on Abaco and Grand Bahama
- Tropical cyclone development under climate change
- Climate change awareness
- Hurricane Dorian’s impacts on coral reefs of Abaco and Grand Bahama
- Climate change response options
- Engineering solutions for climate mitigation
- Coastal and water monitoring
- Coastal restoration
- Perceptions of climate change and health
- Perceptions of climate change risk
- Adaptation capacity of men and women
- Climate adaptation within the tourism sector

The Bahamas Storm Surge Model project is led by the Bahamas Department of Meteorology and funded by Green Climate Fund through the Caribbean Community Climate Change Centre (CCCCC). The first phase of the project resulted in development of a storm surge model, atlas and digital platform. It currently is only for the islands of Grand Bahama and Eleuthera. The model is a TELEMAC hydrodynamic model, which forecasts storm surge and associated flooding. The model, atlas and platform were developed by HR Wallingford out of the United Kingdom with support from SEV Consulting Group as the local firm.

The long-term objective is to include all the islands of The Bahamas, but funding and data (specifically LiDAR) are required. The Department of Meteorology seeks to find funding for continuing the baseline modelling for the remaining islands that were not included in the initial storm surge modelling work. Climate change modelling is also another thing that the atlas can be used for, projecting for future storm impacts. Synthetic storms of various categories and intensities would also be of value in preparing for potential storms.

The Climate Change Adaptation and Resilience Research Centre (CCARRC) is a part of the University of The Bahamas. Established in 2019, the Centre’s research was to focus on climate change adaptation, loss and damage, and comprehensive disaster risk management. The Centre is not currently active.

Non-Governmental organizations in the country conducting climate change research include the Cape Eleuthera Institute and the Perry Institute for Marine Sciences.

7.2. Systematic Observation

The Bahamas Department of Meteorology is the lead agency on systematic observations in the country. The mission of the Department is to provide high quality meteorological and climatological information on a timely basis for the public's use. The Department collects hydromet data using Automatic Weather Observing Stations (AWOS), Doppler radar and a tidal gauge. Climate variables collected include wind direction and speed, air pressure, rainfall (precipitation), air temperature and solar radiation. A cooperative upper air observing station with the United States has been maintained since 1978.

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

Other agencies that collect hydromet data in some capacity include the Water and Sewerage Corporation, Cape Eleuthera Institute, and Perry Marine Institute as well as some private entities.

7.3. RSO Advancement in The Bahamas

Advancing RSO in The Bahamas requires a number of actions including:

6. Participating in the Global Basic Observing Network (GBON)
7. Determining relevant Essential Climate Variables (ECVs)
8. Determining research priorities
9. Developing a national framework inclusive of RSO
10. Engaging with regional and international partners and networks

Some of these actions are already underway while others still need to be initiated.

7.3.1. Global Basic Observing Network

Participating in the GBON will require an assessment of stations within the country to determine if they can meet the Network's requirements and if not, what upgrades or modifications need to be made so they can. These requirements include complying with WIGOS quality management and date exchange in defined WMO formats. Types of observations may be surface-based land observations from weather stations or upper air land-based observations from weather balloons or radiosonde stations. Participating in the GBON may also require installation of new stations to meet the national contribution. Utilizing the Systematic Observations Financing Facility (SOFF) is one way that The Bahamas endeavours to ensure its sustained compliance with the GBON. Compliance with the GBON can strengthen The Bahamas' climate adaptation and resilience efforts through improved weather forecasts and climate services.

7.3.2. Essential Climate Variables

Essential Climate Variables provide the empirical evidence to support climate science and enable better prediction of future change. The Global Climate Observing System (GCOS) currently specifies 54 ECVs. The Bahamas is collecting some ECVs, such as precipitation and temperature, but will need to decide if it needs to expand the number of ECVs it will collect particularly as it related to ocean physical, biogeochemical and biological variables.

The Bahamas also needs to establish additional sea level monitoring stations as well as wave recorders at selected sites. The latter will be used to monitor the impacts of non-tropical processes that generate strong ocean swells.

7.3.3. Research priorities

Essential Climate Variables provide the empirical evidence to support climate science and enable better prediction of future change. The Global Climate Observing System (GCOS) currently specifies 54 ECVs. The Bahamas is collecting some ECVs, such as precipitation and temperature, but will need to decide if it needs to expand the number of ECVs it will collect particularly as it related to ocean physical, biogeochemical and biological variables.

Research priorities identified by stakeholders through the TNC-BUR process include:

1. Identification of resilient areas, such as those with seagrasses and mangroves.
2. Mapping of coastal infrastructure, particularly areas that are impacting water flow.
3. Sea level and storm surge modelling - sea level and storm surge modelling help with predicting factors such as sea level rise and storm surge. Prediction can help save lives during natural disasters, such as a hurricane. Input data for these models will include bathymetry (what is the ocean floor like), tidal boundaries (where is the boundary of the land and sea) and meteorological data, such as wind speed. This research would also include modelling an ensemble of forecast tracks to allow a probabilistic assessment of likely flooding.
4. Tidal gauge measurements at a number of locations around The Bahamas to better establish the relation between mean sea level and vertical datums used in land surveys. Currently, there is a single active gauge at Settlement Point in Grand Bahama.
5. Collection of ocean temperature data.
6. Impacts of climate change based on gender.

7. Collection of LIDAR for the entire country - LiDAR stands for light detection and ranging. It's a remote sensing method that uses light in the form of a pulsed laser to measure distances to the Earth. It generates precise, 3-dimensional information about the shape of the Earth and its surface characteristics.

An important aspect of research also raised by stakeholders was that any climate data be accessible and incorporated into existing and future national monitoring systems, such as the environmental registry under the Department of Environmental Planning and Protection.

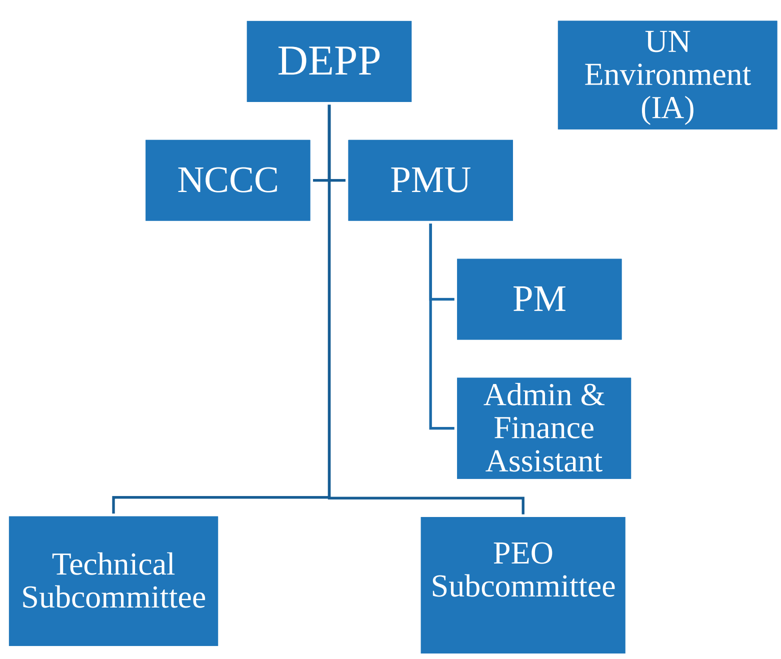
7.3.4. RSO in the national framework

The national framework is the institutional arrangement that has been recommended for National Communication and Biennial Update Reporting to the UNFCCC. Figure 79 shows the framework recommended by national stakeholders. The Technical Subcommittee indicated is a subcommittee of the National Climate Change Committee.

This group of experts is tasked to provide guidance on RSO as follows:

1. Assess the existing system for early warning on extreme weather events and methods of seasonal forecasting.
2. Analyze the existing barriers for development of observation systems and research, and identify the follow-up activities
3. Contribute substantially to development of the National Information Report on Research and Systematic Observation.
4. Assist the Project Management Unit in arranging the national review and awareness raising workshops on RSO, and participate in the sub regional, regional and international trainings on the matter.

Figure 79: The Bahamas National Framework for NC-BUR Reporting



Recommendations by national stakeholders for agency representation on the Technical Subcommittee include the Bahamas Department of Meteorology, Department of Marine Resources, Ministry of Public Works, Water and Sewerage Corporation, CCARRC, BAMSI, private sector partners that collect hydromet data, and University of the West Indies as a regional partner.

7.3.5. Regional and international partners and networks

Various organizations within The Bahamas are already working with regional and international partners and networks on RSO. These include:

Royal Rain Catchers is a program working to deploy a network of rain gauges used to measure small-scale variation in precipitation to groundtruth models of rain distribution. This data could inform models of agricultural and natural ecosystem productivity in light of changes in climate. The program is founded and operated by Young Marine Explorers, a Bahamian NGO.

The Bahamas is active in **WMO** and has been a member since 1973. Trevor Basden, Director of the Bahamas Department of Meteorology is the Permanent Representative. John Bowleg is the Hydrological Adviser. The responsible ministry of Ministry of Transport and Local Government. The WMO Office for Resource Mobilization and Development Partnerships works to secure development assistance for National Meteorological and Hydrological Services to help them establish the levels of weather, water and climate information services needed to support the protection of life, property and environment as well as the security of food production, energy and water resources. SIDS, like The Bahamas, are a priority country grouping for the organization. The Bahamas has benefited from participation in a number of WMO projects including:

1. SIDS-Caribbean Project – Develop better meteorological and climatological knowledge and improve the scientific capabilities

2. CREWS project – CREWS stands for Climate Risk Early Warning System. The CREWs Caribbean project has 3 main components:
   a. Development of a regional strategy to strengthen and streamline early warning and hydromet services
   b. Institutional strengthening and streamlining of early warning and hydromet services
   c. Support for piloting high priority national activities including impact-based forecasting

The project also involves mainstreaming gender and needs of vulnerable populations in early warning systems.

The **Intergovernmental Oceanographic Commission** (IOC) enables its Member States to coordinate marine scientific research programs, ocean services and activities such as capacity development. At the national level, it works with marine, ocean and coastal management agencies to ensure policy makers have access to the best possible ocean science and services. The Bahamas is a Member State through the Ministry of Agriculture & Marine Resources as the National Coordinating Body.

Other partners that The Bahamas may wish to engage include:

POGO (**Partnership for Observation of the Global Ocean**) is a partnership of ocean science, technology and academic institutions globally, which is mostly focused in Europe. In Latin American and the Caribbean, the only member is INVEMAR in Colombia. Its objectives include leading innovation and development of the ocean observing system and training and capacity building. POGO maintains a database of completed research cruises and a first level inventory of oceanographic measurements made and sample taken. The database includes information extending back 50 years of over 50,000 research cruises (primarily for Europe and North America). POGO offers a Shipboard Training Fellowship which provides an opportunity to visit a host institution for one month prior to the start of the research cruise, to participate in cruise preparation and planning, and to go on the cruise. Some fellowships also include one additional month back at the host institution after the research cruise.

The **Global Ocean Observing System** (GOOS) is another IOC-led program created in 1991. It operates on a framework to implement an integrated and sustained ocean observing system which captures essential physical, chemical, biological and ecological ocean properties. Its 2030 Strategy includes provision of critical ocean information to enable policy makers as well as the public and private sectors to adapt to and mitigate climate change. GOOS is an active player in the UN Decade of Ocean Science for Sustainable Development (2021 – 2030). There is no GOOS National Focal Point identified for The Bahamas.

The **Alliance for Hydromet Development** launched in 2019 on the premise that hydromet services provide the foundation for effective climate adaptation and resilience action. Institutions in the Alliance collectively committed to scale up and unite efforts to close the hydromet capacity gap by 2030. The Alliance includes funding mechanisms, such as the Green Climate Fund and Global Environment Facility, multilateral banks, such as the Inter-American Development Bank, and organizations, such as United Nations Environment Programme and WMO. One of the priorities of the Alliance is to create an innovative mechanism to finance developing country surface-based weather and climate observations called the Systematic Observations Financing Facility (SOFF). SOFF will support countries to assess their national hydromet status, define the national GBON (Global Basic Observing Network) gap and develop a plan to close the gap. Over the three phases of the facility, it is projected to provide $141.5 Million in funding. The Bahamas is an eligible country.

Chapter 8 – Information on Research Programmes

Research is critical to understand past and current behaviours, estimate future projections and to determine courses of action that need to be implemented to either encourage, deter or halt the trends identified. This is clearly exemplified in climate research where the Bahamas has seen its need to improve its resilience in the areas of coast management, building codes, water resource management, biodiversity, mental health, and hurricane research. Moreover, the effects of Hurricane Dorian on the coral reefs on Grand Bahama and Abaco demonstrate the grave importance of having historical data by which baselines can be created in order to calculate accurate estimations of changes incurred.

This chapter on Research Programmes in the Bahamas discusses research being done in the areas of: Biodiversity, Forestry, Water Resource Management, Land Use and Land Degradation, Meteorology & Disaster Preparedness & Management, and Health. Also detailed within the chapter are the constraints, gaps, and needs of those sectors that have been revealed via stakeholder consultations.

The final part of this research chapter details a list of technologies that are in various stages of implementation in the region. These have been compiled primarily from the Technology Action Plan (TAP) of the following countries: Jamaica, Antigua and Barbuda, Belize, Guyana, and Grenada. The technologies listed in the sub section may be able to assist the Bahamas in addressing the technology and research gaps that were uncovered.

8.1. Research Programmes in The Bahamas

8.1.1. Biodiversity

8.1.1.1. Current and Recent Research

Coral Propagation

Currently there is considerable work being done to restore the population density of The Bahamian coral reef. Through The Bahamas Coral Innovation Hub; a research facility based at the Cape Eleuthera Institute (CEI): The Nature Conservatory (TNC), Perry Institute and other research partners; research and implementation of the latest and most effective coral reproduction techniques is being conducted.

Mircofragmentation and facilitated sexual reproduction are the two primary techniques utilised. Researchers at the Hub also take advantage of the coral's natural spawning events and collect coral eggs and sperm, applying the latest techniques in facilitated sexual reproduction in order to create healthy new embryos. These efforts result in maintaining or improving the genetic diversity of the reefs and increasing the rate of survival of young corals encouraging reef rehabilitation. This methodology has proven successful as a pilot coral spawning expedition in 2018 resulted in the creation of 1.3 million new embryos.

With continual research and implemented strategies, these advancements will promote coral restoration to the levels needed to address the current rate of reef degradation. An additional and important benefit is the opportunity to study these new coral larvae through their early life stages. The Reef Rescue Network, headed by the Perry Institute for Marine Science (PIMS), currently has 7875 Corals growing - covering a range of 5 species and has planted 4,794 corals, thereby, improving the condition of coral reefs by restoring populations of corals and other species that will build coral reef resilience.

Stoney Coral Tissue Loss Disease

The extremely infectious and fast-moving Stony Coral Tissue Loss Disease (SCTLD) has spread to 25 different countries as of September 2022, since it was first identified off the coast of Florida in 2014. The cause of SCTLD is currently unknown, but it is affecting >30 species of corals. Highly susceptible species are the meandroid corals–*i.e.,* pillar corals *(Dendrogyra cylindrus),* elliptical star corals *(Dichocoenia stokesii),* smooth flower corals *(Eusmilia fastigiata)* and maze corals *(Meandrina* spp.*).* The rapid speed of the deasease coupled with its high mortality rate have infected and killed some of the world's largest and oldest corals, leaving a devastating trail of thousands of dead corals in its wake.

Since its discovery in The Bahamas in November 2019, The Government of The Bahamas assembled a task force representing various Government agencies, scientists, The Bahamas National Trust (BNT), the Perry Institute, The Nature Conservancy, The Bahamas Reef Environment Educational Foundation (BREEF), and other NGOs to learn more about the disease and raise awareness of its presence in the country.

In the five months following the detection of the disease, it had already spread to 20 percent of coral reefs in Grand Bahama's National Parks. The Perry Institute has also trained government officials (Department of Marine Resources [DMR] & Department of Environmental Protection and Planning [DEPP]), scuba divers and partner organizations to administer life-saving antibiotics onto infected reefs.

Dorian's Impact on Reef Habitats

Prior to Hurricane Dorian, PIMS executed surveys of Bahamian reef ecosystems across Abaco and Grand Bahama, between November 2018 - August 2019; enabling researchers to have a baseline for analysing the damage inflicted by Hurricane Dorian.

After the storm, scientists from the Perry Institute surveyed reefs surrounding Abaco and Grand Bahama in November 2019 and April 2021. The selected timeframes allowed for both the immediate medium-term impacts of Hurricane Dorian on the coral reef ecosystems to be catalogued.

They were able to analyse:
1) Structural damage to coral reefs,
2) Broken or dislodged coral colonies,
3) The amount of live coral on reefs
4) The condition of coral colonies on reefs, and
5) The amount of harmful seaweeds that compete with corals and can prevent coral growth and survival, and
6) Fish biomass on reefs.

The results indicate that in April 2021, many of these bleached colonies had recovered, but some saw significant amounts of colony mortality.

For Abaco, overall reef health did not continue to decline in areas affected by Dorian from October 2019-April 2021, however the reefs off Grand Bahama incurred a widespread outbreak of Stony Coral Tissue Loss Disease, which was not present at sites surveyed in October 2019 and caused significant coral loss.

Research also indicates that much damage was incurred to the reefs closest to the shore by the impact of casuarina pine trees, an invasive species to The Bahamas that is easily uprooted during hurricanes. Reduction in fish biomass was also observed. The rare positive was the storm’s removal of seaweed that compete with corals.

Fisheries Research & Conservation

PIMS along with the local government are researching methods to preserve many commercially important fish species, such as the Nassau grouper. These fish are constantly under threat from issues such as loss of habitat, unsustainable fishing practices, and climate change that endanger their long-term viability.

Part of the research seeks to better understand how these species behave within their habitats, and assess the impact human intervention is having on marine populations. Groupers and snappers, as well as other fish that gather in large schools of hundreds to thousands - every year to reproduce (called Fish Spawning Aggregations) are closely monitored to observe the best preservation methods.

Marine Protected Areas (MPAs) are another component of the ongoing research. The proper design of MPAs, engagement with local partners, stakeholders and community outreach, coupled with ecological assessments and socioeconomic criteria, assists in the management and replenish vital fisheries, protect marine ecosystems, and build coral reef resilience and sustainability.

Bahama Warbler Research and Banding Project

Using empirical data collected during BNT’s surveys and comparisons to previous surveys, BNT was successfully able to convince the IUCN to up-listing the Bahama Warbler from ‘vulnerable’ to an ‘endangered’ species.

The new status helps to garner the support of international conservation organizations and foundations that are funding work to save endangered species worldwide. The banding project is part of a larger avian monitoring and research program geared towards increasing the understanding of migratory and resident Bahamian birds and how they are using Bahamian national parks over time. As more knowledge is revealed about the Bahama Warbler, conservation strategies will leverage the protection in National Parks to help restore their populations and ensure their survival into the future will be developed. The birds are safely released back into the forest after examination.

Motus Wildlife Tracking System and Bahama Oriole Project

The Bahamas’ first Motus Wildlife tracking system was installed in Andros on Kamalame Cay. The system was donated by the University of Massachusetts, Amherst with support from Audubon and Virginia Tech.

The Bahama Oriole Project is a joint collaboration between the University of Maryland, Baltimore County (UMBC) and the BNT to conduct research on the endemic Bahama Oriole, considered to be the most endangered bird species in the wider Caribbean. The outreach and research conducted in October 2017 utilized DISTANCE software for the surveys to estimate population densities. At the time of the report in 2017, the software indicated there were approximately 2,000 Bahama Orioles, which was 10 times more than initial estimates of the population. The research was presented to over 500 persons from various schools and communities through presentations on the research and value of this endemic bird.

Saving Abaco's Dolphins after Hurricane Dorian

This research project is being conducted by Bahamas Marine Mammal Research Organisation (BMMRO) and is funded by the Bahamas Protected Areas Fund (BPAF) with a research grant of $24,348.00 USD.

The objective of the project is to use a science-driven, conservation approach to assist in saving a declining population of bottlenose dolphins that were directly impacted by the catastrophic winds and storm surge generated by Hurricane Dorian. Intense hurricanes, such as Dorian, can have direct impacts on marine animals like dolphins and whales that need to surface to breathe and injury from debris can be fatal. Post storm circumstances can also affect the marine mammal population, as the loss of habitat can be pronounced and there can also be changes in the rate of shark attacks following a storm.

The research project will produce a Sea of Abaco Dolphin Recovery Plan, the first of its kind for a marine mammal population in The Bahamas. The plan will include, up-to-date findings of the dolphin population status and project future trends based on various conservation directives and the impacts of climate change and other human activities, on bottlenose dolphins and other marine life in the Sea of Abaco. The project will survey the dolphins and other marine life, which will be critical in providing sufficient photo-identification data to estimate apparent mortality and recruitment; and assess the population status of the dolphins in the Abaco waters post-Dorian.

The Cape Eleuthera Institute’s Island School has numerous research projects and reports on marine animals in The Bahamas. These include: Stranding Report of Bluefin Tuna in South Eleuthera on 1st May 2022; Movement Growth of Bonefish in Bahamian Archipelago (2022); Habitat Preference of Juvenile Lemon Sharks in South Eleuthera (2022); and Species Populations in Patch Reefs in Eleuthera (2022).

8.1.1.2. Gaps, Needs & Constraints

Research conducted by BNT, PIMS, Bonefish & Tarpon Trust, and other partners recorded an alarming number of degraded ecosystems in The Northern Bahamas after Hurricane Dorian. While many of these areas do not fall within the boundaries of national parks, nature is interconnected and supporting their restoration will be critical to achieving The Bahamas’ restoration goals over the next decade. Thus, there is a need to create additional parks in the Bahamas for both the restoration and continuance of biodiversity and also to improve climate resilience and increase food security.

The Bahamas National Trust had the following recommendations for environmental restoration:

- Develop a rapid response protocol for responding to disasters in The Bahamas to conduct assessments of damage to marine and terrestrial systems and rapidly implement strategies to improve ecosystem recovery.
- Create/utilise databases of current or previous studies to identify where pre-storm baseline data exist and facilitate collaborations to assess storm impacts.

- Continued restoration and monitoring to protect coral reefs from threats including hurricanes, coral bleaching, Stony Coral Tissue Loss Disease (SCTLD), and pollution such as oil spills.
- Institute the "polluter pays" model.
- The creation of a national-level conservation plan for threatened species and habitat types, that includes spatial plans.
- The development of a national-level conservation horticulture program that develops and manages ex-situ collections of native plants that are genetically diverse and representative of wild populations to be used for restoration and reforestation.
- Removal of debris from reefs, coastal areas, forests, and other sensitive systems to reduce the impact physical destruction by storms and serve as fuel for uncontrolled wildfires.
- Establish additional marine and terrestrial protected areas to build resilience, the more reserves there are to repopulate non-motile populations like corals or trees.
- Continued removal of invasive Casuarina and other invasive plants from coastal and inland areas to improve coastal resilience.
- Restoration of corals and mangroves in priority areas to help "jump-start" the recovery process.
- Begin prescribed burning in pine forest areas as soon as possible to protect vital surviving mature pines and critical infrastructure and residences.
- Identify and approach priority communities for outreach and education regarding restoration and ecosystem management.

Long-term monitoring is needed to track both the impact due to storms and the evolution of the Bahamian environment due to the effects of climate change. Changes on marine mammals, pine forests, mangroves, coral reefs and seagrass ecosystems and other local fauna and flora, need a baseline of pre-existing data in order to accurately quantify measures of change and subsequently take necessary actions.

In this regard, it is critical that all ecosystems have periodic research analysis including genetic testing to infer health, population density, genetic diversity and other critical variables. This includes the need for data sharing systems to avoid unnecessary duplication of efforts and create a proficient method of data access and retrieval for modelling, reporting needs and transparency.

As recommended in an interview with a professor at University of the Bahamas, a combination of using GIS and drones can be created to survey coral reefs. Additionally, the use of additional MOTUS stations placed throughout the country can record the movement of birds that have been tagged and can reveal changes in the behaviour of those birds which may be early indicators of climate change.

8.1.2. Forestry

8.1.2.1. Current and Recent Research

Establishment of a Seedling Nursery and Replanting for Forest Recovery and Restoration on Grand Bahama

The aftermath of Hurricane Dorian resulted in, the destruction of 24% of pine forests on Abaco and 77% of pine forests on Grand Bahama. The Forestry Unit's post-Dorian rapid forest impact assessment (estimates that 22.5% and 100% of the forest resources on Abaco (148,797 acres) and Grand Bahama (70,289 acres), respectively, suffered severe to catastrophic damage due to hurricane-force winds, saltwater intrusion, tornadoes, and fires.

This project, which is also referenced in the, Environmentally Sound Technologies chapter, is a collaboration between the University of the Bahamas and the Forestry Unit and is the first official planting of pine seedlings.

The research component of the project will answer questions such as: What are the best methods to actually plant pine or plant complementary species trees out in the pine forests? What will be the survival rate? Will invasive species come in if an area is reforested? Will the seedlings take a period of time and with normal cycles of fire commence growth? And would the forest reconvert to a broadleaf deciduous forest such as those which are native to the nation?

The Project seeks not only to reforest the areas on Grand Bahama and Abaco with pine trees, but also complementary species that are typically found in the pine forest ensuring balance in the ecosystem. The restoration of the pine forests is expected to restore the understory vegetation reduce limestone exposure, which will in turn decrease the occurrence of run-off and erosion of the limestone during wet and rainy periods thus protecting the landscape from denaturation. The nursery project is a BPAF funded project granted $99,987.28. The project was awarded in June of 2021.

8.1.2.2. Gaps, Needs & Constraints

National Forest State Establishment and Research

There is still an urgent need to establish a national forest state in The Bahamas. A national forest state was pledged as a part of The Bahamas' initial NDC (in 2015) and updated NDC (in 2022). In order to create an efficiently managed forestry state, a team comprised of experts in forestry management and restoration, financial and technical advisors, and researchers is needed. Additionally, a standard for documentation, record keeping, accountability, and consistent and efficient reporting mechanisms would also need to be established. To aid in the mapping and monitoring of large forest areas, the use of drones and trained Geographic Information System (GIS) analysts can be used to evaluate changes in Land Use and Land cover.

Monitoring the growth and changes of the forests and the flora and fauna that inhabit them are key in not only observing the effects of climate change on the environment, but also the early detection and monitoring of diseases and other issues in the environment that affect biodiversity and the variations in the water table levels.

As mentioned in the subsection on biodiversity, both government and NGO stakeholders have continuously stated the need for long-term monitoring of ecosystems and weather variables such as air quality, rain-fall and sea level rise. This enables the relevant departments to have a baseline of data which is critical for accurate scientific measures of analysis and research integrity. Continuous measurements are necessary to produce accurate measures of greenhouse gas emissions, rates of sea water intrusion, land use, land cover, and other variables. Stakeholders have also continuously advocated for the need of a data sharing network for efficiency and progress.

8.1.3. Water Resource Management

8.1.3.1. Current and Recent Research

Ground Water Conditions and Resources on Grand Bahama Post Dorian

In his reports *Report on the Groundwater Conditions of Grand Bahama after Hurricane Dorian and Proposed Mitigation Measures* and *Impact Assessment and Management Strategies for the Groundwater Resources of Grand Bahama*, Dr. Henrique Marinho L. Chaves, Unesco GRAPHIC-LAC Coordinator, describes the water conditions of Grand Bahama post Dorian. Originally, as stated in the document, the groundwater quality of the freshwater lenses of Freeport is potable, however, it is threatened by pollution, sewage, urban stormwater, and salinization from inundation by hurricane surges. After each of these hurricanes, Hurricane Floyd (1999) and Hurricane Frances (2004), water chloride levels in wellfield 6 increased to 200 ppm and >500 ppm respectively. The later surpassing the USEPA freshwater limit (250 ppm).

After the passage of hurricane Dorian (2019), the chloride concentrations surged to even higher levels. The wellfields and their respective salinities are as follows: Wellfield W-1/20 ~ 1800 ppm, W-1/A-13 ~ 1100, W-1/out main~3100ppm, W-6/119 ~1900, W-6/116 ~3400ppm, W-6/out main ~ 4800pm. Only 161 (46%) of the total 349 wells in the Grand Bahama Utility Company (GBUC) data base, had water quality data, and these were used in the groundwater quality spatial analysis. Besides these staggering salinity numbers, the flooding of the W-6 pumping station and water reservoirs were also casualties of the inundation. Additionally, the high energy and turbulence of the storm surge, brought sediments from the mangroves, silting the soil surface of the wellfield which may reduce groundwater recharge and subsequent freshwater lens dilution in the future.

The 250 km/h winds of Hurricane Dorian devastated a great portion of the pine forest of Wellfield 6, which provided an important natural protection for the aquifer system. The main findings of the *Impact Assessment and Management Strategies for the Groundwater Resources of Grand Bahama* report were the following:

- The mean yearly groundwater recharge in Grand Bahama is 964 mm/yr, and mean monthly recharge varies from 3 mm (Nov.) to 280 mm (Sept.);

- The main hydrogeologic parameters of the freshwater lens of Freeport were obtained locally, allowing further groundwater analysis in the future;

- Theoretical and observed transects of the freshwater lens were obtained by modelling, resulting in a potential groundwater volume of 136.2 x 106 m3 for the target area of Freeport;

- The yearly freshwater lens renewal rate is 102% in the target area, and the freshwater lens is completely renewed every 0.98 years, a fact corroborated by salinity data of past hurricanes in the island;

- The safe yield recommended for the Freeport wellfields is 34.0 x 106 m3/yr, equivalent to 241 mm/yr.

- After the passage of Hurricane Dorian (Sept. of 2019), the inundation of seawater salinised wellfields W-1 (partially) and W-6 (almost entirely). These results were corroborated by the inundation satellite map of the island of Grand Bahama, in Sept. 2019.

The first report, *Report on the Groundwater Conditions of Grand Bahama after Hurricane Dorian and Proposed Mitigation Measures,* indicated that the oil spill caused by Hurricane Dorian at the Equinor terminal was severe, and remedial measures needed to be taken and groundwater below the affected area needed to be frequently monitored for hydrocarbon and heavy metals. Additionally, since soil and vegetation were also affected, these should receive remedial attention and monitoring processes by Bahamian agencies.

Strengthening of Forests Through Groundwater Restoration (SOFTGR)

This is a BPAF funded research project granted 98,900.00 USD to the Forestry Unit in 2021. The project will investigate the extent of forest and groundwater damage that has occurred at Wellfield 6 in Grand Bahama. The objective is to develop strategies for regenerating the forest such as direct seeding and seedling planting; and restoring groundwater that has been impacted due to Hurricane Dorian through groundwater modelling of water quantity and quality to enhance the ability of the island to have a self-sustaining, flood resilient drinking water supply. The research will investigate such questions as: how long will the groundwater take to be replenished? And when and if it will revert to freshwater. The project team will utilise forest survey methods, hydrogeologic data collection, and GIS mapping to characterise current conditions, compare to historic conditions, and develop future strategies for addressing the damage.

i) **The legal framework for the development and implementation of an Integrated Watershed Management Plan for East Grand Bahama.** The aim of the *Integrated Watershed Management Plan For East Grand Bahama (IWEco*) is to “place under a management regime at least 20000 hectares of ecologically important biological corridors (comprising of mangrove wetlands and pine forests) and contribute to reduced pollutant loadings, particularly of sediments and nutrients to avoid excessive eutrophication of nearshore waters and smothering of coral reef systems”.

The Core outputs of the Project will include: a watershed management plan, a biodiversity inventory, restoration methodology and increased sustainable livelihoods to diversify the financial resource base in local communities in East Grand Bahama (‘EGB’). The project aims to address the eco-tourism sector in component 1 of the project. Component 1 will also produce a Biodiversity Inventory which enlists the use of GIS data and will be a useful resource for future researchers. Upon a successful model of integrated landscape and seascape management, the Government of The Bahamas will replicate this project on other islands and can share with other Small Island Developing States (SIDS) regionally and globally.

Ocean Thermal Energy Conversion

As discussed in Chapter 6, Ocean Thermal Energy Conversion (OTEC) is a sustainable technology application that has and is currently being explored as The Bahamas continues the search for sustainable, renewable, available and affordable water resources for its citizens. The Bahamas presently utilises groundwater supply and discharge wells for Seawater Reverse Osmosis (SWRO). The groundwater resources of the nation are comprised of fresh, brackish, saline and hyper saline waters found in the near and deep subsurface and in the lakes and ponds that intercept the surface.

Use of OTEC requires a temperature differential of 20°C (36°F) between hot and cold waters. The Bahamas possesses very warm year-round average surface temperature of 27°C (80.6°F) therefore an estimated depth of 914.4 meters (3,000-feet) gives the necessary difference at 7°C (44.6°F). To improve efficiency and for a proof of concept, a paper by John Bowleg - *Climate change, water resources, & renewable energy in the Bahamas use of the inverted geothermal conditions of the water resources, toward climate adaptation measures for both water and energy – by Ocean Thermal Energy Conversion (OTEC) (2022)* suggests the use of solar photovoltaic cells to warm water from existing cold water supply wells to 50°C (122°F). To improve resiliency, the technologies of SWRO, Seawater district cooling and OTEC can be combined and serve as renewable energy options. Additionally, no fuel storage is associated with Seawater district cooling or OTEC. Other benefits of the technology can be explored to offset the potential cost of digging new or deeper wells such as it by sharing the cold- water intake pipe with the various cold-water industries, from prawn and lobster farming, deep-sea water spa, greenhouses and aquaculture and air-conditioning.

8.1.3.2. Gaps, Needs & Constraints

Both health and water management stakeholders have indicated a need for water catchments to address the watershed issues in New Providence and the Family Islands. The *IWEco* project will formulate a watershed management plan that the country intends to implement in the rest of the nation, following successful implementation in Grand Bahama. However, at this time it is not known if water catchments will be a part of that plan. The securement of rainwater or collection and management of stormwater could address the growing concern of continuance of fresh water supply and the abundance and high cost of energy to produce it. Collected rainwater and storm water could be used in the agriculture industry for drip irrigation or in the hotel and tourism industry for landscape management and toilet water. Home use of this water source could be used similarly, thereby reducing the personal and commercial expense of water and increase water security in the nation. Collected water may also be used for ground water recharge.

As it pertains to capacity in the water management sector, The University of the Bahamas has indicated a need for development in modelling and other machine learning and artificial intelligence to map out and research ground water and other areas of interest. They, as well as well as the aforementioned stakeholders, have also indicated a need for persons trained in the skill of Geographic Information System (GIS) and the critical need for improved inter-agency relationship, collaboration, and data sharing.

8.1.4. Land Use and Land Degradation

8.1.4.1. Current and Recent Research

The Building Code

The building code (edition no. 3) for The Bahamas has not been updated in the last 20 years. The new building code has researched and taken into consideration evaluations made on the building codes and standards of neighbouring countries and its design will include plans for energy efficiency, accessibility, sustainability, and use of renewable energy. These changes will be in line with *Persons With Disabilities (Equal Opportunities)* Bill, 2014. A preliminary report has been made on these findings.

Climate-Resilient Coastal Management and Infrastructure programme

Progression of the research, assessments, analysis and maps that have been produced at part of the Climate-Resilient Coastal Management and Infrastructure programme:

- Component 1: Sustainable Coastal Protection Infrastructure.

Junkanoo Beach

  - Start of Baseline Coastal Studies & Design - October 2022
  - Coastal Zone Photogrammetry Study - August 2022
  - Shoreline Change Study – December 2022
  - Nearshore Wave and Current Study – November-2021
  - Sediment Transport Study - February 2023
  - Coastal Infrastructure Asset Assessment - February 2023
  - Environment & Social Baseline Studies - January 2023
  - Engineering Studies - July 2023
  - Environmental Economic Valuation Baseline Study - January 2023

- Component 2: Natural infrastructure for hazard resilience in Andros.
  - Climate Change, Met-Ocean Coastal Analysis - July 2022
  - Socioeconomic Assessment - August-2022
  - Biophysical Assessment - November- 2022
  - Hazard Assessment Report and Maps - September-2022
  - Vulnerability Assessment Report and Maps - October-2022
  - Hazard Risk Assessment Report - November 2022
  - Final Report - March-2023

- Component 3: Institutional strengthening for coastal risk management.
  - Upgrading the Bahamas Building Code Incorporating Coastal Infrastructure Design Guidance (End of Year-2022 anticipated *Draft* date)

8.1.4.2. Gaps, Needs & Constraints

Environment stakeholders have indicated the need for an Environmental Impact Assessment (EIA) Process. This tool is used to assess the significant effects of a project or development proposal on the environment. This ensures that project decision makers and other stakeholders are made aware of and consider the likely effects on the Bahamian environment at the earliest possible time. The ultimate goal is to avoid, reduce or offset those effects and warrants that proposals are properly understood before decisions are made. This is especially critically as The Bahamas' main industry is tourism, which can influence a constant stream of development in the form of hotels and marinas. This continual development has a direct impact on the extremely vulnerable sea grass which needs clean water to survive. An EIA would ensure that such activities will be sustainably conducted.

The Department of Agriculture has indicated the need for more research to be done and the need for the strengthening of relationships with existing research and tertiary institutions. In order for the Agriculture department to research, develop, implement, and enforce novel and existing Environmentally Sound Technologies; a major capacity supplementation is needed in the form of: A Director of Agriculture (1), Deputy Directors of Agriculture (2), Soil Scientists (2), Microbiologists (2), Entomologists (2), Horticulturalist/Plant Specialists (2), Extension Officer (Crop & Livestock) (10), Apiary Specialist (2), Agronomists (2), Veterinary Officers (4), Veterinary technicians (6), Animal scientists (poultry, swine, small ruminants) (3), Food technologists (2), Lab Technicians (Food Technology Lab) (4), Extension Officers (Food Technology Lab) for training, inspection, regulation of Family Island community kitchen which are food processing units (2), Statisticians (2), Economist/Marketing (1), Project Managers (2), Human Resource Specialists (2), Mechanical Engineer (1), Tractor Operators (6), and Persons trained in Climate Change & Agriculture/similar at the post graduate degree level (2) and GIS analysts. The use of GIS analysts would be useful to enable the Agriculture Department to specifically identify where flocks are throughout the country and critically for traceability in the event of poultry disease outbreak in country such as Avian Influenza.

The Department of Agriculture made created and facilitated a number of projects to create resilience in the food industry. This includes the introduction of the Mulato grass and the Boer goat. However, the department lacks the resources in both staff and budget to research regarding the medium and long-term effects of species introduced on local fauna or microbiology that may strongly depend on the native vegetation, when they have been displaced by or mixed with introduced species.

The raising of farm buildings above ground level is a climate change strategy suggested by the Department of Agriculture that will provide a greater likelihood of food security given storm surges and flooding on the islands. An assessment will need to be done to determine the necessary level of elevation and placement of such buildings. This effort would need to be done in collaboration with the Department of Meteorology, who has been engaged in storm surge modelling, Department of Lands and Surveys, and BNT.

Technologies that would further assist the agriculture industry of The Bahamas would be: Solar drying equipment for plants and seed, bio-ingestion(mitigation), an insemination programme for sheep and goats, the use and development of biogas, expansion of community kitchens, new buildings for the slaughter houses on the Family Islands, tractor equipment upgrades and Tablets for the field technicians.

In interviews with the Ministry of Works, a staff shortage was also indicated as a gap. They, similarly to the aforementioned stakeholders, declared a need for additional staff trained in GIS and the need for a data centre and data sharing. The use of the 52-week training programme was recommended to address the GIS and other capacity gaps. It was recommended that the programme have multiple evaluation benchmarks to evaluate: skill level, teamwork capabilities, work ethic, and ethics in general. Successful trainees would then be able to enter the work force.

8.1.5. Meteorology & Disaster Preparedness & Management

8.1.5.1. Current and Recent Research

The Island School in Eleuthera, part of the Cape Eleuthera Institute, has conducted and is in the midst of numerous meteorological, oceanographic, and climate change related research projects and reports. Their research includes: 2022 North Atlantic Hurricane Forecast: Concerns for The Bahamas; 2021 Ocean Temperature and Salinity Observations; Climate Change & The Bahamas Information Brief; and the Hurricane Glider Project: Bahamas.

The hurricane glider project is being done through a partnership with the University of Miami. The project uses an autonomous drone to collect information on sea surface temperature and salinity data to provide an idea of how hurricanes will intensify as a result of continuous ocean heating and also how this heating affects salinity. Attaining this data makes hurricane and other oceanographic modelling for the international community a lot easier. Using models that have motion characteristics as well as atmospheric characteristics can more accurately detail the degree of storms that may develop in the future. Currently, researchers at the school are in the midst of writing a paper on understanding the trends and changes of hurricanes in the Caribbean.

Another major project for the Island School is focused on building a curriculum for climate change for teachers nationwide to assist students on how to conceptualise climate change.

This project is being done in partnership with the US Embassy via an environmental educational grant.

In 2021, researches at the school embarked on a project where they surveyed individuals about their perceptions on climate change. The survey was modelled on the work done in 2018 by Dr. Adelle Thomas and Dr. Lisa Benjamin at the University of the Bahamas. The 2021 survey expands the sample of respondents to include responses from the entire Bahamas and is promoting involvement via modes of social media to maximize participation.

Finally, in order to ensure the accuracy of climate change models, the institute aims to conduct a comparative study between the automatic weather stations on their campus versus the automatic weather stations set up by the Department of Meteorology on Eleuthera and Cat Island. The project aims to get schools to be more involved to obtain accurate readings on weather data in order to calculate proper climatology to better understand what the weather will look like in the long term and how those changes, heat for example, can affect health.

DisasterAWARE

The Government of The Bahamas has partnered with the Pacific Disaster Centre to create The Bahamas Disaster Risk Profile and produce The Bahamas National Disaster Preparedness Baseline Assessment and the Bahamas Island Risk Profiles. These documents can be obtained from the Pacific Disaster Centre's website. The collaboration between the Government of The Bahamas and the Pacific Disaster Centre has produced some much-needed resources in the area of disaster management software and capacity building by the training of the staff in its use. DisaterAWARE uses data obtained from The Bahamas to provide risk assessments, disaster management strategies, and operates as a forecasting and modelling tool. From this project, information such as: Multi Hazard Exposure, multi-hazard risk, coping capacity, vulnerability, island capacity, logistics capacity, and resilience scores have been produced and mapped out for each island of The Bahamas.

8.1.5.2. Gaps, Needs & Constraints

The Department of Meteorology does not have air quality or recent tidal data available, due to the limitations in the availability of various meteorological instruments in the country. Interviews with BNGIS indicates that at least tidal gauges 20 are needed. Moreover, the Department of Meteorology has indicated the need for Coral Reef Early Warning System (CREWS), a technology that would provide salinity and other meteorological and oceanographic data benefiting both the Met Department, as well as coral researchers.

Regarding capacity, the SNC expressed that the Department of Meteorology needed additional staff and training, to date, the Department is still requesting 16 to 20 additional staff members. There is also a need for additional experts and training in the area of GIS.

8.1.6. Health

8.1.6.1. Current and Recent Research

Mental Health and Climate Change

The aftermath of Hurricane Dorian brought brought the issue of mental health into the forefront of Bahamian society. Persons were able to better connect the issue of post-traumatic stress disorder (PTSD) and mental health to the ongoing climate crisis. As the region prepares to brace itself for more intense and slower moving storms, it becomes critical that not only is the link between mental health and climate change known and understood, but that capacity is put in place to address the issues.

Research conducted by Shultz, et al, 2020 and references therein *Scrambling For Safety In The Eye Of Dorian: Mental Health Consequences Of Exposure To A Climate-Driven Hurricane,* indicate elevated rates of anxiety and other mood disorders throughout the storm-affected sample of people who survived Hurricane Katrina. They also found that survivors diagnosed with post-traumatic stress disorder (PTSD) had experienced severe hurricane-related stressors. For people with pre-existing serious and persistent mental disorders such as schizophrenia, even routine hurricane precautions such as evacuating and sheltering disrupts sleep cycles and care routines that are essential for psychological stability. The research further indicates that both nonevacuators and evacuators of hurricanes experienced moderate-to-severe depression symptoms mostly as a result of staggering loss of resources. Nonevacuators who experienced the full assault of the storm (Hurricane Ike) had a significantly higher prevalence of PTSD.

This is of critical to note, as The Bahamas, being an archipelago, has island-based populations where the complete evacuation of that island – in the path of a powerful storm - may not be possible and material losses are highly probable, as there is no “inland” on most islands. The likelihood of progression to PTSD is positively correlated to extended disruptions of electrical power, water, communications, transportation, and food supplies caused physical discomfort and psychological distress. For the Bahamas, assessments with validated screening measures found that high proportions of Dorian survivors seen at the clinic had significant symptom elevations for major depression, generalised anxiety, or PTSD.

In order for capacity and systems to be put in place in the area of climate related health issues, it is important for the Bahamas to note that researchers demonstrated that mental health interventions can only work well, when hurricane-related stressors and life changes including: displacement, job loss, decreased income, relationship difficulties, legal problems, the ensuing disruption of health care services, harsh living conditions, and heat exposure are effectively addressed. This institutes a strong need for multi-stakeholder collaboration with health, financial, legal, employment, housing, faith services and other welfare groups.

8.1.6.2. Gaps, Needs & Constraints

Through conversations with the Ministry of Health and Department of Environmental Health Services, the following research gaps and needs were indicated:

In the areas of capacity building and necessary staff:

- A Climate Change & Health Leadership Group
- Soil analysts
- Epidemiologists
- Communication Specialist
- Economists
- Improvement in speed and efficiency the hiring process
- Continuous training and upskilling for staff to ensure experts remain knowledgeable and proficient in the latest best practices
- Increasing the number of health care professionals with the capacity to provide care for those dealing with mental trauma.

In the area of research:

- The corelation and current statistics between flood runoff and well water safety
- The relationship between summer food poisoning as a result of increased temperatures due to climate change
- The safety and quality of recreational water in the light of climate change
- Air quality assessment
- Further research on communicable diseases
- Vulnerability indices

In the area of technology:

- Development of water catchments
- Air quality monitors

- Maintenance of existing technologies
- Recycling composting technology
- The building of elevated Shelters and medical facilities

In addition, to these needs and capacity gaps the paper *Emergency Response to Hurricane Dorian: Emergent Volunteer Groups and Public-Private Partnerships (Thomas et al 2021)* also clearly indicates a need for a Systemised Volunteer Network. Storms will come again in the future and it is a healthy community, both local and global, that produces an immediate flow of volunteers. Given that the health care and other systems can be overwhelmed and the volunteers will invariably come, The Bahamas could set a system whereby having identified a list of likely needed skillsets, volunteers can preregister for clearance (especially in more sensitive areas such as health or other capacities that need licensed skills).

8.2. Regional Climate change research programmes with relevance to the Bahamas

The following technologies in this section have been compiled primarily from the Technology Action Plan (TAP) of the following countries: Jamaica, Antigua and Barbuda, Belize, Guyana, and Grenada. The TAP is the final stage of the Technology Needs Assessment (TNA), which indicate that these technologies have passed a rigorous and clearly documented process in their respective countries. The technologies therein also have support from the University of the West Indies (UWI), GEF, the Caribbean Community Climate Change Centre (CCCCC), UNEP and/or other organisations detailed in their respective reports. Additional technologies that may be of relevance to The Bahamas were gathered from the UWI sustainability or research page and the Caribbean Community Climate Change Centre.

The technologies are divided by sector and includes an abstract of the technology's background as well as details regarding the strategy the corresponding country intends to employ to ensure successful implementation.

8.2.1. Forestry and Biodiversity

Project Name: *Seagrass Restoration*
Country of Research/Implementation: Jamaica
Document: Jamaica Technology Action Plan October 2021

Background:
The loss of seagrass beds is linked to natural and anthropogenic factors influencing marine and coastal ecosystems. Degraded seagrass meadows have resulted in loss of a

key habitat that serves as spawning, nursery, feeding grounds and shelter to a variety of marine organisms. This loss has also reduced carbon uptake but more evidently have contributed to a reduction in sand accretion and reef degradation. Seagrass slows down coastal currents which helps stabilise sediments and retain sand, reducing beach erosion, whilst improving the clarity of coastal waters, hence the widespread interrelated impacts associated with their loss.

Strategy:
Under this project, the rhizomes or shoots from healthy donor adult seagrass plants would be harvested for subsequent transplanting into the degraded areas.

8.2.2. Water Resource Management

Project Name: *Atmospheric Water Generators*
Country of Research/Implementation: Antigua and Barbuda
Document: Antigua and Barbuda Technology Needs Assessment Report III Technology Action Plan For Climate Change Adaptation & Mitigation - Water, Building and Transport Sectors – (March 2022)

Background:
Atmospheric Water Generators (AWG) (water makers) produce potable water by extracting vapour from humid, ambient air – either by condensation or exposing the air to hydroscopic substances (drying agents) called desiccants. In modern water makers, vapour from the air is drawn into the external/roof-mounted unit and adsorbed into a specialised desiccant. Water is then desorbed and condensed into droplets. The liquid is piped into a tank where it can receive up to three levels of treatment before the purified drinking water is dispensed at a tap or cooler. Some water makers are solar powered and can even be fitted with network connected water quality monitoring systems.

Strategy: The TAP will focus on piloting roof units on private or public buildings that provide drinking water dispensed at a cooler throughout the day, with specific focus on offices, schools and health facilities. The diffusion targets for the pilot phase is to install AWG units in 50 private offices, 50 schools, 25 clinics and/or doctors' offices and 20 government offices.

Project Name: *Rainwater Harvesting for Irrigation*
Country of Research/Implementation: Antigua and Barbuda AND Jamaica
Documents: Antigua and Barbuda Technology Needs Assessment Report III Technology Action Plan for Climate Change Adaptation & Mitigation - Water, Building And Transport Sectors (March 2022); Jamaica Technology Action Plan (October 2021)

Background:

Rainwater harvesting (RWH) is the diversion, capture, storage, and treatment of precipitation for potable and non-potable uses. All systems typically include catchment surface, transport, storage, treatment, and distribution. Rainwater harvesting technology can help to collect and store water for use during low water periods providing feasible storage options that specifically target the agricultural sector will also be beneficial in increasing on farm storage for irrigation.

Overall, the main aim of this project would be to ensure the supply and availability of water for agricultural use in a scenario of increasing climate change-induced water scarcity. By targeting a climate vulnerable resource key to sustain agriculture, the project will contribute to meeting food security and livelihood objectives that are undermined by the effects of climate change. Furthermore, harvesting at the community level would contribute to greater resilience for vulnerable people who cannot invest in adequate at home storage. Greater adoption of rainwater harvesting would occur if additional cost-effective storage options, that rival reinforced concrete in-ground cisterns, were available on the local market.

Strategy:

Jamaica

Under this project farmers would be able to access special grants or subsidies to fund the initial cost of installation of rainwater harvesting systems for water collection and storage for irrigation use by small and medium sized farmers.

The project would also include the establishment of ongoing capacity building programmes including farmer-field schools for farmers to include:

- Rainwater harvesting techniques, opportunities, and challenges.
- Business planning and project financing.
- Introduction to new technologies for climate change adaptation.
- Accessing and interpreting weather, climate, rainfall, and soil data/information.
- Water management strategies for climate resilience.

Antigua and Barbuda

At present rainwater harvesting is supported by the Building Code (1993) and Physical Planning Act (2003). The Development Control Authority (DCA) guidelines dictate that all newly constructed buildings must include rainwater capture and storage for the architectural plans to be approved.

The prioritised measures were refined into the following concrete actions:

1. Pilot a range of up to five (5) new rainwater storage options for consumers.

2. Launch an Innovators Competition to design and demonstrate novel low-cost rainwater storage options [by increasing access to financing and lowering investment risks].
3. Strengthen technical capacity of registered NGOs and community groups in proposal preparation, project planning, design, coordination, and financial management.
4. Rehabilitate [up to 10] community cisterns with storage, distribution, and income generation streams.

Project Name: *Freshwater Harvesting: Empoldering of Water Collection Areas*
Country of Research/Implementation: Guyana
Document: Government of the Cooperative Republic of Guyana Technology Action Plan for Adaptation January 2018

Background:
Water harvesting (WH) can be described as the collection and management of flood water or rainwater runoff to increase water availability for subsequential beneficial use most commonly domestic and agricultural use. It is an essential component of sustainable land and water management as it can assist in preventing land erosion. Its basic methodology is to collect water in an area and transfer it to other areas where it is most needed to increase the availability and volume of water in that area. The basic physical components of this type of water-harvesting system are:

(i) A catchment or collection area
(ii) A run-off conveyance system
(iii) A storage component and
(iv) An application area.

There are many water-harvesting technologies, depending on their application, but the most common are:

(i) Floodwater harvesting
(ii) Macro catchment water harvesting
(iii) Micro-catchment water harvesting and
(iv) Rooftop and courtyard water harvesting.

Deploying the technology in the agriculture sector contributes to climate change adaptation by providing a source of water for crops, livestock and inland fisheries in dry conditions. The collection area also allows water to be stored during periods of extremely high rainfall and reduces the impact of flooding on communities. The target for the technology is that it should provide an adequate water supply for agriculture and domestic use by communities, particularly in drought-prone areas.

Strategy:
Empoldering for water harvesting ensures that water is stored and available locally, especially in the outlying or inland regions, thus preventing food insecurity and population

displacements because of drought. It is intended that water-harvesting will form part of a broader ‘sustainable water supply management’ project or program, and therefore this technology will be applied on the medium to large scale.

The four measures identified for development into actions are:

1. Conduct research to provide updated data and baseline on the status of water resources to identify suitable areas for empoldering more efficiently
2. Showcase successful technology applications to stimulate interest and promote awareness
3. Promote awareness of the likely impacts of climate change, such as droughts and flooding and the need for water management
4. Update existing regulations to reflect clear lines of authority among the various institutions.

Project Name: *Community-Scale Rainwater Harvesting System*
Country of Research/Implementation: Jamaica
Document: Jamaica Technology Action Plan (October 2021)

Background:
Rainwater harvesting can help to adapt to the effects of climate change as it allows for:
• Diversification of potable water supply
• Creation of new sources of water
• Increase in storm-water control and capture
• Increase in water storage
• Technologies with low setup cost for simple systems, however, this can vary with more complex systems
• The use of a system which is easily scalable, and components can be added over time. Use of technology which can be simple and easily maintained without specialised persons.

Strategy:
Elevated systems will utilise gravity for water delivery in communities. Solar driven water pumps will be used for areas which are flat or have varying elevations.

Action (Measures):

1. Financial support for community scale rainwater supply systems for non-utility supplied communities
2. Rainwater harvesting systems should have a financing component for operations and maintenance to ensure the continuity and sustainability of the system
3. Community organizations can be responsible for the management and operation for the community rainwater harvesting systems, however, they may require financial and professional support

4. Development of national standards and guidelines for rainwater harvesting
5. Government to create a department in an existing agency with related portfolio with the sole responsibility of rainwater harvesting research and development. This should include conducting research into rainfall and watershed analysis, catchment dynamics and rainwater quality.\

Project Name: *Minor Water Tank Networks For Communities*
Country of Research/Implementation: Jamaica
Document: Jamaica Technology Action Plan (October 2021)

Background:
Minor Water Tank Networks for communities creates diversification of the water supply as they allow for the control and capture of storm water. The water is collected into tanks which can provide water for domestic, agricultural and livestock needs. These tanks are large and usually gravity feed to houses or to a communal pipe. They are large enough to support small communities. For densely populated communities, or communities where extensive piping is needed to supply homes, solar water pumping will alleviate the need for diesel pumps and avoidance of emissions. For potable uses the collected water will require some treatment.

Strategy:
Solar driven water pumps will be used for areas which are flat or have varying elevations and where pressured systems are necessary for extensive piping within communities. The target for minor tank networks is to increase water storage and distribution systems for potable uses by 20% in non-utility supplied rural communities by 2024. This target is in keeping with the National Water Sector Policy and Implementation Plan 2019 which outlines the Government of Jamaica's goal to provide potable water access to everyone by 2030.

The strategy of implementation also includes the creation and restoration of tanks which harvest water from surface water bodies, runoff and from direct rainfall. Restoration of tanks that have been damaged or silted will have the following actions:

1. Financial support for community scale minor tank systems for nonutility supplied communities
2. Develop minor tank network systems
3. Facilitate the management and operation of community rainwater harvesting systems

Project Name: *Improved Drip Irrigation/Fertigation Systems*
Country of Research/Implementation: Belize
Document: Government of Belize Technology Action Plan for Climate Change Adaptation and Mitigation Final Report (December 2018)

Background:

An Improved drip irrigation system introduces water directly into the root zone without sprinkling the foliage or wetting the entire soil surface. Such partial-area irrigation methods offer the additional benefit of keeping the greater part of the soil surface, between the rows of crop plants, dry. This discourages the growth of weeds, which would not only compete with crop plants for nutrients and moisture in the root zone but also for sunlight.

This technology can be used in conjunction with other climate change adaptation measures such as water harvesting, multi-cropping and fertilizer management (fertigation system). Promoting drip irrigation contributes to efficient water use, reduces requirements for broadcasting fertilizers, controls weeds, and increases soil productivity. It is particularly suitable in areas with permanent or seasonal water scarcity, since crop varieties planted can adapt to the local conditions.

Strategy:

Investment is required to build farmer’s capacity to efficiently operate and maintain the system and water flow control. Under poor management, even the most sophisticated system can result in water loss and inefficiency. Only knowledgeable, experienced and good management can ensure that irrigation systems achieve their full potential benefits as drip irrigation can be used for small or large-scale crop production, and with low cost or more sophisticated components. It is very important to consider how the system is operated.

Actions:

1. Procure finance to introduce improved drip irrigation / fertigation technology
    a. Conduct a feasibility study and cost-benefit analysis for expansion of drip irrigation countrywide
    b. Draft project proposal for funding to establish seven improved drip irrigation/fertigation systems with water catchment for training and demonstration
2. Organise and run training programme for seed producers
    a. Allocate training budget for Training of Trainers programme
    b. Draft and implement training programme for famers in improved drip irrigation /fertigation and water harvesting in all districts
    c. Write, print and disseminate improved drip irrigation guidelines in English and Spanish
3. Action 3. In coordination with Hydrology Unit, Ministry of Agriculture (MOA) conduct an ongoing awareness programme on water use, conservation and management

    a. Develop information manuals for extension officers, farmers and public for awareness programme on water management and use in agriculture
    b. Hold series of workshops and field demonstrations on use and water harvesting
    c. Participate in radio talk shows, expos and visits to farmer’s groups
4. MOA and Partners review, update and implement relevant provisions of the National Water Irrigation Strategy (NIWS).
    a. Organise and promote networking with university, private entities and others on implementation
    b. Develop programmes for farmers on activating certain provisions of the NIWS
5. Strengthen research, development & demonstration of new technology
    a. Assess the current use of drip irrigation and identify needs and gaps (e.g. equipment, agronomic practices, water use)
    b. Promote network of equipment supplier, importers, & retailors equipment
    c. Strengthen research and development in drip irrigation & best practices

Project Name: *Drip and Sub-canopy/Micro Sprinkler Irrigation with Rainwater Harvesting Infrastructure*
Country of Research/Implementation: Jamaica
Document: Jamaica Technology Action Plan (October 2021)
Background:
Rainwater harvesting infrastructure secures water resources to be used during periods of water stress, lowers the demand on treated water for domestic and other uses and incorporates nutrients such as nitrates from rainfall for farming.

The technology has the following benefits:
- RWHS reduces the cost for delivering water, thus improving the economics of operations.
- Subcanopy Sprinkler and drip irrigation technology is a more efficient distribution system for irrigation water
- Addition of smart sensors for detecting crop root/soil moisture will activate pumps when needed to efficiently deliver irrigation volumes specific to the crop and appropriate for real-time weather conditions.
- Solar pumping avoids the resulting emissions from diesel water pumps and have lower operating costs.
- Eliminates use of open water conveyance channels therefore reducing water loss
- Distributes water more evenly across crops, thus helping to avoid wastage and increases crop/farm yields

- Most suitable for rows, field and tree crops that are grown closely together. These include: sugarcane, groundnut, cotton, vegetables, fruits, flowers, spices and condiments

Strategy:
Install rainwater harvesting systems integrated with drip and sprinkler irrigation systems powered by smart sensor integrated solar PV panels, controllers, DC motors and pumps.
Actions:

1. Provision of special grants or subsidy to fund initial cost of installation of Sprinkler and Drip Irrigation Systems with solar PV and smart sensors for ¼ acre of properties (small and medium-sized farmers).
2. Provision of low-interest or interest-free loans for the expansion of irrigation systems to improve efficiencies above ¼ acre.
3. Provision of tax incentives on capital costs for the installation of efficient irrigation systems from 2021-2025.
4. Establishment of a funding policy/financial framework that would enable the Government of Jamaica through Rural Agricultural Development Authority (RADA) or the Ministry of Agriculture to provide guarantees to selected lending institutions for providing credit to private entities to supply sprinkler and drip irrigation systems to local farmers who meet the determined criteria.
5. Establish ongoing capacity building programmes including farmer-field schools to include:
    a. Business planning and project financing.
    b. Introduction to new technologies for climate change adaptation.
    c. Accessing and interpreting weather, climate, and soil data/information.
    d. Water management strategies for climate resilience

Project Name: *Stormwater Reclamation and Reuse*
Country of Research/Implementation: Antigua and Barbuda
Document: Antigua and Barbuda Technology Needs Assessment Report III Technology Action Plan For Climate Change Adaptation & Mitigation - Water, Building and Transport Sectors (March 2022)

Background:
Stormwater reclamation involves the collection, accumulation, treatment and storage of precipitation for reuse. Runoff is typically collected from storm drains, waterways and roadways instead of rooftops. A series of micro-catchments can be used to divert or slow runoff so that it can be stored before entering receiving waters. Across Antigua and Barbuda, extreme rainfall and seasonal weather events cause local watersheds to be inundated with flash flood waters that quickly drain into the marine environment. Hence, harvesting this water for non-potable uses, such as groundwater recharge, agricultural irrigation or to replenish natural wetlands, could provide social, environmental and

economic benefits. This would in turn combat flooding and soil erosion and lessen nutrient loss via rapid discharge into marine waters.

Strategy:

The measures prioritised above were refined into the following concrete actions:

1. Partner with local heavy equipment and earthworks companies to offset public sector purchase of equipment.
2. Train and certify local heavy equipment operators through collaboration with tertiary institutions and equipment suppliers to avoid outsourcing specialised jobs.
3. Develop comprehensive sustainable procurement plan for equipment and materials. The timeline for completion of the three actions is forty-eight (48) months, with a budget of approximately 500,000 USD to create the enabling environment necessary for the successful construction of micro-catchments in the Christian Valley watershed.

Project Name: *Wastewater Technology*

Country of Research/Implementation: Grenada

Document: Technology Action Plan Adaptation Grenada (September 2018)

Background:

The reuse of the wastewater would result in savings on water utility bills and reduction in the use of potable water for landscape irrigation. Treated wastewater would reduce pressure on the freshwater resources and lead to an improvement in the coastal ecosystems since most of the hotels are located on the coast.

Strategy:

Actions

1. Establishment of incentive scheme comprises percentage loan and percentage grant upgrade of hotel wastewater treatment plants to disinfection level for reuse as landscape irrigation water
2. Capacity building in wastewater treatment and reuse monitoring, and enforcement and operation of wastewater treatment plants
    a. Collaborate with the University of Technology Jamaica Wastewater Management programme and regional institutions
3. Construction of chlorination contact tanks/UV treatment system to treat wastewater in hotels to disinfection standard to be reused for landscape irrigation

Hotels with existing with Sequencing Batch Reactor wastewater technology would be upgraded to disinfection. It is also intended to strengthen the legislative framework and develop a policy and an institutional framework for the treatment and reuse of wastewater. It is also intended to build capacity in surveillance, enforcement and manpower. The chlorine contact tank can be used to disinfect the wastewater produced by the SBR and it could be reused for landscape irrigation.

Project Name: *Water Saving Devices*

Country of Research/Implementation: Antigua and Barbuda

Document: Antigua and Barbuda Technology Needs Assessment Report III Technology Action Plan For Climate Change Adaptation & Mitigation - Water, Building and Transport Sectors (March 2022)

Background:

Water efficient appliances, fixtures and devices, are used to augment in-home conservation efforts. These water savers have a variety of commercial and residential applications within buildings.

Strategy:

Focus will be on formal business in the health, education, retail and tourism sectors, that routinely purchase trucked water to maintain their operations.

Actions

1. Develop and implement a water efficiency labelling system that rates devices based on volumes of water saved
2. Design an educational Water Usage Chart that shows indicative uses of water around the property and complementary water conservation tips

8.2.3. Land Use, Land Degradation and Coastal Management

Project Name: *Heat And Drought Resistant Varieties Of Open-Pollinating Corn And Beans Seeds*

Country of Research/Implementation: Belize

Document: Government of Belize Technology Action Plan for Climate Change Adaptation and Mitigation (December 2018)

Strategy:

The technology diffusion should encompass not only the new varieties of open pollinated corn and bean seeds, but also the complete process from land preparation, planting, harvesting, storage of grains, marketing and replanting. Seed production groups will ensure the viability of the seed stock. Quality seeds for planting and commercial grain will be available for famers at a reasonable price.

Five key actions were prioritised for the diffusion of climate resilient varieties of grain seeds. These are:

ii) Procure finance to strengthen a certified grain seed production system among farmers' groups and the MOA Seed Production Unit;

iii) Organise and run training programme for seed producers;

iv) Establish public-private partnership for technical service provision;

v) Strengthen research, development and demonstration of grain seed production technology; and

vi) Support the Agriculture infrastructure and management.

Project Name: *Crop Protective Covered Structure Cooling Systems*

Country of Research/Implementation: Belize

Document: Government of Belize Technology Action Plan for Climate Change Adaptation and Mitigation (December 2018)

Background:

A tropical greenhouse aims to create an ideal condition in which plants can be protected against heavy rainfalls, direct solar radiation, disease, insects and birds. The high relative humidity and ambient temperature microclimate in a tropical greenhouse creates a complicated dynamic system that is strongly influenced by changes in external conditions, making greenhouses a challenging environmental to control. The fundamental problem with tropical greenhouses or Protective Cropping or Covered Structures (PCSs) is the high, uncomfortable internal temperatures that develop during hot, sunny days in the tropics, limiting the number of working hours inside these structures.

Strategy:

Improved PCS designs may incorporate the following cooling technologies:

- Natural Passive Ventilation (air exchange) and shading systems (cheaper common design);
- Mechanical Active Ventilation powered with a small diesel generator;
- Mechanical Active Ventilation powered with solar energy;
- Evaporative Cooling:
    - Evaporative cooling fan-pads, and
    - High pressure fogging.
    - Earth-to-air heat exchange system.

Actions:

1. Procure finance for refurbishment of PCS cooling systems powered with RE technology
2. Help facilitate & secure local funds for producers to acquire technology
3. Increase services offerings of certified technicians – Public/Private partnership
4. Create awareness of technology and identify financial support mechanisms
5. Strengthen research and development of new PCS technology

Project Name: Concentrated Solar Power (CSP) For Small and Medium Sized Farms

Country of Research/Implementation: Jamaica

Document: Jamaica Technology Action Plan (October 2021)

Background:

To reduce GHG emissions from the multi-dimensional agricultural sector through implementation of Concentrated Solar Power where there is demand for electricity. CSP systems up to 5 MW may be applicable for large commercial farms with large power demands for water pumping, electrical equipment (e.g., cold storage), conveyors, external security lighting and offices, etc.

Benefits

• Production of clean electricity on farm site

• Reduction of electricity costs and GHG emissions avoidance

• CSP energy can be stored before or while powering a steam generator

• Can be used either as a flexible provider of electricity, as a "peaker" plant, or as a base load source of electricity similar to a traditional power plant, however, without the GHG emissions

Strategy:

Activities to be implemented

- Identify suitable Agro-Parks for the installation of CSP technology.
- Consultations with stakeholders about CSP technology, supply, and distribution.
- Application for the requisite grid license.
- Source green financing for the CSP technology
- Procurement process for the CSP technology to be provided to the Agro Parks.
- Stakeholder consultation with stakeholders on the importation of CSP technology and associated accessories.
- Promotion/Consultation with private farmers on the benefits of CSP Technology.
- Sensitization and provide support to private farmers on the process to apply for net billing
- Plan and execute stakeholder consultation.

8.2.4. Chemical and Waste Management

Project Name: *Aerobic Biological Treatment (Composting)*

Country of Research/Implementation: Jamaica

Document: Jamaica Technology Action Plan (October 2021)

Background:

Waste composting can result in economic, social, and environmental benefits. It can reduce the overall need for waste collection in rural areas, which therefore has an impact on economics, and this is generally expensive. The sorting and reuse of biodegradable waste will mean that waste management authorities can focus more efforts and resources on the management of nonbiodegradable waste, therefore contributing to an overall cleaner environment. Waste composting can allow for an effective system for handling agricultural waste while contributing to the reduction of greenhouse gases from decomposition of the organic matter.

Benefits

- Varied economic, social, and environmental benefits.
- Can reduce the overall need for waste collection in rural areas which therefore has an impact on economics, and this is generally expensive.
- Sorting and reuse of bio-degradable waste will mean that waste management authorities can focus more efforts and resources on the management of non-biodegradable waste, therefore contributing to an overall cleaner environment.
- Results in the emissions of carbon dioxide instead of methane. Carbon dioxide is thirty times less potent as a greenhouse gas than methane. Therefore, composting contributes overall to climate change mitigation.
- Reduction in the use of chemical fertilizers which contribute to GHG emissions.

Strategy:

1. Ministry of Agriculture and Fisheries, and Ministry of Industry, Investment and Commerce and their respective agencies should develop a strategy/policy and capacity building for compositing focused sustainable land management and waste management for the agriculture sector. The policy/strategy should focus on reduced use of chemical fertilization, reduce importation of inorganic fertilizers and to increase soil health.
2. Bureau of Standards should establish standards for composted materials to enable incremental pricing for products of the technology and for access to export markets.
3. Establish commercial (largescale) composting demonstration site at an Agro Park. This can also be done through public-private partnership (PPP).
4. Utilise stakeholder consultations and capacity development to train farmers/composters and promote aerobic biological treatment for the agriculture sector.
5. Secure green financing for loans and grants to reduce initial capital costs. Utilise special low interest rates from the Development Bank of Jamaica to finance project.

8.2.5. Meteorlogy & Disaster Preparedness & Management

Project Name: *Coastal and Marine Environmental Monitoring Network and Early Warning System*

Country of Research/Implementation: Belize

Document: Government of Belize Technology Action Plan for Climate Change Adaptation and Mitigation (December 2018)

Background:

The technology for the Coastal and Marine Ecosystem sector through the TNA process aims at increasing the capacity of the Fisheries Department to monitor, assess and report on the physical and anthropogenic-related changes and impacts in the coastal and marine ecosystem, thus contributing to improved management and sustainable use of coastal and marine resources. The proposed technology transfer of an upgraded Coastal Zone monitoring network and Early Warning system is an essential component to this end.

The technology transfer will consist of the following:

1. Eight automatic environmental/marine observation platforms with sensors to record: depth, sea water temperature, pH/ORP (Oxidation/Reduction Potential), salinity, conductivity, turbidity, dissolved oxygen and chlorophyll. Additional above water sensors will be installed to record air temperature, surface wind speed and direction, rainfall, relative humidity, and solar radiation.
2. Eight loggers with transmission facility via smart phone technology.
3. Eight Photo Voltaic solar power equipment to generate, store and energise the observation platforms.
4. Quarterly water quality sampling at four strategic sites for laboratory analysis of nitrates/nitrogen, phosphates, Faecal Coliform, E-coli, etc. during the proposed five years of the project cycle.
5. Develop protocol to retrieve, quality check, archive, and process/analyse data and information for Early Warning Bulletins for stakeholders (including policymakers).
6. Maintain updated and accessible environmental and marine database to inform research, policy recommendation, management strategy and the annual State of the Belize Coastal Zone reports.
7. Establish a protocol for a timely and reliable Marine Early Warning System. This will require additional institutional strengthening of the Fisheries Department for processing and analysing data, and processing and disseminating Marine Early Warning bulletins.

Strategy:

Actions:

1. Procure non-reimbursable finance for Marine monitoring system
2. Upgrade institutional capacity and effectiveness of key agencies
3. Establish an operational and effective marine monitoring network and early warning system and delivery protocol
4. Improve collaboration and networking with other relevant institutions in marine research and development
5. Establish an improved Marine database and early warning in the Fisheries Department

Project Name: *Coral Reef Early Warning System (CREWS)*
Countries of Research/Implementation: Barbados, Belize, Dominican Republic, Jamaica, and Trinidad and Tobago
Institution: Caribbean Community Climate Change Centre

Background:
With the realities of climate change in the form of increasing ocean acidification and thermal stress taking its toll on coral reefs resulting in coral bleaching, it has become critical to monitor the various parameters that impact coral reefs in the Caribbean. Coral Reef Early Warning Systems (CREWS) improve climate-risk planning, management and action necessary to address the impacts of Climate Change, especially coral bleaching. Coral Reef Early Warning System stations consist of meteorological and air-based sensors that measure air temperature, wind speed and direction, barometric pressure, photosynthetically available radiation (PAR) and ultraviolet radiation (UVR) and oceanographic sensors that measure salinity, sea temperature, PAR (at 1m nominal) and UVR (at 1m nominal). The system is capable of expanding to include the use of additional sensors as per research needs and funding. In addition to these sensors, a data acquisition system gathers and averages the data, then transmits the hourly averages via a GOES satellite to NOAA's National Environmental Satellite, Data and Information Service (NESDIS) data download facility where the data are then acquired in turn via automated procedures for saving and processing at NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML).

Strategy:
The Caribbean Community Climate Change Centre, through collaboration with the US National Oceanic and Atmospheric Administration (NOAA), is working to establish an integrated regional network of climate and biological monitoring stations to strengthen the region's early warning mechanism.

Project Name: *Agrometeorological System for Forecasting and Early Warning*
Country of Research/Implementation: Guyana
Document: Government of the Cooperative Republic of Guyana Technology Action Plan for Adaptation (January 2018)

Background:
Agrometeorological forecasting and early warning systems (EWS) are a mature technology worldwide, countries having developed advanced remote-sensing and forecasting technologies. In France, for example, an EWS is used alongside plant protection and extension services to deliver information to farmers. In India, the Indian Meteorological Department (IMD) has developed integrated systems utilizing satellite

technology to produce crop-specific weather-based agronomic advisories, and operational agrometeorological schemes are being implemented country-wide. According to the IMD, agromet services are available in 550 districts. Farmers receive advisories before various stages of farming, and about 2.5 million farmers are using this information through mobiles (Guyana's TAP and references therein).

The application of such systems can range from advanced, modern systems that include numerical models and data analysis to less complex systems using basic climate data. The application depends largely on needs and resources, including human skills. Presently, the Caribbean Climate Outlook Program provides seasonal forecasting using a regional model. Also, the Caribbean Institute for Meteorology and Hydrology (CIMH) provides training and studies in forecasting and modelling for the region.

The modernization of agrometeorology has introduced new tools, which include data acquisition techniques (ground observation, aircraft and satellite), data transmission techniques (including the Internet) and data analysis (models and other software). There are many sources of data and techniques of analysis, including crop models and Geographic Information Systems (GIS). In addition, the transmission of crop and weather data from rural areas to national agromet services is now easier than in the past due to telecommunications and improved transport systems. Nevertheless, modern agromet systems are costly and require constant maintenance.

This technology will be of tremendous benefit to all stakeholders and the country, since it will provide advance information on weather conditions and projections. When early warnings are properly provided to farmers and local communities, they are enabled to manage their farms and water resources in a manner whereby they can adapt to climate change and reduce their vulnerability.

Strategy:

An agromet system should build on the capacity that already exists in respect of historical data, automatic weather stations (AWS) and EWS. Generally, capital costs will include preparation of sites, AWS and computers, mapping and modelling software, licensed fees and staff training in applied meteorology and the forecasting of outputs.

The target for this technology is to provide agromet services, such as weather information and planting advisories. Improved weather and climate early-warning systems have become necessary to assist farmers in the context of climate change. This system will be integrated with the national EWS to provide early warning advisories to the farming community. The effective use of weather and climate information can help to make better informed policy, institutional and community decisions that reduce related risks and enhance opportunities, improve the efficient use of limited resources, and increase crop, livestock and fisheries production. The proposed scope of this technology is to introduce on a large and/or national scale. It will include the development of an agromet system and the communication infrastructure (phone/radio/TV/print) to deliver agromet services to farming communities across the country. The largescale application of this technology will strengthen the quality of extension services and support research in the agriculture sector.

Actions:
1. Identify and secure support for ongoing training and research
2. Promote research with local academic institutions
3. Strengthen inter-agency collaboration
4. Promote local and regional collaboration and data-sharing among government agencies, NGOs and the private sector

8.2.6. Energy, Transport and Technology

Project Name: *Biogas (Anaerobic Biodigestion)*
Countries of Research/Implementation: Grenada and Jamaica
Document: Grenada TNA-Mitigation Technology Action Plan (TAP) Report (June 2018), Jamaica Technology Action Plan (October 2021)

Background:
Biogas technology is a renewable energy source which utilises raw waste materials such as agricultural waste, manure, municipal waste, plant material, sewage, green waste and food waste to produce Biogas by anaerobic digestion. It circumvents the emission of methane, as the fuel can be combusted for heat or electricity. Biogas is produced in an anaerobic digester, biodigester or a bioreactor.

Economic benefits
Several economic development benefits arise from the energy production of the technology:
- National energy self-sufficiency is increased due to the local energy production
- Reduction in the nation's dependency on other countries for fossil fuel imports
- Improved economic balance sheet of the country and a higher level of energy security
- Biogas systems have the potential to reduce on the overall operational cost associated with energy consumed on farms

Waste management and health benefits
Large amounts of animal waste can create serious environmental concerns. When animal manure enters rivers, streams or groundwater supplies it can have environmentally

detrimental effects. In addition, decomposing manure causes air quality concerns associated with ammonia emissions, and the contribution of methane emissions to global climate change. The implementation of an anaerobic digestion offers a number of air and water quality benefits:

- Digester systems isolate and destroy disease causing organisms that might otherwise enter surface waters and pose a risk to animal and human health
- Anaerobic digesters help protect ground water. Synthetic liners provide a high level of groundwater protection for manure management systems (see Jamaica's TAP and references therein)
- The concrete or steel in plug flow and complete mix digesters also effectively prevent untreated manure from reaching the ground water
- Biological treatment of waste, such as composting and anaerobic digestion reduces volume of waste and therefore the lowers landfill requirements
- Recycling of the residual solids as fertilizer further reduces waste volume

Climate change mitigation benefits

- The prevention of methane emissions associated with conventional manure management practices
- The energy produced by biogas facilities offsets energy derived from fossil fuels
- Anaerobic digesters with a biogas recovery system can help reduce overall quantities of CO^2

Strategy:

Grenada

The ambition for the biogas TAP is to introduce small scale biogas systems on farms with the intention of reducing GHG emissions by about 1.5kT of CO^2 equivalent. It is also envisioned that biogas systems will assist farms to reduce their operational costs for energy by about 20%. It is estimate that approximately US$92, 000.00 may be required for this TAP.

Actions:

- Create a soft loan facility to expand access to capital
- Conduct a productivity survey
- Gather, publish and disseminate information

Jamaica

Actions:

- Incorporation of the technology into the Government Procurement Plans to achieve climate change and renewable energy goals
- Application for permit/licenses to generate electricity and provide irrigation water

- Application of Environmental Accounting and traditional accounting methodologies to compare BAU fossil fuel energy sources, versus exploitation of this renewable energy source
- Empower national agencies as the leads for government PPP representatives to facilitate the technology development
- Develop short-term incentives enable importation of equipment as with renewable energy source with similar incentives; and for power generation (if power is exported)
- Access development grants and green financing for PPP initiative

Project Name: *Action Plan for Off-grid Solar PV System*
Country of Research/Implementation: Belize
Document: Government of Belize Technology Action Plan For Climate Change Adaptation And Mitigation Final Report (December 2018)

Background:
An off-grid solar Photovoltaics system receives no assistance from the electrical grid and solely relies on PV technology to produce reliable and cost-effective power. Photovoltaics technologies generate electricity from sunlight using solar cells. The main components of an off-grid solar PV system are: the photovoltaic array, charge controller, battery bank, and inverter. In order to optimise the solar energy production throughout the year solar panels which form the array are placed on tilted or adjustable mounts to account for different seasons. These systems tend to be more economic than establishing transmission lines in isolated areas or areas with low population densities.

Strategy:
The ambition is to implement the installation of off-grid solar PV systems for communities that are in remote areas, without access to the national grid. The scope could be extended to hospitals and ecohotels with similar characteristics. It is the hope that these communities move away from the use of kerosene lamps that pose a hazard to human health and property or the use of diesel generators, improving living conditions, and providing opportunities for educational growth.

The main barrier linked to this technology was the unavoidable high cost of components, thus, tax incentives could be created to mitigate this barrier. In addition, it will also require that technicians, especially in rural areas, be trained to provide servicing of PV systems.

Actions:
1. Reduce or adjust taxes to create incentives;
2. Create awareness of technology and financial support;
3. Increase service offerings of certified technicians.

Project Name: *Co-Generation Plant And Solar Panels: Mona Campus, Jamaica*
Country of Research/Implementation: Jamaica
Document: UWI Climate Action Portal

Background:
A significant project of the Mona campus is the Mona campus' co-generation plant. Co-generation is a more thermo-dynamically efficient use of fuel that generates electricity and makes use of the thermal energy produced in fuel combustion, for heating and cooling purposes. This has resulted in major cost savings for the Campus.

Strategy:
Solar panels have been installed on the Faculty of Medical Sciences' building and on student accommodation halls. A rooftop garden has also been created on the building and water is sourced from underground wells. The Solid-State Electronics Research Laboratory in the campus' Department of Physics has focused on the utilisation of alternate energy sources through photovoltaic cells.

Project Name: *Electric Vehicles And Solar Charging Stations*
Country of Research/Implementation: Antigua and Barbuda
Document: Antigua and Barbuda Technology Needs Assessment Report III Technology Action Plan For Climate Change Adaptation & Mitigation - Water, Building And Transport Sectors – (March 2022)

Background:
The TAPs for Electric Vehicles (EVs) and Solar Charging Stations are presented together due to the mutually inclusive relationship that exists between the technologies. Solar charging stations are needed to experience the zero-emission feature/characteristics of electric vehicles; therefore, it is a measure to overcome one of the barriers to the widespread diffusion of EVs. Electric vehicles were included in the TNA as a mitigation technology due to their potential to reduce GHG emissions in the transportation sector and reduce the country's dependence on oil importation.

Strategy:
The ambitions are:

- increase the capacity of the country to maintain and operate the electric vehicle by upgrading the educational institutions to deliver the necessary courses and
- embark on various public awareness campaigns to accelerate the uptake of the technology
- "train, the trainer" programs for electric vehicles and solar systems to transform the workforce and social development in the country. Therefore, the re-training of at least 10 existing mechanics and teachers to repair and service EVs.

- finally, increasing the number of public solar charging stations to meet the EV demand. A pilot study of 50kW of solar panels to serve 10 level-2 chargers for 20EVs of the government fleet. This project could reduce GHG emissions by 56.15 tCO^2e using an electricity conversion factor of 0.6154 tCO^2e/MWh.
- retrain a minimum of 10 existing mechanics and teachers to repair and service EVs; and
- develop an installation and maintenance training program for EVs and renewable energy technologies

Actions:

- Develop a demonstration project for solar charging EVs using the Government's Fleet
- Develop a training module for EVs and solar systems
- EVs test driving campaign
- Amend External Trades Act to regulate the importation of ICE vehicles

Other Projects

Other technologies that may be of interest to The Bahamas include: *Acquisition of a super-computer (SPARKS) for use by Climate Studies Group Mona to do downscaling* and *Data storage, back-up and fail-over systems installed in Belize, Trinidad and Barbados for the housing of all of the Caribbean Climate Data*.

8.2.7. Human Resources and Capacity

Although there is no specific technology mentioned for data sharing or inter-agency collaboration, the projects that are currently being implemented has these essential components intergraded into the technology. Guyana, in its TAP report for adaptation, has factored in inter-agency collaboration and plans to establish a task force to strengthen inter-agency collaboration in order to ensure the success of its agrometeorological technology. As it pertains to data sharing, Guyana intends to develop mandatory requirements for data sharing and management and establish a framework for data sharing as the county resolves to create efficient data information sharing among institutions.

8.2.8. Summary of research programs beneficial to The Bahamas

Table 119: Summary of research programs beneficial to The Bahamas

Sector	Project Name	Climate Change Mitigation/Adaptation	Country of Implementation
Forestry And Biodiversity	Seagrass Restoration	Adaptation	Jamaica
Water Resource Management	Atmospheric Water Generators	Adaptation	Antigua And Barbuda

	Rainwater Harvesting for Irrigation	Adaptation	Antigua and Barbuda, Jamaica
	Freshwater Harvesting: Empoldering of Water Collection Areas	Adaptation	Guyana
	Community-Scale Rainwater Harvesting System	Adaptation	Jamaica
	Minor Water Tank Networks For Communities	Adaptation	Jamaica
	Improved Drip Irrigation/Fertigation Systems	Adaptation	Belize
	Drip and Sub-canopy/Micro Sprinkler Irrigation with Rainwater Harvesting Infrastructure	Adaptation	Jamaica
	Stormwater Reclamation And Reuse	Adaptation	Antigua and Barbuda
	Wastewater Technology	Adaptation/Mitigation	Grenada
	Water Saving Devices	Adaptation	Antigua and Barbuda
Land Use, Land Degradation and Coastal Management	Heat And Drought Resistant Varieties Of Open-Pollinating Corn And Beans Seeds	Adaptation	Belize
	Crop Protective Covered Structure Cooling Systems	Adaptation	Belize
	Concentrated Solar Power (CSP) For Small And Medium Sized Farms	Mitigation	Jamaica
Chemical and Waste Management	Aerobic Biological Treatment (Composting)	Mitigation	Jamaica
Meteorology & Disaster Preparedness & Management	Coastal and Marine Environmental Monitoring Network and Early Warning System	Adaptation	Belize
	Coral Reef Early Warning System (CREWS)	Adaptation	Barbados, Belize, Dominican Republic, Jamaica, and Trinidad and Tobago

	Agrometeorological System for Forecasting and Early Warning	Adaptation	Guyana
Energy, Transport, and Technology	Biogas (Anaerobic Biodigestion)	Mitigation	Grenada, Jamaica
	Action Plan for Off-grid Solar PV System	Mitigation	Belize
	Co-Generation Plant And Solar Panels: Mona Campus, Jamaica	Mitigation	Jamaica
	Electric Vehicles And Solar Charging Stations	Mitigation	Antigua And Barbuda
	Acquisition of a super-computer (SPARKS) for use by Climate Studies Group Mona to do downscaling	Adaptation	Jamaica
	Data storage, back-up and fail-over systems	Adaptation	Belize, Trinidad and Barbados
Human Resources and Capacity	Data Sharing procedures in ArgoMet technology	Adaptation	Guyana

Chapter 9 – Education, Training and Public Awareness

The Amended New Delhi work programme on Article 6 of the UNFCCC is focused on six elements – education, training, public awareness, public access to information, public participation and international cooperation. This chapter is focused on national activities related to these six elements.

9.1. Education

Education on climate change occurs at the various levels of education within The Bahamas. A summary of key aspects of curriculum and educational opportunities are described in the subsections below.

9.1.1. Primary Education

As early as second grade, students are introduced to the impacts of weather on people. The Earth Science curriculum for second grade speaks to weather in The Bahamas, instruments used to measure weather conditions, ways weather can affect people and safety precautions that can be taken before and during bad weather conditions. The curriculum is expanded in fourth grade to address weather inclusive of meteorology as a science along with being able to distinguish between weather and climate.

In sixth grade, students learn about the use of fossil fuels and their impacts as well as about storms. Activities specifically focused on climate change have been held at the primary school level, such as a climate change workshop held at Columbus Primary School for fourth and fifth grade students; the students learned about global warming, climate change, and its impact on the environment. The workshop was a collaborative effort between the Science Specialist at the Sadie Curtis and Columbus Primary Schools and Innovative Science, a private sector organization that provides interactive science experiments for primary school children.

9.1.2. Secondary Education

The carbon cycle is introduced in the eighth grade when students learn about the importance of forests as carbon sinks and other aspects of the cycle, including the relationship between carbon emissions and global warming. As a part of the eighth-grade curriculum, students have to design and conduct an investigation to show the extent to which people are utilizing one safe practice to reduce carbon dioxide level in the atmosphere. Activities such as this give students the opportunity to explore the practical application of the science they have learned.

Global climate change is a focus of the Environmental Biology curriculum in eleventh grade. Students are engaged on topics specifically related to how climate change will affect The Bahamas, including predicting the decade in which the country will notice the change in climatic factors using scientific models and analysing the efforts of the government to reduce carbon emissions in the country. The students are exposed to what global climate change impacts mean for small islands, like The Bahamas.

9.1.3. Tertiary Education

The largest tertiary educational institution in The Bahamas is the University of The Bahamas (UB). Courses offered at UB which enable students to learn about climate change and research the issue include:

- Geography Bachelor's programme – Climate Change and Society; Introduction to Bahamian Geography; Climatology and Biogeography; Physical Geography
- Architecture Bachelor's programme – Climate change and the built environment inclusive of research on sustainable community development.
- Law programme – International Environmental Law

The Climate Change and Society course involves students conducting analyses of climate change impacts, organizations and policies at international, regional and local scales.

The Bahamas Agriculture & Marine Science Institute (BAMSI) offers an Associate degree in Environmental Science with climate change and global warming as topics covered during the programme.

9.1.4. Informal Education

Informal education is done primarily by Government agencies that have climate change as a part of their mandate and by non-Governmental organizations (NGOs). The websites of these agencies as well as their social media pages are the main vehicles for sharing educational resources. The agencies also use media campaigns, workshops and public meetings as means to educate citizens about climate change and the UNFCCC. Examples of informal education initiatives include:

- Climate Change and Environmental Advisory Unit (C^2EAU) regularly posts information related to climate finance, carbon credits & youth engagement as well its partnerships with local, regional and global entities on the above-mentioned topics.
- Department of Environmental Planning and Protection (DEPP) has texts of the international agreements on climate change on its website, including the UNFCCC and the Paris Agreement. It also has key policy documents available include the

Bahamas National Climate Change Adaptation Policy as well as the National Communications and other key climate reports that have been submitted to the UNFCCC Secretariat.

- The Bahamas Department of Meteorology has weather and climate forecasts and other resources publicly available on its website. The Department's Facebook page also includes videos about tropical storms, hurricanes and natural hazards. In cooperation with Bahamas Information Services, the Department of Meteorology has produced a series of short videos under the theme Met Talk to educate to the public about various issues related to weather and climate change.
- Bahamas Reef Environment Educational Foundation (BREEF), an NGO, has online marine education tools available on its website, including *Consumers, Corals & Climate Change* and the climate change comic book – *Who Tief Muh Conch?* BREEF also hosts an annual teacher training programme each summer on marine conservation and related issues inclusive of climate change.

9.2. Training

Outside of formal education, a number of training activities have been organized or facilitated by Government agencies. Some of these are described below:

- Low Emissions Analysis Platform (LEAP) – The Bahamas participated in training on LEAP to aid in preparation of its first Intended Nationally Determined Contribution (INDC) and Mitigation Assessment for the TNC/BUR1 reports.
- GHG Management Institute/Caribbean Cooperative MRV Hub – Bahamians were trained in development of greenhouse has inventories using the 2006 IPCC Guidelines. In addition to being trained in cross-cutting issues related to compiling an inventory, they also received training on developing inventories for specific sectors, such as agriculture and energy.
- Throughout the TNC-BUR process, various training workshops were held on integrating climate change into policy and research and systematic observations (RSO).
- In preparation for COP-27, C^{2}EAU and Young Marine Explorers (YME) have developed a Climate Crusaders training programme over 19 weeks to educate Bahamian and Caribbean high school and college students about climate change issues and international negotiations on climate change. The training has been supported by Bahamian and regional experts as well as the non-profit, Smart and Strong Sisterhood (SASS).

9.3. Public Awareness

In assessing various organizations involved in climate change, the consensus was that public awareness about climate change is very limited. Even within organizations that are involved in climate change issues, the awareness about climate change rarely extends beyond staff members who have a science background. Bahamians are very aware of hurricanes, what causes them and how to prepare for hurricane impacts. The link between hurricanes and climate change is not well understood. Organizations, both Governmental and NGO, have been challenged to engage the public on the science of climate change and the linkages with various issues including energy use and land use.

9.4. Public access to information and participation

While there is information about climate change policy and initiatives available publicly, public access to information can be challenging in The Bahamas. While the Freedom of Information Act passed into law in 2017, the Government has yet to make the Act operational to enable the public to request information from Government agencies and have those requests responded to. The Government indicated in 2021 that a consultant has been hired to develop an operational strategy to initiate a Freedom of Information pilot programme, but the programme has not yet been launched.

There are certain aspects of governance where the public can request information and participate in decision making. These include during the Environmental Impact Assessment (EIA) review process and the Physical Planning permitting process for land use. Both processes have a legally required public consultation period when documents related to development must be shared with the public and the public may make queries and recommendations. Concerns about climate change have been raised during these processes when citizens are concerned that a particular development may exacerbate the impacts of climate change, such as flooding.

9.5. International cooperation

The Bahamas has cooperated with several regional and global organizations to improve education, training and public awareness on climate change. These organizations include the Caribbean Community Climate Change Centre, GHG Management Institute, Green Climate Fund, United Nations Educational, Scientific and Cultural Organization (UNESCO), and the UNFCCC Secretariat.

9.6. Advancing ETPA in The Bahamas

There are a number of priority gaps and needs to be addressed within education, training and public awareness (ETPA) in The Bahamas. Addressing these priorities would aid in advancing ETPA in the country. Table 120 includes recommendations for the advancing ETPA in the key areas identified in this chapter.

Table 120: Advancing ETPA in The Bahamas

Key Area	**Recommendations**
General	• Develop a national strategy on ETPA supported by completion of an assessment of climate change awareness across the key areas; the strategy will include best tools for reaching each sector as well as the financing needed for its implementation. • Reactivate the Public Education and Outreach (PEO) Subcommittee to focus on coordinating national activities related to the Amended New Delhi Work Programme under Article 6.
Primary Education	• Integrate climate change into all grade levels using different subjects, e.g. reading, math, general science, social studies. • Utilize UN CC:Learn *Resource Guide for Advanced Learning on Integrating Climate Change in Education at Primary and Secondary Level*.
Secondary Education	• Integrate climate change into all grade levels using different subjects, e.g. literature, math, biology, physics, history, geography. • Utilize UN CC:Learn *Resource Guide for Advanced Learning on Integrating Climate Change in Education at Primary and Secondary Level*. • Collaborate with BREEF to develop a summer teacher training workshop specifically on climate change and its impacts for The Bahamas.
Tertiary Education	• Integrate climate change and associated issues into subjects beyond environmental science and geography. For example, gender and climate change can be integrated in social science courses while effectively communicating climate change can be integrated into journalism courses. • Enable student exchange or study abroad programs to expose students to courses or degree programs in climate change (e.g. meteorology, climate modelling, international environmental law).
Informal Education	• Ensure the public is aware of informal educational sources, such as websites and social media pages. • Develop more short PSAs or information graphics that can be shared through social media (e.g. WhatsApp, Facebook and Instagram). • Activate UB's Climate Change Adaptation and Resilience Research Centre (CCARRC) initiatives on public awareness.
Training	• Provide training in priority areas identified by stakeholders during the TNC-BUR process: 1. Climate process and climate system studies 2. Climate modelling 3. Climate prediction 4. Climate research

Key Area	Recommendations
	5. Climate financing 6. Any training that can improve the agricultural sector's response to climate change • Develop a centralized portal where Government and non-Government organizations can share training resources and opportunities as well as information about climate change issues (including research and international negotiations).
Public Awareness	• Provide targeted training opportunities to those who can increase public awareness, such as teachers, journalists, NGOs, Local Government councils, and decision makers. • Engage the public on a more consistent basis through opportunities for them to ask questions about climate change issues; examples of such opportunities may be radio talk shows, virtual forums and public meetings.
Public access to information and participation	• Operationalize the Freedom of Information Act so the public can readily access information on climate change, its impacts and Government initiatives they may wish to engage in. • Provide more opportunities for civil society organizations to contribute to climate change policy development and participate in the international negotiations process.

Chapter 10 – Capacity Building

Capacity building in climate change in The Bahamas needs to occur at three levels (Pierro, 2022):

4. **Individual** – The goals of capacity building at this level are to change attitudes and behaviours as well as providing knowledge and developing skills. Education, training and public awareness (ETPA) outline tools to be used in providing knowledge and developing skills at the individual level. Individual capacity building to change attitudes and behaviours will be discussed in this chapter.
5. **Institutional** – The goals of capacity building at this level are to improve overall institutional performance and functioning capabilities as well as the ability of institutions to adapt.
6. **Systemic** – The goals of capacity building at this level are to ensure there is a policy framework in place within which individuals and institutions can function effectively and interact with those outside their institutions as well as outside the country.

10.1. Individual Capacity Building

Through the TNC-BUR process, stakeholders identified the following capacity needs in being able to effectively work on climate change:

13. Carbon auditing
14. Carbon budgeting
15. Communication on climate change
16. Consultation skills
17. Education or changing behaviour
18. Energy management
19. Embedding climate change into decision making
20. Green economic planning
21. Low-carbon procurement
22. Renewable energy
23. Sustainable planning
24. Sustainable transport planning

Of the twelve capacity need areas identified by stakeholders, four can be addressed through education and training – carbon auditing, carbon budgeting, communication on climate change, and renewable energy. All of the others will require a combination of education, training and a change in attitudes and behaviours. For example, energy management is not simply knowing how to manage energy use within an organization, it is also applying that knowledge to change the habits of day-to-day operations from purchasing decisions to waste management.

Change attitudes and behaviours at the individual level within organizations and communities can be achieve through using tools such as:

1. **Dialogue** – Open and regular dialogue between leaders and staff or community members ensures that everyone is aware of goals related to climate change adaptation or mitigation. Regular check-ins on activities, such as reducing energy use or increasing share of renewable energy in energy production, help to ensure progress is being made. Dialogue helps to hold everyone accountable. Leaders are held accountable in supporting their staff or community members in providing them with the resources needed to implement the required change. Staff or community members are held accountable in implementing agreed activities to achieve common goals related to climate change.
2. **Exchange programmes** – Exchange programmes provide an opportunity to individuals to work or live in a different environment and to see how others have successfully achieved the changes in attitudes or behaviours that their organization or community is trying to achieve. Such programmes can provide a different perspective and hands-on experience related to the climate change goal the individual wants to achieve. Exchange programmes can be with a different organization, a different community or even a different country.
3. **Incentives** - Incentives can provide positive reinforcement to change attitudes and behaviours. Examples of incentives commonly used include salary bonuses, tax incentives, and time off. Incentives can also be negative, such as fines. An example of a positive incentive that can change attitudes or behaviours with respect to climate change adaptation can be a tax break for first-time homeowners that build in low-risk zones or utilize nature-based solutions in the home design. Conversely, a negative incentive would be to penalize homeowners who build in high-risk, coastal areas with higher taxes.
4. **Regulations** – Regulations are a way to change attitudes and behaviours quite effectively. The Bahamas has had success with using regulations in its recent plastic ban where particular plastic products were phased out and eventually banned from use nationwide. An example of regulations that could be used to improve climate resilience in The Bahamas would be establishment of flood zones and regulation of building activities that would be allowed in various zones.

10.2. Institutional Capacity Building

For organizations to function effectively, capacity needs to be built at the institutional level as well as the individual level. Institutional capacity building can be achieved through activities, such as development of institutional policies on climate change and procedural guidelines on climate change adaptation. The Ministry of Agriculture and Marine Resources developed its *Climate Change Policy and Adaptation Strategy for the*

Agriculture and Marine Resources Sectors in 2019. This document is a means to increase the capacity of the Ministry to address climate change and adaptation to it, but it also needs to be strengthened through the development of annual workplans as a means to set incremental goals that the Ministry is working towards. Institutional policies can provide a roadmap that staff can reference and be guided by as they work towards common goals.

The Bahamas Building Code would be an example of procedural guidelines that can aid the construction industry in how to design and build to adapt to climate change. The Code can include guidance on foundation heights, building materials, and nature-based solutions as a means to improve climate resilience in homes and other building types as well as in infrastructure.

10.3. Systemic Capacity Building

Systemic capacity building requires moving beyond institutions to look at national efforts that both individuals and institutions contribute to address climate change. Activities that would facilitate systemic capacity building in The Bahamas include:

- Developing an updated national policy on climate change adaptation;
- Approving and implementing the Integrated Coastal Zone Management (ICZM) Policy Framework;
- Training national negotiators and diplomats in such policies so that they can advocate at the regional and international level to achieve policy objectives; and
- Ensuring agencies are incorporating these national policies into their internal policies and staff are trained in national and internal policies and how to apply them.

As a part of systemic capacity building, it is also important to regularly conduct legislative and policy reviews to amend any legislation or policy that may, through their application, result in reducing climate resilience. For example, a policy that allows for excavation that reduces elevations increases the risk of inundation during storm surge events. The review should also identify amendments that can result in laws, regulations, policies and any associated standards or guidelines improving climate resilience.

Systemic capacity building can enable a country to adopt new models of development as it seeks to adapt to climate change. A single dwelling home with a fenced in lawn may no longer be a sustainable model for The Bahamas as risk of sea level rise increases and more land becomes unsuitable for development. Multi-family housing, such as apartment buildings or row houses, may be a better model. Changing the housing model promoted by the Department of Housing may require policy as well as legislative changes.

Integrating climate change into national development decision-making is vital for systemic capacity building. The Environmental and Social Governance Policy and Framework being undertaken by the Climate Change and Environmental Advisory Unit (C^2EAU) in the Office of the Prime Minister may be a mechanism to achieve climate change integration in development by making climate resilience a requirement for projects in The Bahamas, including those initiated by the Government of The Bahamas.

Chapter 11 – Information Sharing and Networking

As a Small Island Developing State with associated capacity constraints, The Bahamas must engage regionally and internationally to enable information sharing and networking to complement its national efforts to address climate change. Information sharing and networking also enables the country to share its experiences and solutions with respect to climate change impacts.

Nationally, information sharing and networking are mainly done through the National Climate Change Committee (NCCC). This interagency committee, consisting of public, NGO and private sector representatives, meets regularly to engage on climate change issues. The NCCC is leading the development of the Third National Communication (TNC) and Biennial Update Report (BUR). Other than the NCCC, assessment indicated that national information sharing and networking efforts are currently limited.

In January 2022, the Government of The Bahamas (GOB) established the Climate Change and Environmental Advisory Unit (C^2EAU) whose activities include advancing issues related to climate finance, carbon credits and promoting greater youth involvement in climate spaces. This Unit can aid in promoting information sharing and networking opportunities within the country along with the NCCC.

11.1. Regional and International Opportunities

There are a number of regional and international information sharing and networking opportunities that are available to The Bahamas. Some of these are already being accessed by individual agencies within the countries. These include opportunities provided by agencies such as:

- Convention on Biological Diversity (CBD)
- Food and Agriculture Organization (FAO)
- Global Environment Facility (GEF)
- International Fund for Agricultural Development (IFAD)
- International Federation of Red Cross and Red Crescent Societies (IFRC)
- Other United Nations organizations inclusive of UNDP, UNEP, UNITAR and UNWTO
- World Bank
- Inter-American Development Bank (IDB)
- Caribbean Development Bank (CDB)
- World Health Organization (WHO)
- Pan-American Health Organization (PAHO)
- World Meteorological Organization (WMO)
- Caribbean Community Climate Change Centre (CCCCC)

- Caribbean Disaster Emergency Management Agency (CDEMA)

New opportunities that The Bahamas could pursue are described below:

11.1.1. Santiago Network on Loss and Damage

The Santiago Network on Loss and Damage has been established to catalyze the technical assistance to address loss and damage which is needed in developing countries, like The Bahamas, that are particularly vulnerable to the adverse effects of climate change. Functions of the network include actively connecting countries seeking technical assistance with organizations and experts best suited to provide such assistance. Technical assistance can be sought on a myriad of approaches to addressing loss and damage including:

- Types of losses, including economic and non-economic losses;
- Risks of climate change – short-, medium- and long-term; and
- Comprehensive risk management including human mobility options, social protection, and recovery.

With respect to human mobility options, displacement, migration and planned relocation are already realities that The Bahamas is facing; being able to address human mobility in the face of worsening conditions due to climate change is not something that will be feasible solely on a national level with most of the country being at or below sea level.

11.1.2. Inter-American Institute for Global Change Research (IAI)

The IAI consists of 19 Parties in the Americas that work to develop the best possible international coordination of scientific and economic research on the extent, causes and consequences of global change in the Americas. The vision of the Institute is “enabling a well-informed, inclusive and sustainable Americas, which collaboratively meets the challenges posed by global change by supporting flexible science-based policies and actions” (IAI, 2022). Climate change and climate variability is a research theme for the Institute.

Resources available through IAI include an Open Data Catalog as a Harvard Dataverse repository and a database of scientific articles. IAI also has a number of capacity-building programs include the Science, Technology and Policy (STeP) Fellowship Program, Transdisciplinary Academy, International Mobility Research Fellowship Program and an online course on climate change in Latin America.

11.1.3. CAB International (CABI)

Established for entomological research in Tropical Africa in 1910, the Commonwealth Agricultural Bureaux became CAB International in 1986. CABI is an international NGO whose work focuses on agriculture and food security as well as biodiversity. The Bahamas is one of the 49 member countries of CABI, and as such can take advantage of its products and services. These include providing scientific expertise to the farming community to combat threats, such as climate change as well as providing access to scientific information.

CABI also provides knowledge products through its CABI Digital Library, CAB Abstracts database and Global Health database and training opportunities through CABI Academy. Each member country has access to five consultancy days each year to support the development of joint policy papers, concept notes, project proposals and scoping studies.

11.1.4. Climate and Development Knowledge Network (CDKN)

CDKN provides research and advisory services to countries all over the world. The thematic areas it addresses include:

- Adaptation and resilience
- Business action on climate
- Climate finance
- Implementing NDCs
- Loss and Damage
- Low carbon energy
- Physical science of climate change

With 295 projects globally, examples of its projects include:

- *Supporting climate resilience in Ghana* – CDKN is working with the University of Ghana to implement some of the actions outlined in its National Climate Change Plan. Project activities include provision of a peer-learning platform for collaboration between local government institutions on ecosystem-based disaster risk management and organizing events for stakeholders to engage with each other (including a workshop on Gender and Climate Finance).
- *Climate proofing the Sandy Bay water service improvement project in St. Vincent and the Grenadines* – CDKN funded the provision of guidance, capacity building, and technical support to the Central Water and Sewerage Authority to enable them to apply for funding to climate proof the Sandy Bay water service improvement

project. Project activities included identifying and appraising the costs and benefits of building the climate resilience of a water supply system.

To date, The Bahamas has participated in one CDKN project – Low Emission Development Strategies Global Partnership (LEDS GP). Completed in 2018, the project enabled peer learning and provided technical assistance and knowledge resources to participant countries.

11.1.5. Global Climate Change Alliance Plus (GCCA+)

The GCCA+ is an initiative of the European Union to assist SIDS and LDCs to increase their resilience to climate change. The Bahamas is eligible for funding under this initiative through its United Nations listing as a Small Island Developing State.

GCCA+ priority areas include increasing resilience to climate-related stresses and shocks, climate adaptation and disaster risk reduction. Priority sectors include energy, education and research, environment and natural resources, and economic development and tourism.

Countries can apply for funding for multi-year programmes with an average contribution five million Euros per project. Projects that have been funded in the Caribbean region include:

- Building climate and disaster risk reduction resilience in Dominican Republic's coastal-mountainous gradient via Ecosystem-based Adaptation; and
- Support for climate change integration in Haiti's National Development.

11.2. Strategy for information sharing and networking

Recommendations under the strategy for information sharing and networking will enable The Bahamas to strengthen efforts in these areas, both nationally and internationally.

11.2.1. Establishing and enhancing networking activities

Assessments completed during the TNC-BUR process indicated that while individual agencies may be having limited interactions to share information with each other and to create networking opportunities, there is no nationally coordinated mechanism to facilitate these key components of addressing climate change.

The NCCC is an existing mechanism to facilitate interactions between all sectors of society – public, private and NGO. Meetings of the NCCC are an opportunity for sectors represented to share information about their activities related to climate change and to network on high priority national activities. To broaden the reach of the NCCC, the Public Education and Outreach (PEO) Subcommittee should support efforts to expand information sharing and networking to the wider Bahamian community. The agencies represented on the PEO Subcommittee have the capability and resources to do so, particularly Bahamas Information Services, Ministry of Education, University of The Bahamas, Bahamas Chamber of Commerce & Employers' Confederation and Bahamas Press Club.

11.2.2. Information sharing and networking regionally and internationally

While the NCCC also has an important role to play in information sharing and networking by being the conduit for regional and international opportunities available to national sectors, it needs to be supported by UNFCCC National Focal Points.

UNFCCC National Focal Points will likely be the first to become aware of regional and international opportunities. They must share these with the NCCC as well as relevant agencies that may not be represented on the Committee. The NCCC and PEO Subcommittee can then work together to share the opportunities with national stakeholders.

The establishment of a portal or internet-based mechanism for making all stakeholders aware would facilitate sharing of information and opportunities. It is recommended that this portal be established as a webpage within one of the National Focal Points existing websites. One staff member could be tasked with updating the webpage on a regular basis. Social media pages (e.g. Facebook, Instagram) for National Focal Points can also be used to advise national stakeholders of new opportunities.

Chapter 12 – Gender and Climate Change

12.1. Gender Inequality and Climate Change

The Bahamas is a small island developing state (SIDS) classified as amongst the most vulnerable to the effects of climate change.[55] Gender inequality increases vulnerability and exacerbates the impact of climate change on marginalized communities. Gender relations are informed by social, economic, and political institutions that reinforce and reproduce discriminatory outcomes. And gender inequality acts as a determinant of unequal gendered outcomes and the most vulnerable communities face compounding forms of discrimination because of intersectional identities.[56]

Adopting an intersectional approach to climate change and DRM policy ensures that communities that face multiple forms of discrimination have equitable access to climate adaptation resources. Social indicators like migrant status, age, socioeconomic, and disability status may influence the levels of access communities have to resources and opportunities, in addition to gender. Systems of inequality prevent communities from fully enjoying their human rights and subsequently inhibit their ability to respond to the threats of climate change. Gender roles can impact communities and stunt national development due to unequal participation in the economy and engagement in society. Gender inequality is exacerbated by the effects of climate change and the structural & social imbalances of power embedded in various Bahamian institutions can contribute to significant barriers in addressing climate change adaptation and determinants of vulnerability for marginalized groups.

While climate change hazards are not discriminatory in their impacts, the ability of communities to adapt and respond to their effects is determined by sociopolitical and economic factors. Studies highlight that marginalized communities are disproportionately impacted by climate change due to imbalances of power, cultural discrimination, and socioeconomic inequality. Women do not have an inherent increased vulnerability to climate change; rather, socioeconomic, and political institutions that result in disproportionate access to resources increase their vulnerability.[57] Painting women as victims of climate change in CCA and DRM policies is similarly harmful and can lead to climate change being framed as a women's issue, excluding other populations from CCA and DRM initiatives. Thus, CCA and DRM policies should seek to be gender

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Thomas, A., & Benjamin, L. 2018. Perceptions of climate change risk in The Bahamas. *Journal of Environmental Studies and Sciences*, *8*(1), 63-72.

[56] UNFCCC. 2013."Best practices and available tools for the use of indigenous and traditional knowledge and practices for adaptation, and the application of gender-sensitive approaches and tools for understanding and assessing impacts, vulnerability and adaptation to climate change." 67-150.

[57] Valerie Nelson, Kate Meadows, Terry Cannon, John Morton & Adrienne Martin. 2002. "Uncertain predictions, invisible impacts, and the need to mainstream gender in climate change adaptations," *Gender & Development*, 10:2, 55

transformative in their approach and address the sources of inequality and its effects as central to their aim.[58] This section will provide a gender analysis of access to opportunities, areas of vulnerability, and a comparative overview of gender relations in The Bahamas.

12.2. Gender Inequality in The Bahamas

Poverty and socioeconomic equality are key determinants of a population's adaptive capacity. Poverty increases the severity of vulnerability and exacerbates the impact of climate related shocks.[59] Climate related shocks trap people in cycles of poverty as assets are expended to rebuild and they expose new people to poverty because it diminishes their ability to accumulate and maintain assets.[60] Gendered rates of poverty are intrinsically linked to climate justice as poverty is a key barrier to adaptation. In The Bahamas, there is a feminization of poverty wherein there are higher rates of poverty in female headed households. The incidence of poverty is 28 percent higher for Haitian households and 17 percent higher on Family Islands.[61] People living in poverty are amongst the most vulnerable to the effects of climate change because of the lack of financial resources to withstand climate stress, therefore, they are most likely to be dependent on diminishing resources and have unstable living conditions. In addition to an increased vulnerability, they are also the least likely to have access to adaptation resources. The disproportionately high rates of women and migrant households living in poverty significantly inhibit the ability of these communities to withstand the effects of climate change.

Family island populations that are heavily dependent on agriculture and fisheries for income are also notably vulnerable to climate shocks. Although the fisheries industry represents only 2 percent of GDP, it has great importance to the country culturally, as a food source, and economically, especially in the Family Islands.[62] Following Hurricane Dorian there was an estimated $13.6 million lost in damages in the fisheries and agricultural sector and only 38 percent of total damages were insured.[63] The vulnerability of the sector has disproportionate effects on communities dependent on the fisheries industry and impact income earning opportunities for already vulnerable populations. The

[58]Ibid
[59]Stephane Hallegatte, and Julie Rozenberg. 2017. "Climate change through a poverty lens." *Nature Climate Change* 7, 250-256; Demetriades, Justina, and Emily Esplen. 2010. "The gender dimensions of poverty and climate change adaptation." *S*ocial dimensions of climate change: Equity and vulnerability in a warming world, 133-143.
[60]Ibid
[61] A. Bleeker and others. 2021."Advancing gender equality in environmental migration and disaster displacement in the Caribbean", Studies and Perspectives series-ECLAC Subregional Headquarters for the Caribbean, No. 98 (LC/TS.2020/188-LC/CAR/TS.2020/8), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC),
[62]Bethel, B.J.; Buravleva, Y.; Tang, D. 2021. "Blue Economy and Blue Activities: Opportunities, Challenges, and Recommendations for The Bahamas" *Water* 13: 1399
[63]IDB & ECLAC. 2019. "Assessment of the Effects and Impacts of Hurricane Dorian in The Bahamas." 15

tourism sector is one of the main industries of the Bahamian economy, however, the industry's dependence on natural resources makes it vulnerable to climate change. The tourism industry and related sectors employ over 50% of the population, and in 2009, 60% of people employed in the industry were women.[64] The prospective decline of the industry will result in high rates of unemployment amongst women, further impacting their adaptive capacities.

Women account for almost 52% of Bahamians living in poverty and comprise over 72% of Department of Social Services clients.[65] Further, men can make up to 30 percent more than women for the same work in Caribbean countries.[66] Unpaid caregiving roles, the wage gap, and workplace discrimination impact women's ability to fully participate in the formal economy which reinforces and reproduces high rates of poverty among women. Despite equal pay being codified in law, women often do not receive equal pay for doing the same work as their male counterparts.[67] A 2017 analysis of gender wage discrimination in The Bahamas found that men make more annually than women regardless of education levels. Poverty extends beyond financial limitations and encompasses lack of time, social and political capital, legal inferiority, and influences the ability to engage in social relations.

Gender inequality impacts mobility and access to opportunities and shapes livelihood outcomes for all populations. Bahamian males are being left behind in the education system, performing worse on exams, graduating at lower rates, and not pursuing tertiary level education.[68] The national high school graduation rate is around 50 percent, however, boys graduate from schools at lower rates than their counterparts. According to the 2010 census, 6,851 males completed 1-2 years of tertiary education compared to 12,739 females.[69] Between 2010-2017 around 77% of graduates from College of The Bahamas, now University of The Bahamas, and over 80% from The Bahamas Baptist College were women.[70] Low school retention rates in males have been linked to increased participation in crime and higher incarceration rates.[71] In addition to having implications on the ability of men to contribute productively to society, lack of formal education is directly linked with the ability to assess risks.[72] This impacts the adaptive capacity of uneducated populations and their ability to engage in disaster risk management. Further, despite the higher

[64] World Bank. Bahamas Macro Poverty Outlook. <https://pubdocs.worldbank.org/en/505961602705115630/mpo-bhs.pdf>; UNTO (2009) Tourism: An Engine for Employment Creation. 5.
[65] CEPAL. 2019. "Beijing +25 National Review: Bahamas National Report", 15.
[66] Ibid
[67] Ibid, 34.
[68] Fielding & Gibson. 2015. Attitudes and achievements of males and females in The Bahamas. *College of The Bahamas*. 1-51.
[69] The Bahamas Census of Population and Housing. 2010.: 98
[70] CEPAL, 34
[71] Fielding & Gibson, 15
[72] Bennett, I. 2014. Fragile Masculinities: The Loss of Young Men and the Pervasive Models of Masculinity in The Bahamas that Encourage them to Fail. *Caribbean Review of Gender Studies*, (8).

graduation rates of women and girls, women are underrepresented in key leadership positions and occupy a disproportionate amount of middle to lower-level positions.

Gender inequality extends beyond economic disparities. For example, there may be an increased risk for depression, child marriages, leaving school early, and exposure to violence in women. However, while men engage in violence at significantly higher rates than girls, men are more prone to substance abuse and death by suicide, and have lower life expectancies than women.[73] Women in The Bahamas generally occupy the traditional role of homemaker and are responsible for child rearing.[74] This not only limits the time available for income-earning opportunities, but also impacts their ability to participate in community building activities or learn new climate-smart coping mechanisms. Time poverty can severely limit a women's ability to be active in climate-centered community organizing which has lasting impacts on awareness of the risk's climate change presents.[75]

Unfortunately, The Bahamas has recorded high rates of GBV, intimate partner violence (IPV), and femicide. While anyone can be a victim of sexual violence, women and girls are the main victims largely due to unequal power distributions and harmful perceptions of women in society.[76] In 2007, The Bahamas had an average of 133 rapes per 100,000 persons compared to the worldwide average of 15.[77] However, rape is one of the most underreported crimes and this number is likely higher than recorded. Moreover, a survey was conducted highlighting the normalization of violence against women, with 47.8 percent of respondents indicating that it was important for a female partner to be disciplined.[78] These populations are then further exposed to increased rates of HIV/AIDs and sexual health risks.

Femicides are not recognized as an official category in reporting which inhibits an accurate account of murders of women motivated by their gender. However, there were high rates of murders of women between 2010 and 2016. Specifically, there were 831 murders, 91 of which were domestic murders.[79] The high rates of violence against women impact their ability to fully enjoy their human rights and engage in society. These significantly high rates of GBV point to a need for institutional reform on GBV and equality

[73]Sánchez–López, M. D. P., Cuellar–Flores, I., & Dresch, V. 2012. The impact of gender roles on health. *Women & health*, *52*(2), 182-196.
[74] Fielding, William J., and Virginia C. Ballance. 2019. Learning gender-based attitudes in The Bahamas. *International Journal of Bahamian Studies* 25(1): 1-15.
[75] Nelson, V., Meadows, K., Cannon, T., Morton, J., & Martin, A. (2002). Uncertain predictions, invisible impacts, and the need to mainstream gender in climate change adaptations. *Gender & Development*, *10*(2), 78.
[76]Ibid
[77]UN General Assembly. 2017. "Convention on the Elimination of All Forms of Discrimination Against Women (CEDAW)," Consideration of reports submitted by States parties under article 18 of the Convention: Bahamas. "
[78]Wiltshire, Rosina. 2016.Gender-based violence in the Caribbean: A cause for concern and a call to action' *presentation at the Commission on the Status of Women, New York*
[79]CEDAW. 2018."Report of the Special Rapporteur on violence against women, its causes and consequences, on her mission to The Commonwealth of The Bahamas" UNHRC: 5

policies. Rates of violence against women rise during climate related stresses. In some instances, emergency shelters could act as a site for the exploitation of women, girls, migrants, and other vulnerable populations. For example, fearing concerns about deportation following climate-related disasters, undocumented migrants may avoid seeking shelter, thereby increasing their vulnerability & risk of exploitation[80].

Gender socialization and gender roles impacts migration rates following sudden onset disasters and the level of difficulty to return to pre-disaster living conditions. Three months following Hurricane Dorian, 3,360 people were relocated to New Providence from Grand Bahama and Abaco.[81] Women comprised over 54 percent of total people displaced to New Providence, and 70 percent of displaced persons from Grand Bahama were women despite comprising only 51 percent of the island's population.[82] Climate disasters increase the burden of unpaid labor on women as caregivers, particularly as food and water resources diminish. Male-dominated industries, like agriculture and fisheries, can be severely impacted following disasters resulting in migration away from their families in search of employment. Following disasters men are more likely to resort to unhealthy coping mechanisms like alcohol and ignore their mental health needs due to harmful gender stereotypes.[83] Social and economic barriers to mental health resources that address depression and anxiety leads to increased rates of violence against women following widespread migration as a result of climate shocks. Marginalized communities, including persons with disabilities, LGBTQ+ communities, the elderly, and migrant populations, are at heightened risk of negative impacts of environmental migration.

There is limited data available on the effects of climate change disaggregated for multiple social indicators. As a result, it is difficult to accurately capture the experiences of disabled, elderly, migrant communities with irregular states, along with other marginalized groups and their specific vulnerabilities to the effects of climate change.[84] However, the disproportionate access to resources and social, economic, and political discriminations indicates that marginalized populations have increased vulnerability and inequality is exacerbated by climate stress. The lack of robust data collection limits the ability of policies to respond to the needs of marginalized communities because their needs are not represented in CCA and DRM data collection and research processes.[85].

12.3. Exisiting Legal and Political Frameworks on Climate Change

Bahamian climate change policy and political frameworks have employed a gender neutral perspective in their adaptation and mitigation strategies. Notably, the Initial and

[80] ECLAC, 39
[81] Ibid,41
[82] Ibid
[83] Ibid, 25
[84] Ibid, 25
[85] Ibid, 25

Second National Communications to the UNFCCC did not include dedicated chapters on gender mainstreaming climate change policy. Gender neutrality, however, does not account for socioeconomic, political, and cultural structures that impact climate vulnerability. Gender neutral policies operate under the assumption that populations have homogenous access to resources and opportunities which impacts the effectiveness of policies because they do not respond to the needs of marginalized communities and centers the dominant male perspective. Gender transformative policies seek to address the root causes of inequality as part of their climate adaptation and mitigation strategies. Climate change policies should undergo a gendered analysis and be grounded in data from the most vulnerable populations to ensure their effectiveness. Table 121 provides a gendered analysis overview of existing climate change policies in The Bahamas.

Table 121: Gender Analysis of Existing Legal and Political Frameworks on Climate Change

Legal/Political Framework	**Overview of Gendered Analysis**
National Policy for the Adaptation to Climate Change (2005)	The NPACC presents a comprehensive approach to climate change adaptation and mitigation strategies and seeks to bolster national resilience.[86] Since its development, however, there have been significant advancements and increased knowledge on the threats of climate change and the increased vulnerability of The Bahamas as a Small Island Developing State. The Policy needs to be updated to respond to international UNFCCC commitments to include gender mainstreaming in climate change policy development. A notable gap in the NPACC is the lack of a gender responsive approach to climate change. The Policy does not address disproportionate gendered vulnerabilities and outcomes caused by systemic inequalities. The Agriculture and Coastal and Marine Resources and Fisheries sections of the Policy do not address the increased vulnerability of Family Island populations due to their reliance on these industries for income. Notable gaps like the lack of a gender budget, financial strategies to ensure equitable participation in climate entrepreneurship, and

[86] The National Policy for the Adaptation to Climate Change (2005):1-51.

	participation of marginalized groups in decision making further inhibit the strength of the NPACC. Differences in socioeconomic status, power, and opportunity result in women having increased vulnerabilities to the effects of climate change. Populations with intersecting marginalized identities like migrant status, disability status, low socioeconomic backgrounds, and rural communities, are not addressed in this policy. Data collection that disaggregates by key indicators like age, sex, education level, and migrant status are not consistently applied across relevant areas. This prevents analyses of policy implementation and limits the ability to determine its effectiveness. The NPACC does not identify strategies to combat the expected rise in GBV due to climate related stress. A multi-sectoral approach including health, education, civil society NGOs, and legislation are key stakeholders to address GBV. The Bahamas has significantly high rates of GBV, the NPACC should seek to ensure that resources and institutional strategies are available to vulnerable communities to prevent a rise in GBV. The NPACC should be strengthened by mainstreaming gender throughout its Policy Directives. The Policy currently does not address socioeconomic and cultural differences that increase vulnerability to the effects of climate change.
Disaster Preparedness and Response Act (2008)	The Disaster Preparedness and Response Act (2008) establishes the National Emergency Management Agency (NEMA) and outlines the Director's duties, the management of shelters, and the identification of especially vulnerable areas.[87] DRM is important to an island nation because climate change increases the occurrence and severity of sudden onset disasters. Hurricane Dorian was a record-breaking storm that

[87] Disaster Preparedness and Response Act, (2008)

	devastated the islands of Grand Bahama and Abaco in 2019 and highlighted major challenges for DRM including the coordination of emergency services to rural and Family Island communities, and accessibility to emergency shelters. The Act requires an administrator on each Family Island to be appointed to a Consultative Committee that consists of a minimum of five residents from each settlement or area. This provides populations with some agency over their disaster management processes however, there are practices to ensure equitable participation of men and women. Gender mainstreaming requires intentional community involvement throughout policy and programming development and this needs to be bolstered in DRM and EWS systems.[88] Emergency shelters have been identified as a site where women and children are at an increased risk of sexual violence and human trafficking because of overcrowding, lack of privacy, and poor lighting throughout shelters. Following Hurricane Dorian, 4,731 females and 4,545 males were in emergency shelters.[89] Currently, the Act provides that the NEMA Director can deploy security to the shelter. Shelters should undergo a gender analysis to ensure their safety and adhere to the Sphere minimum guidelines for shelter safety. This would also ensure that all communities have access to emergency shelters. In addition, robust sex disaggregated data collection should be standardized across shelters. National early warning systems are necessary to ensure that people have ample time to evacuate and prepare for disasters. EWS should seek to partner with community leaders and local NGOs to develop a more efficient and accurate system that reaches

[88] Dulal, H. B., Shah, K. U., & Ahmad, N. 2009. Social equity considerations in the implementation of Caribbean climate change adaptation policies. *Sustainability*, *1*(3), 363-383.
[89] International Federation of Red Cross. 2021."Operation Update No. 7 The Bahamas: Hurricane Dorian", 6

	marginalized communities. These systems should be gender mainstreamed and follow the UN Sendai Framework for Disaster Risk Reduction and regional DRM plans.
Intended Nationally Determined Contribution (2015)	The 2015 INDC developed per UNFCCC commitments highlights challenges the country faces and progress made from the first and second National Communication to the UNFCCC. The Report outlines potential adaptation and mitigation strategies and means of implementation however the Initial and Second National Communication were not gender responsive and the INDC maintains a gender-neutral analysis. The INDC notes the vulnerability of the tourism industry to the effects of climate change and national economic dependence on tourism. The expected rise in unemployment due to the tourism industry's vulnerability will further impact individuals' adaptive capacity and national resilience to climate change. A sustainable tourism plan needs to be adopted to strengthen the longevity of the industry. In addition, economic measures need to be adopted that prepare social security institutions for increased strain as a result of the expected rise in unemployment. The Health strategies for the INDC include identifying locations and population groups that are at the greatest risk for specific health threats.[90] Notably, the Report does not include strategies to combat a rise in GBV, SV, or an increase in HIV/AIDS that occurs during climate stress. Mental health resource accessibility during and post disasters are not addressed in the report. Following Hurricane Dorian, over 6,000 people received mental health services.[91] The Financial and Insurance Sectors section of the INDC identifies a poverty reduction strategy that

[90] Government of The Bahamas. 2015. *"Intended Nationally Determined Contribution (Indc) Under The United Nations Framework Convention On Climate Change."*: 1-10.
[91] Care, 6

	reduces insurance costs for high elevation lots. There are opportunities for economic poverty reduction strategies that simultaneously engage the Bahamian population as agents of CCA and mitigation while also addressing increased vulnerability. Conditional Cash Transfer programs. The now discontinued CCT program, RISE, operated through the Department of Social Services sets a positive precedent for their implementation in The Bahamas.[92]
National Development Plan (2016, Draft)	The National Development Plan, Vision 2040, intermittently adopts a gender responsive approach to its climate change and DRM strategies through its use of gender sensitive language. The NDP seeks to strengthen the legislative framework for gender equality by addressing discriminatory laws and ensuring the implementation of human rights conventions The Bahamas is to signatory in order to develop an enabling environment for gender equality.[93] The Environment (Built and Natural) section of the Plan does not comprehensively mainstream gender throughout its strategies. Data collection disaggregated by social indicators and the development of a gender budget are absent from the Natural Environment section of the NDP which are crucial for measuring the impact of policies and allocating resources specifically aimed at addressing unequal adaptation capacities. Some Strategies adopt a gender blind approach to their Actions. Actions identified under Strategy 9 that are aimed at land ownership do not seek to address barriers to land ownership for marginalized groups. Unequal access to assets is a determinant of disproportionate rates of women living in poverty. While there are no legislative barriers that prevent women from accessing land, there are social and cultural barriers that need to be addressed in the NDP.

[92] CEPAL, 15
[93] The National Development Plan: Vision 2040. 2016.

	Strategy 11.1 of the NDP on Climate Change Adaptation and Mitigation Measures highlights social inequities as a barrier to adaptation. The Plan includes public education on adaptation and mitigation, training, and increasing capacity for green technology. The NDP does not include ways to reach high risk communities that experience barriers to resource access through their public education and training programs. Gender equality is a determinant of national resilience to climate change and requires a multi-sectoral and stakeholder approach that encourages collaboration and maintains transparency. The Actions in the NDP should also include specific time frames with attainable goals that prioritize the needs of populations with the highest risk of vulnerability.
National Gender Equality Policy (2018, Draft)	The National Gender Equality Policy drafted by the Department of Gender and Social Services seeks to mainstream gender throughout national development. Goal 7 focuses on promoting a gender perspective in climate change and DRM policies and programming.[94] There are two objectives identified within Goal 7. The first is to ensure that resources are available for vulnerable groups, and the second is to mainstream gender throughout all climate change and DRM policies. The strategies identified to achieve these goals need clarity on the lead agents and the specific actions needed to achieve the objectives. While the policy does center the needs of vulnerable groups in its approach, the time frames to complete objectives are unclear and do not respond to the immediacy of the threats of climate change. The National Gender Equality Policy requires more depth in its plan to address climate change and DRM. The Plan targets unequal access to resources through

[94] The Department of Gender and Family Affairs, "Draft National Gender Equality Policy. ".2018.

	targeted economic, health, and education strategies. This plan is gender specific as it actively targets structural inequalities and takes into consideration access and control over resources.[95] The plan is comprehensive however the timelines allotted to complete the strategies are too lenient. Further, The National Gender Equality Policy Action Plan does not include specific strategies to engage stakeholders and community members concerning gender and climate change programming.

12.4. Exisiting Legal and Political Frameworks on Climate Change

Mainstreaming gender into CCA and development policies is a necessary step to develop national resilience and address the disproportionate impacts of climate change on marginalized populations. These policies should seek to create an enabling environment for public engagement in CCA through the empowerment of marginalized communities, increased awareness, and capacity building initiatives.[96] Through challenging traditional gender roles in capacity building and technical training, engaging in meaningful partnerships with NGOs, and engaging disadvantaged communities as agents of climate change resilience, CCA and development policies can stimulate awareness of the effects of climate change amongst the population.[97] Increasing the technical capacity of women in non-traditional sectors like sanitation and energy sectors challenges gender norms and increases their income earning opportunities.

Developing a legal framework for gender equality provides legislative authority and protections for marginalized communities and is crucial for addressing discrimination. Fully complying with international conventions like CEDAW and Belém do Para Convention and implementing a national gender equality policy and a policy to address violence against women will seek to address disproportionate outcomes. The goal of these policies should be transformative gendered outcomes. However, the adoption of policy alone is not sufficient to address systemic inequalities and gendered analysis of their implementation and possible dysfunctions can determine the extent of their impact.[98] Engaging marginalized communities in the decision-making processes of policy development amplifies their perspectives and strengthens their effectiveness. The

[95]UNFCCC . 2013. "Best practices and available tools for the use of indigenous and traditional knowledge and practices for adaptation, and the application of gender-sensitive approaches and tools for understanding and assessing impacts, vulnerability and adaptation to climate change.":67-150.
[96] Ibid, 40
[97]Value for Women. 2020."Study of the impacts of climate change on the women and men of the Caribbean. Pilot Programme for Climate Resilience Countries" *Inter-American Development Bank*
[98] Engeli, Isabelle, and Amy Mazur. 2018. "Taking implementation seriously in assessing success: The politics of gender equality policy." *European Journal of Politics and Gender*, 113

archipelagic structure of The Bahamas supports local and community agencies in carrying out CCA initiatives with strong institutional support from the central government.[99] This ensures that Family Island communities have ownership over their adaptive and mitigative strategies.

Gender sensitive monitoring and evaluation of policy outcomes are crucial to ensure that programs are responsive to the needs of marginalized communities. Data collection and management systems need to be updated for greater transparency and accuracy to increase the reliability of data. The limited availability of data disaggregated by social indicators impacts the ability to accurately understand living conditions within the country and develop responsive DRM and CCA policies.[100] Information systems must go beyond sex-disaggregated data to include social indicators like age, education, disability and socioeconomic status to capture intersectional circumstances.[101] Data collection and transparent monitoring and evaluation systems are necessary for informed climate policy and program development. Uniformed data collection systems should be ingrained throughout development and CCA policy and programming to aid in collaboration and knowledge sharing amongst stakeholders. A comprehensive data action plan that streamlines statistics linked to adaptation and DRM will ensure policies are informed and responsive to community's needs.

Gender budgeting in development and CCA policy initiatives ensures that programs aimed at facilitating the bolstering the adaptive capacities of marginalized communities and addressing barriers to resources are funded and can be effectively implemented.[102] As of 2016, the Department of Gender and Family Affairs annual budget was $2 million dollars.[103] Gender responsive budgeting promotes equitable participation in the economy and supports national goals to address the disproportionate impacts of climate change. Further, the 2030 agenda for Sustainable Development Goals includes a specific indicator under Goal 5 that commits countries to track and publicize budgetary allocations for gender equality.[104] Allocating specific resources to CCA and development policies ensures that they can be implemented and produce transformative outcomes.

CCA and development policies should similarly ensure equitable access to healthcare as part of their adaptation strategies. Climate change will have significant impacts on physical and mental health. Children, and the elderly are particularly vulnerable to the effects of heat stress as global temperatures rise; and following disasters women have

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[99] Lightbourne, Shacara, Programa Hemisférico. 2021.Integrated Landscape Management for Addressing Land Degradation, Food Security and Climate Resilience in The Bahamas. *Cambio Climático, and Recursos Naturale*
[100] CEPAL, 31
[101] Ibid
[102]Sejal Patel, Delaine McCullough, Paul Steele, and others. 2021. "Tackling Gender Inequality and Climate Change Through The Budget." *International Budget Partnership*
[103]CEPAL, 73
[104]Ritchie, Roser, Mispy, Ortiz-Ospina. 2018. "Measuring progress towards the Sustainable Development Goals." <SDG-Tracker.org>

limited access to reproductive healthcare and menstrual products.[105] Family Island and rural populations face heightened risks of vulnerability because of the lack of secondary and tertiary healthcare resources in their communities. DRM and CCA policies should seek to address disproportionate access to healthcare services in these communities. National Health and Climate Change Action Plans would allow for a targeted approach to health vulnerabilities, the identification of populations that require priority assistance, and present an action plan to mitigate negative health impacts.[106]

Increased financial inclusion is a driver of development and reduces poverty rates, allowing individuals to better manage financial risks, and increase their savings.[107] Relevant policies should challenge socioeconomic inequality and provide avenues to include marginalized communities in the economy through poverty reduction strategies as part of adaptation and mitigation strategies. Interventions like CCT's, climate risk insurance, and increasing land titling for marginalized communities address barriers vulnerable communities face to the formal economy. Addressing disproportionate rates of poverty and economic inequality as barriers to climate adaptation centers increasing the adaptive capacities of vulnerable communities.

All aspects of CCA, development, and DRM policy and programming should undergo a gender analysis and mainstream gender in their initiatives at all stages. Disproportionate societal outcomes in the socioeconomic and political sphere should be challenged through these policies as part of national adaptation strategies to ensure equitable outcomes. The unique needs of communities with increased vulnerability are not currently reflected in existing climate adaptation and development policies. Gender mainstreaming should span across various sectors and include legislative, financial, and operational measures to address social, economic, and political barriers to adaptation and requires collaboration across departments and large institutional and public support to be successful. Systemic and behavioral discrimination act as significant barriers to adaptation and will require widespread education, training, and capacity building initiatives.

[105] WHO & PAHO. 2021. "UNFCCC Health and Climate Change Country Profile" 3.
[106] Ibid, 12.
[107] Demirgüç-Kunt, Asli, Leora Klapper, Dorothe Singer, Saniya Ansar, and Jake Hess. 2018. The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution. Washington, DC: World Bank.

Chapter 13 – Constraints, gaps and related financial, technical and capacity needs, including information on support received for preparation and submission of the TNC

13.1. Constraints, gaps, and prioritized needs

In its previous submissions to the UNFCCC (FNC, SNC, and NDC), The Bahamas has identified data gaps and transparency issues that have hindered complete and accurate reporting. Lack of timely improvement and the detailed modalities, procedures, and guidelines (MPGs) that elaborate the enhanced reporting requirements under the ETF has guided the Government of The Bahamas to identify the following during the TNC/BUR1 reporting process:

- Constraints and gaps in GHG inventory, mitigation, adaptation, and climate finance reporting
- Prioritised needs and improvements to facilitate improved reporting for future cycles in adherence with the TACCC principles

The following Table 122 and Table 123 provides a summary of observed constraints and gaps provided by the relevant compilation teams and validated by in-country stakeholders as well as identified prioritised needs.

Table 122: Constraints and gaps by reporting type

Reporting Type	Constraints and gaps observed during TNC/BUR1 reporting process
GHG Inventory	**Lack of adequate data** – Data quality and availability from national sources for key emitting sectors were main challenges for estimating emissions and removals for this GHG inventory. **Limited coordination for GHG inventory cycle** – The institutional and legal arrangements for coordinating timely GHG Inventory reports was noted as a limiting factor in this reporting cycle, while noting that efforts have been made to identify roles and responsibilities of coordinating entity, data providers, and sector experts. **Capacity constraints in applying GHG inventory methodologies** – The lack of technical capacity was noted and affected the overall flow of information from data collection, to emissions estimations, and then to reporting.

	Limited understanding of all GHG emitting activities in the country – A clear understanding of all emitting categories was difficult to determine during the data collection process, however as capacity increases in understanding the scope and necessity of reporting, this is expected to improve. **Lack of archiving from previous reporting cycles** – The data, methods, and calculations from previous GHG Inventories has not been successfully documented, requiring all new efforts to source historical data for its time series
Mitigation	**Lack of adequate data** - Data quality and availability were identified as the main challenges throughout the development of the model. Insufficient data will result in limited accuracy in the modelling and also create major challenges for monitoring, verification and reporting in the future. **Willingness to supply data** to relevant authorities which creates a lack of transparency. **Intra-ministerial coordination and communication** - Although the mitigation actions are clearly identified under separate sectors, the Governance of some of these actions were not always clearly defined across Ministries and Departments. It is important that continued efforts of coordination through the National Climate Change Committee, which consist of persons from various ministries to minimise this challenge. **High capital costs** – Renewable energy initiatives normally require high capital costs. Although The Bahamas is considered a high-income country, the unique challenges of SIDS need to be taken into consideration. It is essential that access to climate finance grants and low-interest loans be made available to SIDS to help reduce the costs of implementation.

	Technology suitability/availability – The Bahamas, in its mitigation assessment, have proposed some common technologies and others that are still in their infancy. In addition, The Bahamas archipelago is vast and therefore, it is essential that studies and testing be conducted in various regions in The Bahamas to identify what is most suitable for each territory based on national circumstance. In addition, capacity building in the technologies identified as most suitable is important for the sustainability of implementation. **Data transparency issues** – There is a lack of development and implementation of agreements to facilitate data sharing among institutions.
Adaptation	**Stakeholders with technical capacity constraints,** both in terms of human resource numbers, and ability to meet the technical demands for consistent V&A reporting. **Intra-organizational/inter-organization coordination and communication** - Lack of coordination across ministries, local government, private sector, academia, NGOs and other stakeholders who participate in climate change actions across all sectors. **Lack of regulatory framework to support and promote** V&A data collection, tracking, monitoring, reporting and dissemination, resulting in gap in data and knowledge needed to inform policy and decision making **Lack of key equipment** to support V&A MRV due to high costs for procurement, implementation and ongoing use, supply chain matters, etc. **Lack of adequate data** - Data quality and availability were identified as a challenge throughout the development of impact chains/models **High capital costs** – Adaptation initiatives can cost even more than mitigation initiatives to implement. With The Bahamas classification as a high-income country is a major barrier in access to capital, therefore, its unique

	challenges of SIDS need to be taken into consideration. It is essential that access to climate finance grants and low-interest loans be made available to SIDS to help reduce the costs of implementation.
MRV Assessment	**Intra-organizational coordination and communication** - Lack of coordination across ministries, local government, private sector, and other stakeholders who participate in climate change actions across all sectors. **Need for greater public awareness** around climate change initiatives through planned education and awareness campaigns from primary education to broader public awareness campaigns. **Limited staff**, particularly full-time staff, to keep up with the demands of new national commitments for enhancing national climate MRV systems, and other related permanent functions such as participation in National GHG Inventory preparation, tracking of NDC goals, gender experts, climate support tracking. **Lack of adequate funding** to implement climate goals and monitor execution in the medium to long term. **Limited legislation or compliance mechanisms** in place to mandate the execution and continuity of climate related activities that are internationally binding (reporting under the Paris Agreement, Montreal Protocol, etc.) **Stakeholder hesitation** in participation in meeting nationally determined climate change goals as a result of limited incentives offered to the private sector and other significant stakeholders. **Difficulty in collecting data** and reporting across all sectors, as data is not collected for the purpose of reporting on climate change indicators

Table 123: Identified prioritized needs by reporting type

Reporting Type	Prioritised Needs identified during TNC/BUR1 reporting process
GHG Inventory	Set up appropriate institutional, procedural, legal arrangements, and documentation for recurring preparation of the national GHG inventory. Appoint a national GHG inventory compilation team. Fully establish and implement QA/QC procedures for the national GHG inventory. Fully establish data collection and archiving procedures for the national GHG inventory.
Adaptation	Assessment of data transparency issues and development of agreements to facilitate data sharing among institutions Improve intersectoral linkages between sectors (public and private) to avoid duplication of efforts, this will help to take advantage of common challenges and opportunities: i.e. improvement in data collection, disaggregation, usefulness, and implementation of adaptation initiatives Training and increased capacity of individuals across agencies, particularly those highlighted in priority adaptation areas, to ensure they understand role in the national (cyclical) adaptation MRV process, and support future reporting efforts Advancing a national climate research agenda to support the availability of recent (up-to-date) data is available for modelling and adaptation MRV purposes Enhanced legislative agenda, including regulations and policies for land use and conservation to improve efficacy in planned adaptation interventions
Mitigation	Improvement in data collection, having more disaggregated and updated data for energy consumption and production in The Bahamas would allow for more detailed modelling of the energy sector and its GHG emissions. This would create a more transparent assessment of mitigation actions in this sector, which for the purpose of this study were mainly estimated outside of the main modelling framework. Assessment of data transparency issues and development of agreements to facilitate data sharing among institutions,

	for example, by anonymizing data (e.g. sharing semi-aggregate information by power plant type instead of by individual facilities so that interests of private companies are protected while also contributing to the public knowledge). Improvement in the baseline projections for the LULUCF sector. Better data collection in the LULUCF sector will allow for improvement in the assessments of the trends and the baseline emissions for the LULUCF sector. The LEAP model can be a useful tool for monitoring the implementation of projects. Therefore, further examination of the model needs to be conducted and adequately skilled persons identified for monitoring the implementations projects and updating the LEAP model.
MRV Assessment	Ensure that all relevant government agencies are involved in the inventory process. Initiate appropriate legislation to facilitate access to data and data collection. Contact the main industries in the country and open a communication channel for data collection/exchange, considering the confidentiality option. Establish a process to ensure a common understanding of data needs and a consensus on data to use. Organise enough joint meetings between all parties to ensure a good and common understanding of the data needs and communication throughout the inventory process. Produce meeting reports explaining the objectives and the conclusions and include a link in the NIR as a reference of these activities. Set up a national inventory management system, that includes the procedural arrangements to produce the inventory in timely manner.

	Set up a National GHG Inventory Management System, that includes legal arrangements for inventory planning, preparation, and management.

13.1.1. Progress towards addressing constraints and gaps

The Bahamas has made progress towards addressing constraints and gaps since submission of its SNC (See Table 124). The identified next steps for the future reporting cycle provide an overview of the outstanding needs for human resource development, research, monitoring and evaluation, technology transfer, and broader domestic MRV system infrastructure development.

Table 124: Progress made from SNC to TNC

Gaps identified in SNC	Progress identified during TNC/BUR1	Identified next steps for future reporting cycle
High Capital Costs/ Lack of access to funding	Scoping and set-up of initial framework for climate finance MRV though the GCF Readiness and Support Programme to improve transparency in reporting and improve chances of climate funding	Building on the outputs of the MRV GCF Readiness project- The Bahamas will continue to address data gaps in financial flows and address barriers outlined in the feasibility study produced as an output.
Lack of Awareness/knowledge and skills	Capacity building activities undertaken by local stakeholders in the fields of GHG inventory, mitigation and MRV	Continuation of planned capacity building within the scope of persons identified for GHG, Mitigation, Adaptation and Finance technical working groups
Availability and Suitability of Technology	Conducting country driven Technology Needs Assessment (TNA) in prioritised sectors	Implement action plan of the TNA based on final outputs (2023 completion)
Applicable laws and regulation to allow for IPPs	-	Conduct analysis of current legislation and policies through CBIT and use recommendation for drafting of new policies that mandate the execution and continuity of climate-related institutional

		arrangements and activities that are internationally binding.
Lack of incentives	-	-
Data gaps in particularly the transport sector	Identified and engaged key stakeholders in the transportation sector, and identified main data sources for improvement	Bottom-up data collection activities through customs, licensing, and fuel providers
Establishing a measurement, reporting and verification (MRV) mitigation system for The Bahamas	Conducted an MRV Assessment during the TNC/BUR1 reporting cycle and indicated prioritised actions to implement an integrated National MRV System comprising all reporting sectors	Set up an integrated National MRV System comprising all reporting sectors, that includes legal arrangements for inventory planning, preparation, and management.
Updating of the information relevant for the reporting on Mitigation actions.	Scoping of potential mitigation actions as well as compilation into a mitigation action database	Improvements in data collection and archiving system to capture historic and current mitigation activities, including a monitoring system for tracking of mitigation actions
Provision of training to build or improve the capacities of the relevant stakeholders to complete all or portions of the research, assessments, studies, inventories, and any other capacities required for reporting requirements taking into consideration the new reporting requirements of the Paris Agreement.	Capacity building activities undertaken by local stakeholders in the fields of GHG inventory, mitigation and MRV. Stakeholders were trained not just in technical elements of the reporting requirements but procedural elements as well to increase institutionalised memory of local stakeholders/experts	Continued capacity building training of relevant stakeholders involved in the TNC/BUR1 compilation and review process.

13.2. Technology needs

The Technology Needs Assessment (TNA) is a country-driven process that allows the unique opportunity for Parties to track their needs for new technologies, capacity building, skills, and equipment necessary to reduce the vulnerability of sectors and livelihoods attributed to climate change as well as to mitigate GHG emissions. The assessment facilitates the implementation of prioritised climate technologies as well as sustainable development through a portfolio of environmentally sustainable technology (EST) projects and programmes.

Cognisant of these benefits as well as the support provided through the process to implement a Party's commitment to the Paris Agreement and revision of NDCs (Phase IV), the Government of The Bahamas submitted its endorsement letter to the GEF in October 2019 for inclusion in the latest project phase.

As highlighted in its first NDC, The Bahamas has identified potential adaptation actions in the sectors of agriculture, tourism, health and water resource management as well as the commitment through mitigation actions to reduce its GHG emissions by 30% when compared to its Business as Usual (BAU) scenario by 2030.

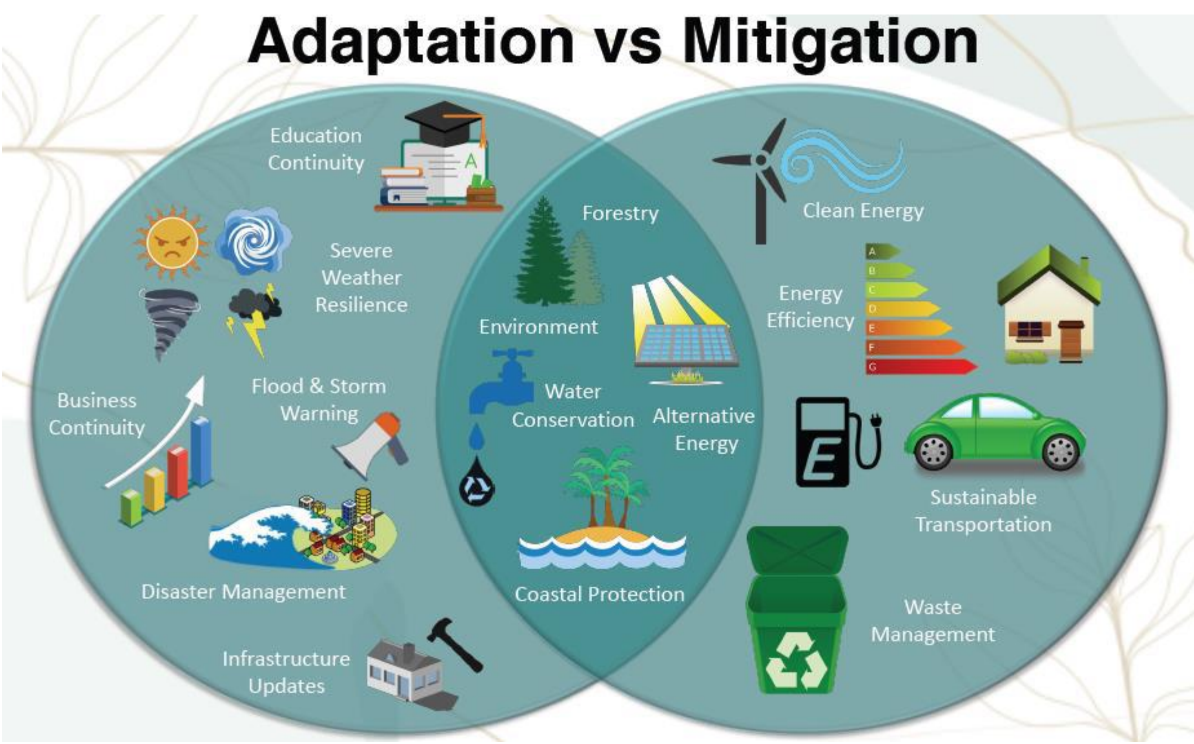
To achieve these goals, The Bahamas will require external support I the forms of investment, finance, capacity building and technology development and transfer in its efforts to prioritise greater implementation of renewable energy sources and to adapt to the negative impacts of climate change. The Bahamas TNA process started in October 2020 and is scheduled to be completed by 2023 with activities being conducted simultaneously with the TNC/BUR1 reporting process.

During the initial activities of the assessment, The Bahamas conducted multi-criteria analysis, reviewed existing planning documents, and engaged stakeholders to prioritise specific sectors to identify technologies for market analysis and eventual inclusion in the National Technology Action Plan (output). Rationale for the chosen sectors as presented by the Bahamas are highlighted in Table 125 and displayed within Figure 80 as an illustration of the integrated nature of intended adaptation and mitigation measures.

Table 125: Rationale for chosen priority areas (as presented during TNA inception workshop)

Identified Priority Area	Rationale
Waste (Mitigation)	One of the largest sources of GHG emissions in the country, probability to increase after climate disasters, need to upscale interventions (especially in an island context)
Forestry (Mitigation)	Significant GHG sink, under threat from climate change and destructive human activities
Meteorology (Adaptation)	Need for accurate forecasting for protection of population and adaptation planning
Education (Adaptation)	Climate change (including disasters) have significantly interrupted the formal education sector, public education and outreach required to enhance climate action

Figure 80: Integrated nature of adaptation and mitigation measures



Through the inception workshop and accompanying stakeholder surveys, The Bahamas formed both adaptation and mitigation working groups that include government public entities, private entities, and academia (gender balanced). Based on SNC submissions, and other key national climate documents, Table 126 through Table 129 are the initial list of technologies under consideration for analysis and review by conducting country interviews and utilizing expert judgement by the aforementioned working groups. It should be noted that due to the stage reached in the assessment process and at the time of writing, the initial lists presented are not exhaustive and may be revised or adapted in future reporting cycles according to the final outputs of the completed TNA process.

Table 126: Initial working group technologies list for Meteorology (Adaptation)

Identified Technology	Specific Name of Technology (If known)	Orgware/Software/Hardware
Coastal Mapping	Lidar Survey	Hardware
Storm Surge Mapping	Lidar Survey	Hardware
Land Survey	Lidar Survey	Hardware
Flood Hazard Mapping	Lidar Survey SLOSH: Sea Lake and Overland Surges from Hurricanes	Hardware
Flood Warning System	-	Orgware
Forecasting and early warning systems	-	Hardware/Orgware
Climate Modelling with Machine Learning/Deep Learning	Python	Software
Climate Forecasting with Machine Learning/Deep Learning	Python	Software
Severe Weather Monitoring and Data Collection	Lightening detector	Hardware/Software
Open water weather monitoring	Fixed weather buoys and drifting weather buoys	Hardware
Air Quality Monitoring	Air pollution Sensor	Hardware
Automatic Weather Stations	-	Hardware/Software
Precipitation Monitoring	Optical and acoustic rain gauge	Hardware
Tide Monitoring	Tide Gauge	Hardware

Table 127: Initial working group technologies list for Education (Adaptation)

Identified Technology	Orgware/Software/Hardware
Trauma Support Programmes	Orgware/Software

Infrastructure Assessment and Upgrades	Orgware/Software
Wireless Network	Orgware/Software
Alternative Energy- Solar	Orgware/Software/Hardware
Rainwater Harvesting and Distribution Systems	Orgware/Software/Hardware
Solar Water Heating	Orgware/Software/Hardware
Curriculum: National adoption of swimming programme	Orgware
Curriculum: Assessment, enhancement of Disaster Preparedness Programme	Orgware/Software
Curriculum: Inclusion of Meteorology, Oceanography, Environmental Studies at undergrad and graduate level	Orgware/Software
Curriculum: Assessment and expansion/enhancement of climate change programmes at the primary and secondary school level	Orgware/Software

Table 128: Initial working group technologies list for waste (Mitigation)

Identified Technology	Orgware/Software/Hardware
Sargassum Seaweed Reuse/Disposal - sustainable Livelihood project	Hardware/Software
Conch Shell Reuse/Disposal - sustainable livelihood project	Hardware/Software
Landfill disposal	Hardware
Waste-energy Technology	Hardware
Waste Incineration	Hardware
Waste Biological Treatment bio-digestor	Hardware
Effluent disposal methods - deep disposal well regulations	Hardware/Software
Alternatives to Cultural Waste Burial/ Open Burn Methods	Software/Orgware
Composting of Organic Waste	Hardware

Table 129: Initial working group technologies list for forestry and other land use (Mitigation)

Identified Technology	Orgware/Software/Hardware
Develop Protection and conservation methods	Orgware/Software
Sustainable Management of the Resources	Software
Forest Restoration Efforts	Hardware/Software
Wood based bio-energy technology	Hardware
Alternative land/property development clearing	Hardware/Software
Tree ordinance/ Replant Initiatives	Orgware/Software
Programme of work relating to ecosystem management	Orgware/Software
National Forestry Estate- Forest Reserves, Protected Forests, and conservation of forests	Software
Sustainable Livelihoods Pilot Projects - indigenous craft industry on Andros and Cascarilla Bark Cultivation/ Processing of Cascarilla Oil in Acklins/ Crooked Islands	Hardware/Software
Management Regime for ecologically important watersheds	Orgware/Software

13.3. Support needed

An assessment and quantification of support needed has not yet been conducted for the prioritized needs identified during the TNC/BUR1 reporting cycle for The Bahamas. Across all areas of climate MRV in The Bahamas, technology transfer, capacity-building, and financial support is needed as soon as possible.

13.4. Support received

As highlighted in the climate finance section of the domestic MRV chapter (2022), The Bahamas through the GCF Readiness and Preparatory Support Programme, engaged in a project to develop a national database system for the MRV of financial investments with specific emphasis on identified actions in the Party's NDC.

Previous reporting and analysis of relevant climate change documents in The Bahamas indicated that there was no clear indication of climate finance inflows as this data was previously collected on a project-by-project basis in an ad-hoc manner. Priority was given to the following tasks in an effort to track historical data flows and provide a baseline for future climate finance reporting improvements in adherence to the TACCC principles:

- Clear overview of NDC related financial flows, sources, and purposes
- Indication of the recipients of the financial support and identification of data gaps

After extensive analysis of readily available documentation and a data collection mission in-country (inclusive of stakeholder interviews), The Bahamas was able to provide an initial mapping of climate finance recipients, mobilising entities and support received values (USD) for the time period 2010-2020. It should be noted that due to data gaps from stakeholders as well as the need to improve on the outputs of the project, that the information provided in Table 130 **through** Table 133 has not yet been validated and will be improved upon in future reporting cycles. Financial information by year was also not readily available and the project team was not able to disaggregate the total figures for the timeseries on a year-by-year basis.

Table 130 provides the sources of climate funds disaggregated by global and regional support as well as multilateral, bilateral, international NGO, and private sector funding.

Table 130: Sources of climate funding disaggregated by region and type (2010-2020)

Type		Name of Institution
Global	Multilateral	United Nations Development Programme (UNDP) (own funds and GEF funds) United Nations Environment (own funds and GEF and GCF funds) Food and Agriculture Organisation of the United Nations (FAO) International Fund for Agricultural Development (IFAD) World Health Organisation (WHO) through the Pan-American Health Organisation (PAHO)

Type		Name of Institution
		United Nations Industrial Development Organization (UNIDO) World Bank (WB) International Finance Corporation (IFC) World Meteorological Organisation (WMO) Global Environment Facility (GEF) Small Grants Programme (SGP) Bahamas Green Climate Fund (GCF) European Investment Bank (EIB)
Global	Bilateral	Japanese International Cooperation Agency (JICA) German Development Bank (KfW) German Development Agency (GIZ) United Kingdom's Department for International Development (DFID) United States Agency for International Development (USAID) Government of Italy Government of the United Arab Emirates
Global	International NGO	International Union for the Conservation of Nature (IUCN)
Global	Private Sector	US-based foundations Bahamas Chamber of Commerce and Employers' Confederation (BCCEC) Bahamas Hotel and Tourism Association (BHTA) Grand Bahama Power Company St. Georges Cay Power Company Ltd. Bahama Solar Sustainable Energy Ltd. Green Revolution Green Bahamas Company Ltd. Bahamas Energy Solutions Enviro Technologies Ltd.
Regional	Multilateral	Inter-American Development Bank (IDB) Caribbean Development Bank (CDB) Caribbean Community Climate Change Centre (5Cs) (own funds and GCF funds) Caribbean Community (CARICOM) Organization of American States (OAS)

Type		Name of Institution
		Economic Commission for Latin America and the Caribbean (ECLAC)
Regional	International NGO	Inter-American Institute for Cooperation on Agriculture (IICA)

Table 131 provides a summary of the financial inflows based on the disaggregated information available in Table 130. Values for private-sector financing have been removed from global support as there was insufficient information to include in the global support totals with GEF and GCF funds currently accounted for under UNDP and UNEP categorisations.

Table 131: Summary of The Bahamas climate finance inflows (2010-2020)

Sources				
Scale	**Type**	**Sum of Total**	**Sum of Adaptation**	**Sum of Mitigation**
Global	Bilateral	$ -	$ -	$ -
	International NGO	$ 50,000	$ 25,000	$ 25,000
	Multilateral	$ 96,136,919	$ 1,615,311	$ 94,521,609
Global Total		**$ 96,186,919**	**$ 1,640,311**	**$ 94,546,609**
Regional	International NGO	$ 247,911	$ 92,842	$ 155,069
	Multilateral	$ 7,348,754	$ 2,074,655	$ 5,274,100
Regional Total		**$ 7,596,665**	**$ 2,167,496**	**$ 5,429,169**
Domestic	Private sector	**$ 51,249,999**	**$ 10,400,000**	**$ 40,849,999**
Overall Total		**$ 155,033,583**	**$ 14,207,807**	**$ 140,825,777**

Table 132 and Table 133 provide the institutions that mobilise resources from international climate change funds in The Bahamas.

Table 132: Mobilising entities in The Bahamas (2010-2020)

Type of Institution	Name of Institution
Global / Multilateral / United Nations	United Nations Development Programme (UNDP) United Nations Environment Food and Agriculture Organisation of the United Nations (FAO) International Fund for Agricultural Development (IFAD) World Health Organisation (WHO) through the Pan-American Health Organisation (PAHO) United Nations Industrial Development Organization (UNIDO)
Regional	Caribbean Community Climate Change Centre
National	Ministry Of Environment and Housing

Table 133: Financial flows disaggregated by mobilising entity (2010-2020)

Entity Mobilising Funds			
Name of Institution	**Total**	**Adaptation**	**Mitigation**
United Nations Development Programme (UNDP)	$ 9,999,999.00	$ -	$ 9,999,999.00
United Nations Environment	$ 85,296,321.00	$ 800,000.00	$ 84,496,321.00
Food and Agriculture Organisation of the United Nations (FAO)	$ -	$ -	$ -
International Fund for Agricultural Development (IFAD)	$ 1,355.00	$ 1,355.00	$ -
World Health Organisation (WHO) through the Pan-American Health Organisation (PAHO)			$ -
United Nations Industrial Development Organization (UNIDO)	$ -	$ -	$ -
World Meteorological Organisation (WMO)	$ 789,222.00	$ 789,222.00	$ -
Caribbean Community Climate Change Centre (5Cs)	$ 1,163,677.20	$ 1,020,335.80	$ 143,341.40
Ministry of Environment and Housing	$ 56,558,325.00	$ 11,679,162.50	$ 44,879,162.50
Total	$ 153,808,899.20	$ 14,290,075.30	$ 139,518,823.90

13.4.1. Support received for the preparation of BUR1

The Bahamas received multilateral financial support from the GEF in 2019 in the amount of 852,0000 (USD) to develop its TNC (in addition to its BUR1). The funding was administered through the Global Environment Facility (GEF) with the United Nations Environment Programme (UNEP) having the responsibility as the implementing agency, and the Department of Environmental Planning and Protection (formerly known as The Bahamas Environment, Science and Technology (BEST) Commission) serving on behalf of the Government of The Bahamas, as the executing agency. The funding was used to contract the Caribbean Cooperative MRV Hub, Greenhouse Gas Management Institute, SEV Consulting Group, University College London, Factor Integral Services Limited, and two independent consultants. Moreover, the National Project Coordinator and external auditor would have also been contracted with this funding to ensure successful implementation and fiscal management of the TNC/BUR1 project.

13.5. Data and information gaps and needs for improvement of reporting

The Government of The Bahamas has prioritised improvements in its climate finance MRV for the next reporting cycle. The financial flow tables presented in this chapter have been presented in an effort to improve transparency in reporting, though the Party is cognisant that more efforts need to be made to comprehensively mapping and validating financial flows to The Bahamas. Furthermore, a list of climate change projects and allocation of support across these projects remains a prioritised improvement for The Bahamas. Improvements in charting public, domestic, international, and private financial flows in The Bahamas is an on-going exercise, noting that understanding these flows facilitates financial planning and resource mobilization to meet The Bahamas' international commitments on climate mitigation and adaptation.

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Annexes: Related to Greenhouse Gas (GHG) Inventories

Annex I - GHG emission tables

Table 134: Total GHG emissions 2001-2010

Categories	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total National Emissions and Removals	5077.85	5157.60	4852.38	4901.25	3640.68	3744.15	3765.39	3832.61	3738.27	5926.03
1 - Energy	2435.21	2512.78	2207.71	2243.39	2407.76	2501.62	2517.49	2583.99	2485.98	2583.91
1.A - Fuel Combustion Activities	2435.20	2512.78	2207.70	2243.38	2407.75	2501.61	2517.48	2583.98	2485.97	2583.90
1.A.1 - Energy Industries	1532.51	1593.82	1217.35	1159.20	1177.49	1223.71	1234.82	1291.91	1200.84	1327.57
1.A.1.a - Main Activity Electricity and Heat Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.1.a.i - Electricity Generation	1532.51	1593.82	1217.35	1159.20	1177.49	1223.71	1234.82	1291.91	1200.84	1327.57
1.A.1.a.ii - Combined Heat and Power Generation (CHP)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.1.a.iii - Heat Plants	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.1.b - Petroleum Refining	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

1.A.1.c.i - Manufacture of Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.1.c.ii - Other Energy Industries	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.2 - Manufacturing Industries and Construction	177.18	188.55	187.28	245.98	290.65	279.34	304.83	283.12	288.83	239.32
1.A.2.a - Iron and Steel	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.2.b - Non-Ferrous Metals	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.2.c - Chemicals	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.2.d - Pulp, Paper and Print	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1.A.2.e - Food Processing, Beverages and Tobacco	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1.A.2.f - Non-Metallic Minerals	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.2.g - Transport Equipment	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.2.h - Machinery	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.2.i - Mining (excluding fuels) and Quarrying	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1.A.2.j - Wood and wood products	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1.A.2.k - Construction	33.42	35.57	35.52	46.65	55.13	52.99	57.82	53.70	54.80	45.41
1.A.2.l - Textile and Leather	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1.A.2.m - Non-specified Industry	143.76	152.98	151.76	199.33	235.52	226.35	247.01	229.43	234.04	193.91
1.A.3 - Transport	494.45	504.45	562.57	585.06	621.10	634.05	620.64	627.34	641.82	658.85
1.A.3.a - Civil Aviation	75.79	67.53	75.51	81.90	85.55	90.82	80.99	79.90	67.87	69.87

1.A.3.a.ii - Domestic Aviation	75.79	67.53	75.51	81.90	85.55	90.82	80.99	79.90	67.87	69.87
1.A.3.b - Road Transportation	402.93	420.56	479.88	493.39	524.42	532.94	528.10	536.45	563.54	580.58
1.A.3.b.i - Cars	278.29	285.02	345.83	313.91	309.67	326.41	301.26	327.72	349.22	406.55
1.A.3.b.i.1 - Passenger cars with 3-way catalysts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b.i.2 - Passenger cars without 3-way catalysts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b.ii - Light-duty trucks	83.90	87.60	99.83	102.89	109.50	111.21	110.33	111.95	117.57	120.85
1.A.3.b.ii.1 - Light-duty trucks with 3-way catalysts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalysts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b.iii - Heavy-duty trucks and buses	40.52	47.72	33.93	76.34	105.00	95.05	116.26	96.52	96.47	52.85
1.A.3.b.iv - Motorcycles	0.22	0.23	0.28	0.25	0.25	0.26	0.24	0.26	0.28	0.32
1.A.3.b.v - Evaporative emissions from vehicles	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.3.b.vi - Urea-based catalysts	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.3.c - Railways	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.3.d - Water-borne Navigation	15.72	16.35	7.18	9.77	11.13	10.29	11.55	10.99	10.41	8.40

1.A.3.d.i - International water-borne navigation (International bunkers) (1)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.3.d.ii - Domestic Water-borne Navigation	15.72	16.35	7.18	9.77	11.13	10.29	11.55	10.99	10.41	8.40
1.A.3.e - Other Transportation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.e.i - Pipeline Transport	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.3.e.ii - Off-road	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1.A.4 - Other Sectors	231.07	225.96	240.50	253.15	318.51	364.50	357.19	381.60	354.47	358.16
1.A.4.a - Commercial/Institutional	184.82	184.85	198.20	197.87	258.36	305.49	293.81	320.30	297.46	304.43
1.A.4.b - Residential	30.17	23.72	24.98	32.53	33.10	33.05	35.02	35.04	30.03	31.58
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	16.08	17.39	17.32	22.75	27.05	25.97	28.36	26.26	26.98	22.15
1.A.5 - Non-Specified	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.B - Fugitive emissions from fuels	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1.B.1 - Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.B.2 - Oil and Natural Gas	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1.B.2.a - Oil	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1.B.2.a.iii.3 - Transport	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1.B.2.b - Natural Gas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

1.B.3 - Other emissions from Energy Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.C - Carbon dioxide Transport and Storage	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2 - Industrial Processes and Product Use	3.75	8.43	2.84	2.84	3.42	4.17	3.25	3.59	3.09	3.17
2.A - Mineral Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B - Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C - Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D - Non-Energy Products from Fuels and Solvent Use (6)	3.75	8.43	2.84	2.84	3.42	4.17	3.25	3.59	3.09	3.17
2.D.1 - Lubricant Use	3.75	8.43	2.84	2.84	3.42	4.17	3.25	3.59	3.09	3.17
2.D.2 - Paraffin Wax Use	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.D.3 - Solvent Use (7)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D.4 - Other (please specify) (3), (8)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.E - Electronics Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F - Product Uses as Substitutes for Ozone Depleting Substances	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G - Other Product Manufacture and Use	NO/NE	NO/NE	NO/NE	NO/NE	NO/NE	NO/NE	NO/NE	NO/NE	NO/NE	NO/NE
2.G.1 - Electrical Equipment	NO/NE	NO/NE	NO/NE	NO/NE	NO/NE	NO/NE	NO/NE	NO/NE	NO/NE	NO/NE

2.G.1.a - Manufacture of Electrical Equipment	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.G.1.b - Use of Electrical Equipment	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G.1.c - Disposal of Electrical Equipment	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G.2 - SF6 and PFCs from Other Product Uses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.G.3 - N2O from Product Uses	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G.4 - Other (Please specify) (3)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.H - Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3 - Agriculture, Forestry, and Other Land Use	2393.69	2387.17	2388.73	2397.80	967.73	971.70	973.12	968.57	967.69	3052.16
3.A - Livestock	1.93	3.43	2.82	2.94	2.94	2.82	2.89	2.91	2.91	2.96
3.A.1 - Enteric Fermentation	1.36	2.06	1.51	1.59	1.60	1.48	1.53	1.55	1.56	1.60
3.A.2 - Manure Management	0.58	1.37	1.31	1.34	1.34	1.34	1.35	1.35	1.35	1.36
3.B - Land	2377.60	2377.60	2377.60	2377.60	955.66	955.66	955.66	955.66	955.66	3042.82
3.B.1 - Forest land	-930.54	-930.54	-930.54	-930.54	-1341.03	-1341.03	-1341.03	-1341.03	-1341.03	-1059.49
3.B.1.a - Forest land Remaining Forest land	-361.60	-361.60	-361.60	-361.60	-434.70	-434.70	-434.70	-434.70	-434.70	-527.69

3.B.1.b - Land Converted to Forest land	-568.94	-568.94	-568.94	-568.94	-906.32	-906.32	-906.32	-906.32	-906.32	-531.80
3.B.1.b.i - Cropland converted to Forest Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.1.b.ii - Grassland converted to Forest Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.1.b.iii - Wetlands converted to Forest Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.1.b.iv - Settlements converted to Forest Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.1.b.v - Other Land converted to Forest Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.2 - Cropland	380.16	380.16	380.16	380.16	318.55	318.55	318.55	318.55	318.55	146.16
3.B.2.a - Cropland Remaining Cropland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.2.b - Land Converted to Cropland	380.16	380.16	380.16	380.16	318.55	318.55	318.55	318.55	318.55	146.16
3.B.2.b.i - Forest Land converted to Cropland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.2.b.ii - Grassland converted to Cropland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

3.B.2.b.iii - Wetlands converted to Cropland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.2.b.iv - Settlements converted to Cropland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.2.b.v - Other Land converted to Cropland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.3 - Grassland	1750.81	1750.81	1750.81	1750.81	1053.48	1053.48	1053.48	1053.48	1053.48	2599.54
3.B.3.a - Grassland Remaining Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.3.b - Land Converted to Grassland	1750.81	1750.81	1750.81	1750.81	1053.48	1053.48	1053.48	1053.48	1053.48	2599.54
3.B.3.b.i - Forest Land converted to Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.3.b.ii - Cropland converted to Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.3.b.iii - Wetlands converted to Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.3.b.iv - Settlements converted to Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.3.b.v - Other Land converted to Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.4 - Wetlands	324.78	324.78	324.78	324.78	302.22	302.22	302.22	302.22	302.22	1103.24

3.B.4.a - Wetlands Remaining Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.4.a.i - Peatlands remaining peatlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.4.a.ii - Flooded land remaining flooded land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.4.b - Land Converted to Wetlands	324.78	324.78	324.78	324.78	302.22	302.22	302.22	302.22	302.22	1103.24
3.B.4.b.i - Land converted for peat extraction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.4.b.ii - Land converted to flooded land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.4.b.iii - Land converted to other wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.5 - Settlements	819.38	819.38	819.38	819.38	598.61	598.61	598.61	598.61	598.61	217.44
3.B.5.a - Settlements Remaining Settlements	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.5.b - Land Converted to Settlements	819.38	819.38	819.38	819.38	598.61	598.61	598.61	598.61	598.61	217.44
3.B.5.b.i - Forest Land converted to Settlements	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

3.B.5.b.ii - Cropland converted to Settlements	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.5.b.iii - Grassland converted to Settlements	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.5.b.iv - Wetlands converted to Settlements	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.5.b.v - Other Land converted to Settlements	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.6 - Other Land	33.01	33.01	33.01	33.01	23.83	23.83	23.83	23.83	23.83	35.94
3.B.6.a - Other land Remaining Other land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.6.b - Land Converted to Other land	33.01	33.01	33.01	33.01	23.83	23.83	23.83	23.83	23.83	35.94
3.B.6.b.i - Forest Land converted to Other Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.6.b.ii - Cropland converted to Other Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.6.b.iii - Grassland converted to Other Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.6.b.iv - Wetlands converted to Other Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

3.B.6.b.v - Settlements converted to Other Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.C - Aggregate sources and non-CO2 emissions sources on land (2)	14.15	6.14	8.30	17.26	9.13	13.21	14.58	10.01	9.12	6.38
3.C.1 - Emissions from biomass burning	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3.C.2 - Liming	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.C.3 - Urea application	0.05	0.19	0.15	0.23	0.00	1.68	0.04	0.31	1.15	0.69
3.C.4 - Direct N2O Emissions from managed soils (3)	10.51	4.12	5.79	12.49	6.53	8.33	10.61	6.96	5.65	3.93
3.C.5 - Indirect N2O Emissions from managed soils	3.45	1.40	1.92	4.10	2.16	2.75	3.49	2.31	1.88	1.32
3.C.6 - Indirect N2O Emissions from manure management	0.14	0.43	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44
3.C.7 - Rice cultivation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.C.8 - Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.D - Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.D.1 - Harvested Wood Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.D.2 - Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4 - Waste	245.20	249.22	253.11	257.22	261.77	266.67	271.52	276.46	281.51	286.79
4.A - Solid Waste Disposal	205.78	209.13	212.62	216.27	220.07	224.02	228.10	232.32	236.62	240.94

4.B - Biological Treatment of Solid Waste	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4.C - Incineration and Open Burning of Waste	1.32	1.34	1.37	1.39	1.42	1.45	1.47	1.50	1.53	1.55
4.C.1 - Waste Incineration	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4.C.2 - Open Burning of Waste	1.32	1.34	1.37	1.39	1.42	1.45	1.47	1.50	1.53	1.55
4.D - Wastewater Treatment and Discharge	38.09	38.74	39.12	39.56	40.28	41.20	41.95	42.64	43.37	44.29
4.D.1 - Domestic Wastewaster Treatment and Discharge	38.09	38.74	39.12	39.56	40.28	41.20	41.95	42.64	43.37	44.29
4.D.2 - Industrial Wastewater Treatment and Discharge	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4.E - Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo Items										
1.A.3.a.i - International aviation (International bunkers)	1080.62	1083.8	519.225	626.017	571.601	755.03	915.785	752.082	615.814	609.6922
1.A.3.d.i - International water-borne navigation (International bunkers)	976.426	979.294	469.16	565.655	516.485	682.228	827.483	679.565	556.436	550.9042

Table 135: Total GHG emissions 2011-2018

Categories	2011	2012	2013	2014	2015	2016	2017	2018
Total National Emissions and Removals	5771.82	5902.51	5941.44	6045.44	6053.83	6063.13	6115.05	6264.31
1 - Energy	2427.07	2553.17	2588.42	2686.94	2752.86	2759.77	2805.72	2949.58
1.A - Fuel Combustion Activities	2427.06	2553.16	2588.41	2686.93	2752.85	2759.76	2805.71	2949.56
1.A.1 - Energy Industries	1300.38	1165.09	1156.89	1291.53	1334.40	1383.86	1363.47	1430.77
1.A.1.a - Main Activity Electricity and Heat Production	NO	NO	NO	NO	NO	NO	NO	NO
1.A.1.a.i - Electricity Generation	1300.38	1165.09	1156.89	1291.53	1334.40	1383.86	1363.47	1430.77
1.A.1.a.ii - Combined Heat and Power Generation (CHP)	NO	NO	NO	NO	NO	NO	NO	NO
1.A.1.a.iii - Heat Plants	NO	NO	NO	NO	NO	NO	NO	NO
1.A.1.b - Petroleum Refining	NO	NO	NO	NO	NO	NO	NO	NO
1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries	NO	NO	NO	NO	NO	NO	NO	NO

Categories	2011	2012	2013	2014	2015	2016	2017	2018
1.A.1.c.i - Manufacture of Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO
1.A.1.c.ii - Other Energy Industries	NO	NO	NO	NO	NO	NO	NO	NO
1.A.2 - Manufacturing Industries and Construction	253.17	365.38	335.03	320.99	327.69	309.69	339.29	350.19
1.A.2.a - Iron and Steel	NO	NO	NO	NO	NO	NO	NO	NO
1.A.2.b - Non-Ferrous Metals	NO	NO	NO	NO	NO	NO	NO	NO
1.A.2.c - Chemicals	NO	NO	NO	NO	NO	NO	NO	NO
1.A.2.d - Pulp, Paper and Print	IE	IE	IE	IE	IE	IE	IE	IE
1.A.2.e - Food Processing, Beverages and Tobacco	IE	IE	IE	IE	IE	IE	IE	IE
1.A.2.f - Non-Metallic Minerals	NO	NO	NO	NO	NO	NO	NO	NO
1.A.2.g - Transport Equipment	NO	NO	NO	NO	NO	NO	NO	NO
1.A.2.h - Machinery	NO	NO	NO	NO	NO	NO	NO	NO

Categories	2011	2012	2013	2014	2015	2016	2017	2018
1.A.2.i - Mining (excluding fuels) and Quarrying	IE	IE	IE	IE	IE	IE	IE	IE
1.A.2.j - Wood and wood products	IE	IE	IE	IE	IE	IE	IE	IE
1.A.2.k - Construction	48.07	69.40	63.66	60.98	62.27	58.85	64.50	66.58
1.A.2.l - Textile and Leather	IE	IE	IE	IE	IE	IE	IE	IE
1.A.2.m - Non-specified Industry	205.10	295.98	271.38	260.02	265.42	250.84	274.79	283.62
1.A.3 - Transport	567.16	681.13	639.38	650.10	675.76	654.90	704.57	727.65
1.A.3.a - Civil Aviation	63.46	66.46	54.11	68.51	72.64	67.34	72.24	74.29
1.A.3.a.ii - Domestic Aviation	63.46	66.46	54.11	68.51	72.64	67.34	72.24	74.29
1.A.3.b - Road Transportation	496.56	605.42	577.62	573.70	596.06	580.96	626.36	647.33
1.A.3.b.i - Cars	309.81	333.26	329.69	337.32	355.73	352.70	375.15	390.52
1.A.3.b.i.1 - Passenger cars with 3-way catalysts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b.i.2 - Passenger cars without 3-way catalysts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b.ii - Light-duty trucks	103.59	126.56	120.68	119.80	124.44	121.25	130.75	135.12

Categories	2011	2012	2013	2014	2015	2016	2017	2018
1.A.3.b.ii.1 - Light-duty trucks with 3-way catalysts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalysts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b.iii - Heavy-duty trucks and buses	82.91	145.34	126.99	116.31	115.62	106.73	120.15	121.38
1.A.3.b.iv - Motorcycles	0.25	0.27	0.26	0.27	0.28	0.28	0.30	0.31
1.A.3.b.v - Evaporative emissions from vehicles	NO	NO	NO	NO	NO	NO	NO	NO
1.A.3.b.vi - Urea-based catalysts	NO	NO	NO	NO	NO	NO	NO	NO
1.A.3.c - Railways	NO	NO	NO	NO	NO	NO	NO	NO
1.A.3.d - Water-borne Navigation	7.14	9.24	7.66	7.89	7.06	6.60	5.97	6.03
1.A.3.d.i - International water-borne navigation (International bunkers) (1)	NO	NO	NO	NO	NO	NO	NO	NO
1.A.3.d.ii - Domestic Water-borne Navigation	7.14	9.24	7.66	7.89	7.06	6.60	5.97	6.03

Categories	2011	2012	2013	2014	2015	2016	2017	2018
1.A.3.e - Other Transportation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.e.i - Pipeline Transport	NO	NO	NO	NO	NO	NO	NO	NO
1.A.3.e.ii - Off-road	IE	IE	IE	IE	IE	IE	IE	IE
1.A.4 - Other Sectors	306.36	341.57	457.11	424.32	415.00	411.31	398.38	440.95
1.A.4.a - Commercial/Institutional	252.08	267.35	383.92	351.62	336.62	342.79	325.55	356.71
1.A.4.b - Residential	30.74	40.13	42.08	43.00	48.18	39.80	41.27	51.98
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	23.53	34.09	31.10	29.70	30.19	28.73	31.56	32.27
1.A.5 - Non-Specified	NO	NO	NO	NO	NO	NO	NO	NO
1.B - Fugitive emissions from fuels	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02
1.B.1 - Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO
1.B.2 - Oil and Natural Gas	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02
1.B.2.a - Oil	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02
1.B.2.a.iii.3 - Transport	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02
1.B.2.b - Natural Gas	NO	NO	NO	NO	NO	NO	NO	NO

Categories	2011	2012	2013	2014	2015	2016	2017	2018
1.B.3 - Other emissions from Energy Production	NO	NO	NO	NO	NO	NO	NO	NO
1.C - Carbon dioxide Transport and Storage	NO	NO	NO	NO	NO	NO	NO	NO
2 - Industrial Processes and Product Use	1.42	1.08	1.75	1.00	1.00	1.00	1.17	1.08
2.A - Mineral Industry	NO	NO	NO	NO	NO	NO	NO	NO
2.B - Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO
2.C - Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO
2.D - Non-Energy Products from Fuels and Solvent Use (6)	1.42	1.08	1.75	1.00	1.00	1.00	1.17	1.08
2.D.1 - Lubricant Use	1.42	1.08	1.75	1.00	1.00	1.00	1.17	1.08
2.D.2 - Paraffin Wax Use	NE	NE	NE	NE	NE	NE	NE	NE
2.D.3 - Solvent Use (7)	NO	NO	NO	NO	NO	NO	NO	NO
2.D.4 - Other (please specify) (3), (8)	NO	NO	NO	NO	NO	NO	NO	NO
2.E - Electronics Industry	NO	NO	NO	NO	NO	NO	NO	NO
2.F - Product Uses as Substitutes for Ozone Depleting Substances	NE	NE	NE	NE	NE	NE	NE	NE

Categories	2011	2012	2013	2014	2015	2016	2017	2018
2.G - Other Product Manufacture and Use	NO/NE	NO/NE	NO/NE	NO/NE	NO/NE	NO/NE	NO/NE	NO/NE
2.G.1 - Electrical Equipment	NO/NE	NO/NE	NO/NE	NO/NE	NO/NE	NO/NE	NO/NE	NO/NE
2.G.1.a - Manufacture of Electrical Equipment	NO	NO	NO	NO	NO	NO	NO	NO
2.G.1.b - Use of Electrical Equipment	NE	NE	NE	NE	NE	NE	NE	NE
2.G.1.c - Disposal of Electrical Equipment	NE	NE	NE	NE	NE	NE	NE	NE
2.G.2 - SF6 and PFCs from Other Product Uses	NO	NO	NO	NO	NO	NO	NO	NO
2.G.3 - N2O from Product Uses	NE	NE	NE	NE	NE	NE	NE	NE
2.G.4 - Other (Please specify) (3)	NO	NO	NO	NO	NO	NO	NO	NO
2.H - Other	NO	NO	NO	NO	NO	NO	NO	NO
3 - Agriculture, Forestry, and Other Land Use	3051.84	3052.31	3050.36	3052.66	2991.21	2989.65	2991.64	2993.34
3.A - Livestock	2.90	2.96	2.94	3.10	3.01	2.95	3.07	3.14

Categories	2011	2012	2013	2014	2015	2016	2017	2018
3.A.1 - Enteric Fermentation	1.53	1.60	1.55	1.66	1.60	1.54	1.64	1.69
3.A.2 - Manure Management	1.37	1.37	1.38	1.44	1.41	1.41	1.43	1.45
3.B - Land	3042.82	3042.82	3042.82	3042.82	2979.11	2979.11	2979.11	2979.11
3.B.1 - Forest land	- 1059.49	- 1059.49	- 1059.49	- 1059.49	- 1042.62	- 1042.62	- 1042.62	- 1042.62
3.B.1.a - Forest land Remaining Forest land	-527.69	-527.69	-527.69	-527.69	-503.33	-503.33	-503.33	-503.33
3.B.1.b - Land Converted to Forest land	-531.80	-531.80	-531.80	-531.80	-539.28	-539.28	-539.28	-539.28
3.B.1.b.i - Cropland converted to Forest Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.1.b.ii - Grassland converted to Forest Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.1.b.iii - Wetlands converted to Forest Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.1.b.iv - Settlements converted to Forest Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.1.b.v - Other Land converted to Forest Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Categories	2011	2012	2013	2014	2015	2016	2017	2018
3.B.2 - Cropland	146.16	146.16	146.16	146.16	138.31	138.31	138.31	138.31
3.B.2.a - Cropland Remaining Cropland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.2.b - Land Converted to Cropland	146.16	146.16	146.16	146.16	138.31	138.31	138.31	138.31
3.B.2.b.i - Forest Land converted to Cropland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.2.b.ii - Grassland converted to Cropland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.2.b.iii - Wetlands converted to Cropland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.2.b.iv - Settlements converted to Cropland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.2.b.v - Other Land converted to Cropland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.3 - Grassland	2599.54	2599.54	2599.54	2599.54	2986.35	2986.35	2986.35	2986.35
3.B.3.a - Grassland Remaining Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.3.b - Land Converted to Grassland	2599.54	2599.54	2599.54	2599.54	2986.35	2986.35	2986.35	2986.35

Categories	2011	2012	2013	2014	2015	2016	2017	2018
3.B.3.b.i - Forest Land converted to Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.3.b.ii - Cropland converted to Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.3.b.iii - Wetlands converted to Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.3.b.iv - Settlements converted to Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.3.b.v - Other Land converted to Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.4 - Wetlands	1103.24	1103.24	1103.24	1103.24	550.03	550.03	550.03	550.03
3.B.4.a - Wetlands Remaining Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.4.a.i - Peatlands remaining peatlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.4.a.ii - Flooded land remaining flooded land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.4.b - Land Converted to Wetlands	1103.24	1103.24	1103.24	1103.24	550.03	550.03	550.03	550.03
3.B.4.b.i - Land converted for peat extraction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Categories	2011	2012	2013	2014	2015	2016	2017	2018
3.B.4.b.ii - Land converted to flooded land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.4.b.iii - Land converted to other wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.5 - Settlements	217.44	217.44	217.44	217.44	304.20	304.20	304.20	304.20
3.B.5.a - Settlements Remaining Settlements	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.5.b - Land Converted to Settlements	217.44	217.44	217.44	217.44	304.20	304.20	304.20	304.20
3.B.5.b.i - Forest Land converted to Settlements	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.5.b.ii - Cropland converted to Settlements	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.5.b.iii - Grassland converted to Settlements	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.5.b.iv - Wetlands converted to Settlements	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.5.b.v - Other Land converted to Settlements	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.6 - Other Land	35.94	35.94	35.94	35.94	42.83	42.83	42.83	42.83

Categories	2011	2012	2013	2014	2015	2016	2017	2018
3.B.6.a - Other land Remaining Other land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.6.b - Land Converted to Other land	35.94	35.94	35.94	35.94	42.83	42.83	42.83	42.83
3.B.6.b.i - Forest Land converted to Other Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.6.b.ii - Cropland converted to Other Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.6.b.iii - Grassland converted to Other Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.6.b.iv - Wetlands converted to Other Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.6.b.v - Settlements converted to Other Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.C - Aggregate sources and non-CO2 emissions sources on land (2)	6.12	6.53	4.60	6.74	9.10	7.59	9.47	11.09
3.C.1 - Emissions from biomass burning	NE	NE	NE	NE	NE	NE	NE	NE
3.C.2 - Liming	NO	NO	NO	NO	NO	NO	NO	NO

Categories	2011	2012	2013	2014	2015	2016	2017	2018
3.C.3 - Urea application	0.76	0.15	0.09	0.88	0.49	0.06	0.18	0.11
3.C.4 - Direct N2O Emissions from managed soils (3)	3.67	4.44	3.04	4.04	6.12	5.30	6.64	7.99
3.C.5 - Indirect N2O Emissions from managed soils	1.24	1.49	1.03	1.36	2.03	1.77	2.20	2.65
3.C.6 - Indirect N2O Emissions from manure management	0.46	0.44	0.45	0.46	0.45	0.46	0.45	0.35
3.C.7 - Rice cultivation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.C.8 - Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.D - Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.D.1 - Harvested Wood Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.D.2 - Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4 - Waste	291.49	295.94	300.90	304.83	308.75	312.71	316.51	320.31
4.A - Solid Waste Disposal	245.20	249.32	253.25	256.98	260.56	264.04	267.46	270.85

Categories	2011	2012	2013	2014	2015	2016	2017	2018
4.B - Biological Treatment of Solid Waste	NO	NO	NO	NO	NO	NO	NO	NO
4.C - Incineration and Open Burning of Waste	1.57	1.59	1.60	1.62	1.63	1.65	1.67	1.68
4.C.1 - Waste Incineration	NO	NO	NO	NO	NO	NO	NO	NO
4.C.2 - Open Burning of Waste	1.57	1.59	1.60	1.62	1.63	1.65	1.67	1.68
4.D - Wastewater Treatment and Discharge	44.72	45.03	46.05	46.23	46.55	47.02	47.38	47.77
4.D.1 - Domestic Wastewaster Treatment and Discharge	44.72	45.03	46.05	46.23	46.55	47.02	47.38	47.77
4.D.2 - Industrial Wastewater Treatment and Discharge	NO	NO	NO	NO	NO	NO	NO	NO
4.E - Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO
Memo Items								
1.A.3.a.i - International aviation (International bunkers)	682.02	918.05	783.60	698.12	556.18	565.48	632.14	682.47

Categories	2011	2012	2013	2014	2015	2016	2017	2018
1.A.3.d.i - International water-borne navigation (International bunkers)	616.26	829.53	708.04	630.80	502.55	510.95	571.19	616.67

Table 136: GHG emissions in 2018

	Emissions (Gg)			Emissions CO2 Equivalents (Gg)				Emissions (Gg)					Total Emissions
Categories	Net CO2 (1)(2)	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors (3)	Other halogenated gases without CO2 equivalent conversion factors (4)	NOx	CO	NMVOCs	SO2	**CO2 Equivalents (Gg)**
Total National Emissions and Removals	5909.26	11.68	0.12	NE	NE	NE	NE	NE	NE	NE	NE	NE	6264.31

1 - Energy	2928.14	0.38	0.05						NE	NE	NE	NE	2949.58
1.A - Fuel Combustion Activities	2928.12	0.38	0.05						NE	NE	NE	NE	2949.56
1.A.1 - Energy Industries	1426.02	0.06	0.01						NE	NE	NE	NE	1430.77
1.A.1.a.i - Electricity Generation	1426.02	0.06	0.01						NE	NE	NE	NE	1430.77
1.A.2 - Manufacturing Industries and Construction	349.02	0.01	0.00						NE	NE	NE	NE	350.19
1.A.2.k - Construction	66.35	0.00	0.00						NE	NE	NE	NE	66.58
1.A.2.m - Non-specified Industry	282.66	0.01	0.00						NE	NE	NE	NE	283.62
1.A.3 - Transport	711.93	0.24	0.03						NE	NE	NE	NE	727.65
1.A.3.a Aviation	73.72	0.00	0.00						NE	NE	NE	NE	74.29
1.A.3.a.ii - Domestic Aviation	73.72	0.00	0.00						NE	NE	NE	NE	74.29
1.A.3.b - Road Transportation	632.24	0.24	0.03						NE	NE	NE	NE	647.33
1.A.3.b.i - Cars	380.43	0.18	0.02						NE	NE	NE	NE	390.52
1.A.3.b.ii - Light-duty trucks	131.97	0.05	0.01						NE	NE	NE	NE	135.12
1.A.3.b.iii - Heavy-duty trucks and buses	119.52	0.01	0.01						NE	NE	NE	NE	121.38
1.A.3.b.iv - Motorcycles	0.31	0.00	0.00						NE	NE	NE	NE	0.31
1.A.3.c Water-borne Navigation	5.97	0.00	0.00						NE	NE	NE	NE	6.03
1.A.3.d.ii - Domestic Water-borne Navigation	5.97	0.00	0.00						NE	NE	NE	NE	6.03
1.A.4 - Other Sectors	441.16	0.07	0.00						NE	NE	NE	NE	440.95
1.A.4.a - Commercial/Institutional	358.25	0.06	0.00						NE	NE	NE	NE	356.71
1.A.4.b - Residential	50.84	0.01	0.00						NE	NE	NE	NE	51.98

1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	32.06	0.00	0.00						NE	NE	NE	NE	32.27
1.B - Fugitive emissions from fuels	0.02	0.00	0.00						NE	NE	NE	NE	0.02
1.B.2 - Oil and Natural Gas	0.00	0.00	0.00						NE	NE	NE	NE	0.02
1.B.2.a.iii.3 - Transport	0.02	0.00	0.00						NE	NE	NE	NE	0.02
2 - Industrial Processes and Product Use	1.17	0.00	0.00						NE	NE	NE	NE	1.08
2.D - Non-Energy Products from Fuels and Solvent Use	1.17	0.00	0.00						NE	NE	NE	NE	1.08
2.D.1 - Lubricant Use	1.17								NE	NE	NE	NE	1.08
3 - Agriculture, Forestry, and Other Land Use	2979.22	0.08	0.04						NO	NO	NO	NO	2993.34
3.A - Livestock	0.00	0.08	0.00						NO	NO	NO	NO	3.14
3.A.1 - Enteric Fermentation		0.06							NO	NO	NO	NO	1.69
3.A.2 - Manure Management		0.02	0.00						NO	NO	NO	NO	1.45
3.B - Land	2979.11	0.00	0.00						NO	NO	NO	NO	2979.11
3.B.1 - Forest land	-1042.62								NO	NO	NO	NO	-1042.62
3.B.1.a - Forest land Remaining Forest land	-503.33								NO	NO	NO	NO	-503.33
3.B.1.b - Land Converted to Forest land	-539.28								NO	NO	NO	NO	-539.28
3.B.2 - Cropland	138.31								NO	NO	NO	NO	138.31
3.B.2.b - Land Converted to Cropland	138.31								NO	NO	NO	NO	138.31
3.B.3 - Grassland	2986.35								NO	NO	NO	NO	2986.35

3.B.3.b - Land Converted to Grassland	2986.35								NO	NO	NO	NO	2986.35
3.B.4 - Wetlands	550.03		0.00						NO	NO	NO	NO	550.03
3.B.4.b - Land Converted to Wetlands	550.03		0.00						NO	NO	NO	NO	550.03
3.B.5 - Settlements	304.20								NO	NO	NO	NO	304.20
3.B.5.b - Land Converted to Settlements	304.20								NO	NO	NO	NO	304.20
3.B.6 - Other Land	42.83								NO	NO	NO	NO	42.83
3.B.6.b - Land Converted to Other land	42.83								NO	NO	NO	NO	42.83
3.C - Aggregate sources and non-CO2 emissions sources on land	0.11	0.00	0.04						NO	NO	NO	NO	11.09
3.C.1 - Emissions from biomass burning	NE	NE	NE						NE	NE	NE	NE	NE
3.C.2 - Liming	0.00								NO	NO	NO	NO	0.00
3.C.3 - Urea application	0.11								NO	NO	NO	NO	0.11
3.C.4 - Direct N2O Emissions from managed soils			0.03						NO	NO	NO	NO	7.99
3.C.5 - Indirect N2O Emissions from managed soils			0.01						NO	NO	NO	NO	2.65
3.C.6 - Indirect N2O Emissions from manure management			0.00						NO	NO	NO	NO	0.35
3.C.7 - Rice cultivation		NO							NO	NO	NO	NO	NO
3.C.8 - Other (please specify)		NO	NO						NO	NO	NO	NO	NO
3.D - Other	NO	NO	NO						NO	NO	NO	NO	NO

3.D.1 - Harvested Wood Products	NO								NO	NO	NO	NO	NO
3.D.2 - Other (please specify)	NO	NO	NO						NO	NO	NO	NO	NO
4 - Waste	0.74	11.22	0.02						NO	NO	NO	NO	320.31
4.A - Solid Waste Disposal	0.00	9.67	0.00						NO	NO	NO	NO	270.85
4.C - Incineration and Open Burning of Waste	0.74	0.03	0.00						NO	NO	NO	NO	1.68
4.C.2 - Open Burning of Waste	0.74	0.03	0.00						NO	NO	NO	NO	1.68
4.D - Wastewater Treatment and Discharge	0.00	1.52	0.02						NO	NO	NO	NO	47.77
4.D.1 - Domestic Wastewater Treatment and Discharge	0.00	1.52	0.02						NO	NO	NO	NO	47.77
Memo Items													
1.A.3.a.i – International aviation (International bunkers)	677.31	0.00	0.02						NE	NE	NE	NE	682.47
1.A.3.d.i - International water-borne navigation (International bunkers)	610.83	0.06	0.02						NE	NE	NE	NE	616.67

Annex II Institutions and Roles of involved in the Preparation of The Bahamas' NIR

Inventory Phase	Sector	Institution and Contacts	Roles
Planning	Crosscutting	• Department of Environmental Planning and Protection	Coordinating and policymaking authority with respect to environment and climate change in the Bahamas. Overseeing the entire national inventory process from the early stages of data collection through processing and reporting. This includes liaising with data providers, and identifying members of the National Inventory Team and coordinating their capacity building
Data Collection	Energy	• Ministry of the Environment and Housing • Central Bank of the Bahamas • National (reports)	Provides information on GHG emissions associated with electricity generation, national fuel consumption data,

Inventory Phase	Sector	Institution and Contacts	Roles
		• Bahamas Power and Light Company Ltd. • Bahamas National Statistical Institute (reports) • Grand Bahama Power Company • Ministry of Transport and Local Government • Port Department • Ministry of Transport and Local Government (Port Department) • Department of Statistics • Road Traffic Department • Road Traffic Department (Family Islands) • Rubis Bahamas Ltd. • Grand Bahama Port Authority • Bahamas Maritime Authority	energy balance, and vehicle registration data.
	Agriculture	• Department of Agriculture, Ministry of Agriculture and Marine Resources • Bahamas Agricultural Health and Food Safety Authority • Customs Department (Reports) • Caribbean Agriculture and Research Institute	Provides data and technical support when compiling GHG emissions for agriculture Provides technical support when compiling GHG emissions for land Provides maps for the land sector

Inventory Phase	Sector	Institution and Contacts	Roles
		● Forest and Agriculture Organization (FAO) (reports)	
	Forestry	● Forestry Unit ● Bahamas National Trust ● Bahamas Reef Environment Educational Foundation (BREEF) ● The Nature Conservancy ● Perry Institute for Marine Science ● University of Bahamas, Climate Change and Adaptation Centre ● Forest and Agriculture Organization (FAO) (reports)	
	Waste	● Bahamas Waste Limited ● New Providence Ecological Park (NPEP) ● The Bahamas Water and Sewerage Corporation ● Department of Environmental Health Services ● UN Statistics (reports)	Provides information on the waste sector Provides statistical parameters that can be applied when estimating GHG emissions from the waste sector Provides information on the country's wastewater treatment works.

Inventory Phase	Sector	Institution and Contacts	Roles
	Industrial Processes and Product Use	• Ozone Unit, Department of Environmental Health Services (DEHS) • Ministry of Works	Provide GHG information for the IPPU sector, particularly on refrigerants
Preparation	Sectors and Crosscutting	• Caribbean Cooperative MRV Hub Greenhouse Gas Management Institute • Support of National Experts and Data Providers	Provide Capacity to National members of the NIT to take on hands on role in preparation of National Greenhouse Gas Inventories Collecting and evaluating data Selection of methodological approaches Estimation of emissions Assessment of uncertainty and analysis of key categories preparation of inventory report
Quality Control	Crosscutting	• External MRV Hub and GHGMI experts	Review of estimations by experts not involved in the compilation of greenhouse gases

Inventory Phase	Sector	Institution and Contacts	Roles

Quality Assurance/ Review	All Sectors	• Sectoral Experts, and Data Providers including
		• Department of Environmental Planning and Protection
		  ○ Nikita Charles Hamilton
		  ○ Larissa Cartwright
		• Department of Meteorology
		  ○ Jeffrey Simmons
		• University of The Bahamas
		  ○ Dr. George Odhiambo
		• Bahamas Power and Light Company Ltd.
		  ○ Rochelle J McKinney
		  ○ Andrew Bastian
		• Grand Bahama Power Company
		  ○ Garelle Hudson
		• Rubis Bahamas Ltd.
		  ○ Kirk Johnson
		• Department of Agriculture
		  ○ Gina Pierre
		• Forestry Unit
		  ○ Danielle Hanek
		• Bahamas National Trust
		  ○ Giselle Deane
		• The Nature Conservancy
		  ○ Shenique Albury
		  ○ Marcia Musgrove
			Review National Circumstances of methods, approaches and assumptions
			
			Formal and informal technical reviews of National Inventory Report

<table>
<tr><th>Inventory Phase</th><th>Sector</th><th>Institution and Contacts</th><th>Roles</th></tr>
<tr><td></td><td></td><td>● Department of Environmental Health Services
○ Ryan Perpall
○ Launa Williams
● New Providence Ecological Park (NPEP)
○ Jamie Strachan
● The Bahamas Water and Sewerage Corporation
○ John Bowleg</td><td></td></tr>
<tr><td>Validate</td><td>Sectors and Crosscutting</td><td>● National Climate Change Committee

● Cabinet</td><td>Provide oversight on the compilation of the report, including reviewing and providing inputs on technical information, in order to ensure the reports reflect the national circumstances.

Validates the final NIR before submission to the Cabinet

Provides final approval of NIR, BURs, etc. before submission to the UNFCCC</td></tr>
<tr><td>Management</td><td>Crosscutting</td><td>● Department of Environmental Planning and Protection</td><td>Documentation, archiving, reviewing, checking and evaluation of planned improvements and data collected</td></tr>
</table>

Inventory Phase	Sector	Institution and Contacts	Roles
			Submission of final report to the UNFCCC Review of necessary inventory improvements and archiving

Annex III Details of the improvement plan

N°	CRF code	Identified issues for Improvements	Recommendations for the actions to be taken	Proposed timeline for implementation	Priority level
G1	n.a.	Set up appropriate institutional, procedural, legal arrangements and documentation for the preparation of the national GHG inventory	In order for the GHG inventory to be sustainable appropriate institutional, procedural, legal arrangements and documentation are needed	2022-2023	High
G2	n.a.	Fully establish and implement QA/QC procedures for the national GHG inventory	QA procedures are to be embedded into the MRV system, while the set of QC procedures should ensure the accuracy of the GHG inventory estimates	2022-2023	High
G3	1.A.1	Quality and completeness of CBB data is unclear	Together with CBB staff, understand how data is collected and whether it covers all relevant activities (e.g., all fuel imports)	2022-2023	High
G4	1.	Develop a national energy balances	Create a Task Force with the national actors related to fuel statistics, to assess the steps to define the institutional, procedural	2023-2025	High

			(including the mechanism to collect information) and legal arrangements to build annual energy balances of The Bahamas, including all populated islands, taking into account national circumstances.		
E1	1.A.1	Data could not be obtained from all fuel distributors	Contact fuel distributors and, in close alignment with the assessment of the CBB data, consider obtaining detailed data annually from fuel distributors where appropriate (avoid double effort with existing customs / CBB data collection)	2022-2023	High
E2	1.A	No country-specific emission factors for fuel consumption available	As the categories 1.A.1.a.i, 1.a.2.m, 1.A.3.b.i-iii, and 1.A.4.a are key categories with regards to CO_2, country-specific emission factors should be developed to allow moving to a Tier 2 approach. As a first step, however, we suggest that the a	2023-2025	Low

			thorough data collection approach is established.		
E3	1.A.1	Incomplete BPL fuel consumption and power generation time series	Collect historic fuel and diesel oil consumption as well as power generation from BPL, GBPC and, if possible, from other smaller power generators on the private islands, ideally back to 2001.	2022-2023	High
E4	1.A.2	Unclear, which activities under manufacture and construction take place	Assess company registers, work with business associations	2022-2023	Mediu m
E5	1.A.3. a	No information on whether aviation gas is also used for international flights and if so, what amounts	Obtain information on fuels sold to airports, from airports themselves or fuels distributors	2022-2023	Mediu m
E6	1.A.3. b	Car registration numbers fluctuate strongly over time	Assess registration data from the transport department, understanding reasons for data fluctuations, improve data where necessary	2022-2023	High
E7	1.A.3. b	Limited information on car population	Assess improved registration data to understand fuel to understand shares of	2022-2023	High

			vehicle types and assess to which extent these fit the IPCC vehicle categories. The motor technologies would also be helpful to understand, but are of lower relevance, as 1.A.3.b is not a key category for N_2O and CH_4.		
E8	1.A.3.b	No information on number of car trips and average distances per trip available	Conduct a study to develop estimates for number of car trips and average distances per trip	2023-2024	Medium
E9	1.A.3.c	No information on fuel consumption for domestic waterborne navigation is available	Assess whether information can be obtained from fuel distributors (potentially as share of fuel consumption reported to the CBB)	2023-2024	Medium
E10	1.A.3.a.i and 1.A.3.c.i	Information on consumption of bunker fuels reported by CBB only as total in TJ, not by fuel type and by area of consumption	Work with CBB and fuel distributors to obtain the consumption of bunker fuels in a disaggregated manner	2022-2023	Medium
I1	2.D	There is no activity data available on non-energy products from fuel and solvent use	Work with customs, industry associations to understand import and use of lubricants, paraffin	2023-2024	Low

		from the use of paraffin waxes and solvents use. Also, lubricant use shows a steep decrease in activity data by over 70% between 2001 and 2018. There is also indication that recollected lubricants are used as fuels under category 1.A.2. Where this was the case, the resulting emissions would have to be reallocated from category 2.D.1 to 1.A.2	waxes and solvents. According to experts lubricants are collected, stored at BPL and treated outside of the Bahamas, so they can be reused. This could potentially explain some of the reduction in lubricant consumption. As GHG emissions from these categories are typically low, these improvements are considered less urgent.		
I2	2.F	Information on the import and consumption of HFCs/ PFCs/SF6 is not available	Work with customs to obtain past import data of HFC and PFC species and of equipment already containing HFCs and PFCs. The National Ozone Office will be able to view future imports of ozone depleting substances through a single window system at the customs which is	2022-2023	High

			currently being implemented. Consider, pesticides / insecticides as a potentially large source of HFC emissions (use as propellant).		
I3	2.F	There is no information on the amount of HFCs/PFCs banked in The Bahamas	Conduct a study together with customs, the National Ozone Officer and the importers/distributors of refrigeration and air conditioning equipment.	2023-2024	High
I4	2.G.	There is no information on the amount of N_2O consumed in The Bahamas	Work with customs to obtain data on N_2O imports and uses. Assess whether N_2O is produced in The Bahamas and production amounts.	2023-2024	Low
I5	2.G.	Experts indicated that at least BPL uses electrical equipment containing SF_6, however such data was not available at the time of the assessment.	Work with BPL and GBPC to understand amounts of SF6 banked and consumption of SF_6 during maintenance (where appropriate). Obtain data on SF_6 imports from customs for validation.	2022-2024	Medium
A1	3.A.1	Livestock data is very limited, not readily available on an annual basis	Work with customs import reports and Agriculture Field officers to collect and validate livestock data	2022-2023	Medium

A2	3.B	Satellite images for 2003 onwards suffer from scan-line error due to failure of on-board scanning instrument resulting in strips of data-gaps. and 2010 contains noise and errors which significantly affects the LULUCF emission estimates for the period 200-2005; 2005-2010 and from 2010-2015	Make plans to establish permanent sampling plots in the main land use categories to improve field training points for land classification map	2022-2023	High
A3	3.B	No country specific emission factors available for land use categories	Categories 3.B.1.a-b, 3.B.2.b, 3.b.3.b, 3.B.4.b and 3.b.5.b are key categories with regards to CO_2. Conduct field survey and measurements to develop country specific emission factors will help improve accuracy of GHG emissions. Generating emission factors for forest, grasslands and wetlands with woody should be made priority.	2022-2024	High

A4	3.B	No digital land use maps available with IPCC land use categories	Conduct training with those with ground knowledge of the country and some GIS expertise will help The Bahamas to calculate emissions for future reporting requirements to produce land use information based on 20 years period	2022-2023	High
A5	3.C.1	Data on biomass burning of crop residues is not available, only anecdotally referenced that 30% of farmers practice slash and burn in the absence of mechanization.	Work with Agriculture Department and field officers to get an appropriate sample of areas where biomass burning occurs to improve non CO_2 emissions estimates.	2022-2023	Mediu m
A6	3.C.2	Agricultural lime application is not estimated as soils are calcareous, however customs report indicates yearly imports.	Verify with Customs on end usage of lime that is imported, and include this category in the next cycle.	2022-2023	High
A7	3.C.6	Manure management practices of different	Conduct a survey of livestock manure	2022-2023	Mediu m

		types of livestock is not well documented	management practices to improve accuracy of estimates		
W 1	4.A	There is no information on the depth and size of landfills in The Bahamas, no information on solid waste generation and composition.	Conduct a study assessing waste generation (including from tourism) and composition and providing an overview on the depth and size of landfills in The Bahamas allowing to move to a Tier 2 approach over time. Category 4.A is a key category with regards to CH_4.	2022-2023	High
W 2	4.D	There is no information on industrial wastewater from companies in The Bahamas, no information on solid waste generation and composition.	Map industries, and engage stakeholders early on to provide data, and secure buy-in for wastewater discharge.	2022-2023	High
W 3	4.C	There is anecdotal evidence that open burning of waste takes place in smaller islands of The Bahamas, but no information amounts	Conduct a study assessing open burning practices	2023/2024	Medium

		burned and type of waste burned			
W 4	4.B	There is no information on whether incineration of waste takes place (e.g. in industrial facilities or hospitals)	Approach Bahamas Waste and industry associations about incineration of hazardous and other wastes. Late in the GHG inventory compilation process an expert indicated that Pharmachem in Grand Bahama burn hazardous liquid chemical waste and that other industrial facilities operate smaller incinerators. Conduct a study assessing waste management practices at hospitals	2023/2024	Mediu m

Annex IV Matching fuels and activities in the energy balance with the IPCC categories

OLADE has prepared an energy balance for the years 2010-2012. The energy balance (EB) presents fuel consumption by activity. These activities mostly show good alignment with the categories of the IPCC 2006 Guidelines. Table 137 shows how the fuels and activities in the energy balance were mapped against the categories in the IPCC 2006 Guidelines. Empty cells in the table indicate that the specific fuel/activity combination did not occur, e.g. there was no firewood consumption in industry.

Table 137: Matching of fuels and activities in the energy balance to the categories in the IPCC 2006 Guidelines

Activity	Fuel consumption							
	Firewood	LPG	Gasoline Alcohol	Jet Fuel Kerosene	Diesel Oil	Fuel Oil	Charcoal	Non-Energy
Power plants	-	-	-	-	1.A.1.a Main electricity and heat production	1.A.1.a Main electricity and heat production	-	-
Self-producers	-	-	-	-	1.A.1.a Main	-	-	-

					electricity and heat production			
Transportation	-	-	1A3b - Road transportation	1A3aii - domestic aviation	1A3b - Road transportation	1A3dii - Domestic water borne navigation	-	-
Industry	-	1A2m - Non-specified industry	1A2m - Non-specified industry	-	1A2m - Non-specified industry	1A2m - Non-specified industry	-	-
Residential	1A4b - residential	1A4b - residential	1A4b - residential	1A4b - residential	1A4b - residential	-	1A4b - residential	-
Commercial, services, public sector	-	1A4A - commercial/institutional	1A4A - commercial/institutional	-	1A4A - commercial/institutional	-	1A4a - commercial/institutional	-

Agriculture, fishing, mining	-	-	1A4c Agriculture/Fishing	-	1A4c Agriculture/Fishing	-	-	-
Construction	-	1A2k - construction	1A2k - construction	-	1A2k - construction	-	-	-

Annex V Land use Change Matrices - 2000 to 2020

The following tables demonstrate the breakdown of land use between individual land use categories for each 5 year interval from 2000-2020.

Table 138: Land use Change Matrix between 2000 and 2005

2000-2005	Area change in ha						Total
	Forestland	**Grassland**	**Cropland**	**Wetland**	**Settlement**	**Other land**	**Area (ha)**
Forestland	174,695	8,047	8,733	6,793	19,478	568	218,313
Grassland	47,850	40,822	30,428	22,554	37,250	1,412	180,315
Cropland	6,885	4,758	16,657	3,040	23,188	1,053	55,581
Wetland	5,075	9,313	2,262	15,502	5,838	11,476	49,465
Settlement	16,586	5,114	15,139	5,311	63,590	7,984	113,724
Other land	355	1,772	470	9,725	6,011	54,111	72,444

Total Area (ha)	251,446	69,826	73,687	62,925	155,354	76,605	689,841

Table 139: Land use Change Matrix between 2005 and 2010

2005-2010	**Area change in ha**						**Total**
	Forestland	**Grassland**	**Cropland**	**Wetland**	**Settlement**	**Other land**	**Area (ha)**
Forestland	210,014	12,259	14,920	8,423	23,650	398	269,664
Grassland	30,242	15,692	19,480	10,124	20,354	7,979	103,871
Cropland	5,230	4,448	16,832	2,244	16,511	547	45,813
Wetland	5,050	31,002	2,201	17,064	4,149	11,787	71,254
Settlement	11,374	4,720	18,796	3,871	59,560	5,424	103,745
Other land	379	667	495	4,841	5,080	43,985	55,447
Total Area (ha)	262,289	68,789	72,723	46,566	129,304	70,121	649,792

Table 140: Land use Change Matrix between 2010 and 2015

2010-2015	**Area change in ha**						**Total**
	Forestland	**Grassland**	**Cropland**	**Wetland**	**Settlement**	**Other land**	**Area (ha)**
Forestland	254,936	6,369	8,558	5,937	21,088	231	297,119

Grassland	71,619	42,578	46,592	30,598	64,678	7,016	263,081
Cropland	2,830	1,227	3,333	1,039	4,948	86	13,463
Wetland	21,927	8,604	1,882	13,051	3,229	4,113	52,805
Settlement	4,391	2,118	7,430	1,271	25,517	2,484	43,212
Other land	373	2,733	744	7,774	7,242	28,451	47,317
Total Area (ha)	356,076	63,629	68,539	59,669	126,702	42,380	716,996

Table 141: Land use Change Matrix between 2015 and 2020

2015-2020	**Area change in ha**						**Total**
	Forestland	**Grassland**	**Cropland**	**Wetland**	**Settlement**	**Other land**	**Area (ha)**
Forestland	243,171	2,424	2,191	14,061	7,288	216	269,351
Grassland	74,795	50,329	7,903	29,760	17,266	10,085	190,138
Cropland	2,506	1,789	2,976	2,569	2,333	33	12,206
Wetland	10,046	11,571	2,445	27,961	824	2,860	55,706
Settlement	5,786	1,516	2,701	749	17,702	1,586	30,040
Other land	372	1,764	65	5,286	2,228	32,929	42,643
Total Area (ha)	336,675	69,393	18,281	80,385	47,641	47,709	600,085